**Carbaryl Executive Summary for Final Biological Evaluation**

This Biological Evaluation (BE) assesses potential risks that registered uses of carbaryl (PC code 056801) may pose to an individual of a listed species or designated critical habitat. The federal action considered in this BE is the Registration Review for carbaryl, which encompasses the review of all the registered uses, and the approved product labels for all pesticide products containing carbaryl.

The term “listed species” includes those that are federally listed as endangered and threatened, as well as those that are proposed and candidates for listing and experimental populations. The methods employed in this BE follow the Revised Method for National Level Listed Species Biological Evaluations of Conventional Pesticides (referred to as the “Revised Method”)[[1]](#footnote-2). The Revised Method incorporates input from the public, US Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS) and US Department of Agriculture (USDA).

As described in the Revised Method, EPA’s development of this BE includes two steps. The BE includes an evaluation of whether an individual of a listed species is reasonably expected to be exposed to a pesticide at a level that results in a discernable effect, and, if so, distinguishes effects that are likely to adversely affect an individual of a species from those that are not likely to adversely affect an individual. This process is also applied to the designated critical habitat of listed species (when available). In Step 1, for every listed species and designated critical habitat, EPA determines whether carbaryl will have No Effect (NE) or May Affect (MA) (separate determinations made for each species and critical habitat). For those species and critical habitats with MA determinations, in Step 2, EPA will determine if carbaryl is Not Likely to Adversely Affect (NLAA) or Likely to Adversely Affect (LAA) an individual species or critical habitat. Details on the method, models and tools used for making NE, NLAA and LAA determinations are provided in the Revised Method document.

In March 2020, EPA released the Revised Method for National Level Listed Species Biological Evaluations (BEs) of Conventional Pesticides. EPA used the Revised Method to conduct the draft BEs for carbaryl. On March 17, 2020, EPA released the draft BE for carbaryl for public comment. EPA received public comments on the proposed Revised Method and the carbaryl BE through July 2, 2020, which included a 45-day extension of the original public comment period. Updates to the Revised Method and updates that were specific to carbaryl were implemented in the final BE.

# General Information

Carbaryl is used on a wide variety of terrestrial food and feed crops, as well as uses in turf management, ornamental production, rangeland, and residential settings. Additionally, carbaryl is used to thin fruit in orchards to enhance fruit size and enhance repeat bloom. Carbaryl is also used to control mud and ghost shrimp in commercial shrimp ponds in Texas. There are currently five active technical registrants of carbaryl with 61 active product registrations (60 Section 3s and 1 Special Local Needs), which include formulated products (**APPENDIX 1-1**). Carbaryl can be applied in liquid (*i.e*., flowable concentrate, emulsifiable concentrate, wettable powder, water soluble powder), bait, granular, or dust forms. Aerial and ground application methods are allowed, as are pressure sprayers, dust applicators, spreaders and shank applicators, and baits (see **APPENDIX 1-2** for details).

This BE assesses all currently registered labels. **APPENDIX 1-2** provides the master use summary table summarizing all currently registered use patterns. **APPENDICES 1-3** and **3-1** provide additional details on how these uses were modeled.

Carbaryl enters the environment via direct application to use sites. It may move off-site via spray drift and runoff. Major routes of carbaryl transformation in the environment include alkaline hydrolysis, photolysis in water, and soil and aerobic aquatic metabolism. Abiotic hydrolysis under acidic conditions and anaerobic metabolism do not seem to play a significant role in the degradation and dissipation processes. Information on leaching and adsorption/desorption indicate that carbaryl is considered moderately mobile. The logarithm octanol-water partition coefficient (log Kow 2.36) suggests that carbaryl has a low tendency to accumulate in aquatic and terrestrial organisms. Carbaryl has no degradates that are considered residues of toxicological concern.

Carbaryl is an N-methylcarbamate insecticide which acts by inhibiting acetylcholinesterase, thereby reducing the degradation of the cholinergic neurotransmitter acetylcholine. As a result, inter-synaptic concentrations of acetylcholine increase as the neurotransmitter accumulates leading to increased firing of the postsynaptic neurons which may lead to convulsions, paralysis, and death of an organism exposed to the chemical. Acetylcholinesterase inhibition is rapidly reversed in many taxa once exposure to an N-methylcarbamate insecticide has ended. Carbaryl is also used to thin blossoms in orchards; its activity in the abscission of flower buds may be related to its structural similarity to plant auxins, such as α-naphthalene acetic acid. Additional details on the fate of carbaryl are provided in **Chapter 3** of the Biological Evaluation.

Carbaryl is practically nontoxic to birds and moderately toxic to mammals on an acute exposure basis. However, carbaryl demonstrated a variety of growth and reproductive effects at a range of exposure concentrations in birds and mammals as discussed in **Chapter 2**. Carbaryl is highly toxic to beneficial insects and bees. Carbaryl is moderately toxic to freshwater fish, and highly toxic to freshwater and estuarine/marine invertebrates on an acute exposure basis. Carbaryl has demonstrated adverse effects on growth to both vascular and non-vascular aquatic plants as well as terrestrial plants. There are reported ecological incidents involving carbaryl use for birds, mammals, terrestrial invertebrates, and terrestrial plants which are detailed in **Chapter 2**.

# Exposure Methods

Exposure estimates are based primarily on fate and transport model results. Aquatic exposures (surface water and benthic sediment pore water) are quantitatively estimated for representative carbaryl uses in specific geographic regions within generic habitats (referred to as bins) using the Pesticide Root Zone Model (PRZM5) and the Variable Volume Water Model (VVWM)[[2]](#footnote-3) in the Pesticides in Water Calculator (PWC) version 2.001. Aquatic exposure results for the bin(s) most appropriate for the species and/or critical habitat are discussed in **Chapter 3**. Also discussed in **Chapter 3** are available water monitoring data for carbaryl. For terrestrial exposures, existing models [*i.e*., AgDRIFT, earthworm fugacity model, Terrestrial Herpetofaunal Exposure Residue Program Simulation (T-HERPS), Terrestrial Residue Exposure model (T-REX) and portions of the Terrestrial Investigation Model (TIM)] were combined and modified into a single tool that is referred to as the MAGTool (**Chapter 4**). This assessment replaces EPA’s TerrPlant model with the Plant Assessment Tool (PAT), the latter is a more refined exposure model for terrestrial, wetland and aquatic plants. Between the draft BE and the final BE, an updated methodology was utilized to estimate exposure in residential settings.

# Overlap Analyses

Step 1 of the BE involves an analysis of the potential overlap of the action area and individual species ranges and critical habitat. The action area was derived in ArcGIS 10.8 by combining the data layers representative of carbaryl potential uses plus off-site transport. The overlaps of action area and individual species’ ranges or critical habitats were calculated. This analysis used spatial data of species’ ranges and habitats from the Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS). In the contiguous United States (ConUS), agricultural potential use sites are represented using the USDA Crop Data Layer (CDL) (**APPENDIX 1-5**). Other data sources are used to represent agricultural areas in states and US territories outside of the contiguous United States, for which the CDL is not available (**APPENDIX 1-6)**. All species or critical habitats with some overlap of the action area and their range or designated critical habitat, or with some overlap on species that the listed species depends on (**Chapter 4**) are assessed in the MAGTool to make LAA/NLAA determinations. Between the draft BE and the final BE, several UDLs were updated include splitting alfalfa and other agricultural grasses (non-grazing area) from the pasture/rangeland (grazing areas).

# Effects Determinations

This BE makes effects determinations (NE, NLAA or LAA) for 1,805 listed species, and 791 designated critical habitats. For each species and designated critical habitat, the effects determination is based on the methodology detailed in **Chapter 1** of this BE and the Revised Method document[[3]](#footnote-4). NE determinations were made for three species and their designated critical habitats; all other species received a MA determination. All species and critical habitats with a MA determination progressed to the Step 2 analysis where a NLAA or LAA determination is made. NLAA determinations were made for 162 species and 52 species’ critical habitat and LAA determinations were made for 1,640 species and 736 species’ critical habitats. Most NLAA determinations were based on a qualitative analysis of species, based on factors such as being presumed extinct or having incomplete exposure pathways. Specific species determinations are provided in **APPENDIX 4-1.**

The MAGTool estimates the number of individuals of a listed species that are potentially affected, incorporating the degree of overlap of a species range with potential use sites and associated usage data for a chemical (and associated off-site transport areas) into the effects determinations. Using the toxicity endpoints for each taxon (**Chapter 2**), the MAGTool utilizes both deterministic and probabilistic methods to assess the likelihood that carbaryl will adversely affect an individual of a given species. To help determine the potential for risk, the MAGtool incorporates many of EPA’s standard pesticide exposure models to estimate exposures to listed species and their prey, pollination, habitat, and dispersal vectors (PPHD). Details on the individual effects determinations are found in **APPENDIX 4-1**. If the model estimates are not considered representative of the exposure of the species (due to an inconsistency in the exposure model and assessed species’ habitat), a qualitative analysis is conducted. In those cases, EPA makes either a LAA or a NLAA determination based on a qualitative weight of evidence. For each LAA determination, this assessment employs three categories (*i.e.,* strongest, moderate and weakest) to characterize the strength of the weight of evidence. Each species or critical habitat was assigned a weak, moderate or strong evidence in the LAA determination based on multiple factors, including: the impact of using less conservative assumptions in the analysis, the quality of the species range or usage data, impacts to both the species and PPHD as opposed to only one, the presence of reported incidents involving the species taxa or PPHD taxa, the presence of monitoring data that exceeds endpoints, exposure only due to spray drift and the likelihood of drift into a species habitat (*e.g*., if the species inhabits forests).

Of the LAA determinations, the majority (70% of species and 73% of critical habitats) were considered to have moderate evidence. Strongest evidence was found for 8% of species and 10% of critical habitat LAA determinations. Weakest evidence was found for 22% of species and 18% of critical habitat LAA determinations.

Non-agricultural UDLs, including Open Space Developed, Right of Way and Developed UDLs were often cited as the top use sites associated with predicted impacts to species or critical habitats with LAA determinations, although numerous other non-agricultural and agricultural UDLs may also impact species. When interpreting UDL rankings based on impact to the species, it is important to remember the UDLs are not mutually exclusive from one another. Therefore, other influences related to this lack of independence may influence the high rankings of a given layers. LAA determinations were made for species across all taxa. For certain species, there were uncertainties in the carbaryl effects determinations based on the resolution of spatial data. For species and critical habitats there were uncertainties in the resolution of usage data and the threshold for assessing impacts on PPHD (detailed in **Chapter 4**).**Tables 1** and **2** summarize the NE, NLAA and LAA determinations for species and critical habitats. **Table 3** summarizes the strength of evidence classifications for the LAA determinations.

**Table 1. Summary of Species Effects Determinations for Carbaryl (Counts by Taxon).**

|  |  |  |  |
| --- | --- | --- | --- |
| **Taxon** | **Step 1 Effects Determinations** | **Step 2 Effects Determinations** | **Totals** |
| **No Effect** | **May Affect** | **Not Likely to Adversely Affect** | **Likely to Adversely Affect** |
| Mammals | 1 | 101 | 27 | 74 | 102 |
| Birds | 0 | 107 | 26 | 81 | 107 |
| Amphibians | 0 | 38 | 0 | 38 | 38 |
| Reptiles | 0 | 46 | 14 | 32 | 46 |
| Fish | 0 | 192 | 11 | 181 | 192 |
| Plants | 0 | 950 | 38 | 912 | 950 |
| Aquatic Invertebrates | 0 | 209 | 24 | 185 | 209 |
| Terrestrial Invertebrates | 2 | 159 | 22 | 137 | 161 |
| Total | 3 | 1802 | 162 | 1640 | 1805 |
| Percent of total | 0% | 100% | 9% | 91% |   |

**Table 2. Summary of Critical Habitat Effects Determinations for Carbaryl (Counts by Taxon).**

| **Taxon** | **Step 1 Effects Determinations** | **Step 2 Effects Determinations** | **Totals** |
| --- | --- | --- | --- |
| **No Effect** | **May Affect** | **Not Likely to Adversely Affect** | **Likely to Adversely Affect** |
| Mammals | 0 | 33 | 6 | 27 | 33 |
| Birds | 0 | 31 | 1 | 30 | 31 |
| Amphibians | 0 | 25 | 0 | 25 | 25 |
| Reptiles | 2 | 14 | 6 | 8 | 16 |
| Fish | 0 | 106 | 2 | 104 | 106 |
| Plants | 1 | 459 | 20 | 439 | 460 |
| Aquatic Invertebrates | 0 | 71 | 5 | 66 | 71 |
| Terrestrial Invertebrates | 0 | 49 | 12 | 37 | 49 |
| Total | 3 | 788 | 52 | 736 | 791 |
| Percent of total | 0% | 100% | 7% | 93% |   |

**Table 3. Classification of LAA Determinations by Strength of Evidence.**

|  |  |  |
| --- | --- | --- |
| **Strength of LAA call** | **Species range** | **Critical Habitat** |
| **Number** | **% of LAA determinations** | **Number** | **% of LAA determinations** |
| Strongest evidence of LAA | 131 | 8% | 70 | 10% |
| Moderate evidence of LAA | 1147 | 70% | 534 | 73% |
| Weakest evidence of LAA | 362 | 22% | 132 | 18% |

1. Available at: <https://www.epa.gov/endangered-species/revised-method-national-level-listed-species-biological-evaluations-conventional> [↑](#footnote-ref-2)
2. The exposure models can be found at: <http://www.epa.gov/pesticides/science/models_pg.htm> [↑](#footnote-ref-3)
3. USEPA. 2020. *Revised Method for National Level Listed Species Biological Evaluations of Conventional Pesticides*. March 12, 2020. Environmental Fate and Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at <https://www.epa.gov/endangered-species/revised-method-national-level-listed-species-biological-evaluations-conventional>. [↑](#footnote-ref-4)