Integration and Synthesis Summary for Crustaceans

This Integration and Synthesis Summary includes our jeopardy analysis for any crustacean species that we or EPA determined will "likely be adversely affected" by the proposed action. Our jeopardy analysis of the proposed action's impacts to listed species is split into three major factors: vulnerability, exposure, and toxicity. The tables below contain summaries of our rankings (high, medium, low) for vulnerability, exposure, and toxicity. Data and information used to determine each individual species' rankings, including environmental baselines, cumulative effects, exposure information, and expected toxic effects for all species, and a template worksheet to show how rankings were assessed and combined are in Appendix E. Status of the species for each species can be found in Appendix B.

Vulnerability

For the crustacean species that we or EPA determined are "likely to be adversely affected" by the proposed action, we considered several factors to summarize the current vulnerability of that species to additional stressors. This effort allows us to consider whether a species' current condition is moving toward recovery, or in further decline. In general, we expect the species' vulnerability to additional stressors to be higher if they are moving toward further decline than if their condition is improving. We also identify which species are most (and least) susceptible to additional stressors in general based on information that could be surmised from species listing and recovery documents, or other sources as cited and considered in the Status section of this biological opinion.

Our assessment of vulnerability focuses on six factors: (1) the species listing status and recent 5-year status review recommendation (if available), (2) distribution, (3) number of populations, (4) species population trends, (5) if pesticides have been noted as a threat, and (6) impacts from activities associated with environmental baseline and cumulative effects. We obtained the information to create the vulnerability summary from the Status of the Species accounts (Appendix B), the overarching Environmental Baseline section of this Opinion, 5-year species status reviews, species recovery plans, species status assessments, and other sources containing the best available scientific information for the species.

We scored each of the six vulnerability components with high, medium, or low scores. We assigned a high vulnerability ranking to a species if all vulnerability components were scored as medium or high. We assigned a medium vulnerability ranking if a species' scores were a mix of high, medium, and low (though exceptions were allowed for species that have a low status score or an uplisting recommendation). We assigned a low vulnerability ranking to species with only low scores. Considerations regarding specific aspects of the species' vulnerability or beyond what was included in the vulnerability ranking were applicable for some species depending on unique aspects of their life history. This information is reflected in the rationales for conclusion below.

Exposure

We anticipate crustaceans will primarily be exposed to carbaryl through contact with contaminated water in their habitats. We assume all carbaryl that is transported off-site, whether through spray drift or runoff, is likely to end up in local water bodies, which may distribute carbaryl residues throughout the entire watershed. Carbaryl degrades quickly (i.e., within a few days) in aerobic aquatic habitats and, as such, is not likely to persist in water bodies for long periods of time, be transported long distances in surface waters, or occur in groundwater sources.

Exposure to Agricultural Uses

We characterize the expected level of exposure using overlaps between the species' ranges and agricultural land uses where carbaryl is registered for use (i.e., overlaps), past carbaryl usage data (when available; the amount and location where carbaryl has been used in the past), any species-specific considerations such as life history information (e.g., habitat preferences, dispersal behavior), and existing protections or conservation actions (e.g., existing label measures, conservation measures from the action agency). Species with greater than 10% overlap between their range and agricultural carbaryl use sites are assigned a high overlap score, species with 5-10% overlap are assigned a medium overlap score, and species with less than 5% total overlap are assigned a low overlap score. In addition to range overlaps with carbaryl use sites, we considered past carbaryl usage data within a species' range to determine how much of a species' range we expect to be treated with carbaryl each year of the proposed action. Except where otherwise noted, usage data is provided by EPA from their National and State Summary Use and Usage Matrix, as described in the Usage Analysis section of this biological opinion. Species that we expect will have a large portion of their range (>10%) treated with carbaryl each year based on past SUUM usage are assigned a high usage score. Species with 5-10% total usage are assigned a medium usage score, and species with less than 5% total usage are assigned a low usage score. Agricultural uses of carbaryl in the state of Hawai‘I are no longer registered; however, agricultural uses are still registered for other island territories. We determine the overall exposure ranking by qualitatively considering both the total overlap and total usage, as well as any additional exposure considerations that might modify the level of exposure likely to occur. When overlap and usage scores are the same, we assign the overall exposure ranking the same score (e.g., if both overlap and usage is high, the overall exposure ranking is high). In cases where overlap is high and usage is medium or when overlap is medium and usage is low, we use the overlap score as the overall exposure ranking to maintain conservative exposure assumptions. (As usage is a subset of overlap, the overlap score will always be greater than the usage score). In cases where overlap is high, but usage is low, we anticipate a moderate portion of the range may be treated over the duration of the proposed action even if only a small portion of the range is treated in any given year (particularly if the areas treated occur in different locations each year), leading to an overall exposure ranking of medium. Past usage data for carbaryl is not available for species located on Pacific or Caribbean islands, including the Commonwealth of The Northern Mariana Islands (CNMI), Guam, American Sāmoa, U.S. Virgin Islands, and Puerto Rico. Thus, in the absence of any additional exposure considerations for these species, our

ranking is based on total overlap of carbaryl use sites for species that occur in these areas. For all species, where there are additional exposure considerations, we adjust the overall exposure ranking to reflect this additional information, as appropriate.

Exposure to Non-Agricultural Uses

Carbaryl has several registered non-agricultural uses, including use sites within developed, open space developed, nurseries, rangeland, managed forests, and rights of way Use Data Layers (UDLs). Rights of way includes roadsides, and we refer to roadsides when applicable. In many cases, data provided by EPA indicate low to high levels of overlap between species' ranges and non-agricultural UDLs. However, UDLs for non-agricultural uses tend to be less defined than those for agricultural UDLs and may not accurately represent the actual footprint of these use sites on the landscape. As such, we assess exposure of species to non-agricultural uses of carbaryl in a qualitative manner, considering the life history of species, methods of application, carbaryl usage, and any existing conservation measures to reduce drift and runoff or otherwise limit exposure to species.

For most species, we anticipate that non-agricultural uses will not meaningfully add to the overall level of anticipated exposure considered in our analysis of agricultural uses and discuss each use in more detail in the *Overall Considerations for the Opinion* section of this Opinion. Briefly, we expect listed species are generally unlikely to be exposed to non-agricultural uses of carbaryl due to low levels of past usage and/or existing mitigation measures that are protective of listed species. Usage data summarized by the EPA indicate that all non-agricultural UDLs have very low levels of past usage (at most 2.5% treatable areas treated with carbaryl annually across the country). Some use patterns, like rights of way, are particularly low usage areas, with less than 500 labs of carbaryl applied nationally each year.

Additionally, based on application information, we anticipate carbaryl use in these UDLs are restricted to small treatment areas that are treated infrequently over long periods of time. Use patterns like forestry, rangeland, or rights of way may even be geographically restricted as available past usage data indicate carbaryl usage is only in certain areas of the country, such as the western conterminous United States. Available usage data from the U.S. Forest Service indicate that, over a five-year period (from 2016-2020), the Forest Service treated 322 acres of forests in California and 557 acres of forests across three Forest Service Regions (covering North Dakota, Montana, South Dakota, Idaho, Kansas, Nebraska, Colorado, Wyoming, Utah, and Nevada), with the majority of applications taking place in small areas (less than 1 acre in size). Similarly, usage data from the U.S. Department of Agriculture Animal and Plant Health Inspection Service (APHIS) show limited past carbaryl usage as well. From 2019-2023, APHIS treated 92,309 acres of rangeland in seven states (Arizona, Idaho, Montana, Nevada, Utah, Washington, Wyoming) and 25 counties. While this represents a large area overall, when distributed across the areas within the seven states where usage occurs, we anticipate only a small percentage of any species' range is likely to be treated for this use pattern. Additionally, all but one of these applications were made using carbaryl bait, which we expect has a much lower

risk profile as bait applications are less likely to cause off target exposures as there is no spray drift exposure likely to occur.

Additionally, there are several existing conservation and mitigation measures for non-agricultural uses of carbaryl that will reduce the likelihood of exposure to listed species. For example, from the 2022 FIFRA Proposed Interim Decision and the 2024 NMFS biological opinion for carbaryl, residential treatments are limited to spot and crack treatments (defined as a 2 ft^2 area), crack-and-crevice treatment, or narrow perimeter bands around urban structures (from 1 inch to 6 feet). This limitation in application method renders off-site spray drift unlikely and greatly reduces the extent of area that can be treated in the developed and nurseries UDLs. Similarly, we anticipate all rangeland applications of carbaryl will be carried out in association with USDA APHIS as part of their grasshopper and Mormon cricket suppression program (USFWS 2024), which include many conservation measures that are meant to protect listed species from exposure. Examples of measures included a reduced agent area treatment strategy that minimizes the amount of pesticide applied within a treatment block, allowance of only one application per year, reduced application rates, minimized treatment area size within 500 feet and 1,000 feet from listed species' ranges for ground and aerial applications, respectively, and extended application buffers when applications are made near the listed species' habitat (e.g., up to 750 feet for some ground applications and up to a mile for some aerial applications).

To assess the likelihood of exposure to non-agricultural uses of carbaryl, we conducted a habitat assessment for each listed species, incorporating available information regarding habitat preferences, known occurrences, relevant life history traits or behaviors, as well as relevant available usage data (summarized in the above sections). For species whose habitat is known or presumed to occur in or adjacent to non-agricultural use sites, we consider, individually and qualitatively, the extent and manner of non-agricultural carbaryl usage within the species' range to generally determine whether a small, moderate, or large number of individuals are likely to be exposed and the expected level of adverse effects from non-agricultural exposure of carbaryl.

Toxicity

We characterize the expected toxic effect to species based on the anticipated level of direct and indirect[1] adverse effects to individuals. Our analysis of toxicity assumes individuals are exposed to carbaryl at levels estimated by EPA's environmental exposure modeling and is focused on determining the level of adverse effect expected to occur once exposure has taken place. Direct effects are based on the anticipated level of mortality and sublethal effects (e.g., reduced growth)

[1] While our Opinion considers all consequences of the proposed action (per the definition of effects of the action at 50 CFR Part 402.02), the terms "direct" and "indirect" effects were used in EPA's BE, and are used in environmental risk assessment terminology in general, and do not have the same meaning as used in ESA regulations. As used in the effects analysis section, direct effects to species are those caused by the pesticide itself through dietary, dermal, or inhalation routes of exposure. Indirect effects occur when the pesticide acts on elements of the ecosystem that are required by the species, such as alterations to prey or shelter. Thus, in the effects analysis section, we may use these terms to link back to the analysis in EPA's BE.

likely to occur in exposed individuals. Indirect effects are based on the impact a listed species is likely to experience when the organisms they rely on, such as those that act as food or habitat resources, are exposed to carbaryl and experience adverse effects.

We consider estimated concentrations of carbaryl on the landscape or within the environment and effects reported in available toxicity studies to determine the level of direct and indirect adverse effects to listed species or critical habitat. Concentrations of carbaryl can vary greatly depending on where exposure takes place. For instance, exposures on or near carbaryl use sites are at higher levels than exposures that occur in areas far away from carbaryl use sites. Based on available toxicity data, we anticipate crustaceans are highly sensitive to carbaryl at estimated environmental concentrations and are likely to experience high levels of mortality, even in habitats that only accumulate low levels. While sublethal effects, such as reduced growth or reproduction, are also possible with carbaryl exposure for some taxa groups, we expect crustaceans will die from carbaryl exposure before sublethal effects would occur.

We anticipate species that only rely on plant-based resources, such as aquatic vegetation for food or habitat, are not likely to experience any indirect adverse effects, as available toxicity data in plants indicate no reductions in plant survival or growth are likely to occur with carbaryl exposure. In contrast, species that rely on other arthropods for food resources may experience high levels of indirect adverse effects as carbaryl exposure will likely reduce the abundance and availability of prey.

We determine the overall toxicity ranking for crustaceans by qualitatively assessing both the expected levels of direct adverse effects (e.g., mortality) and indirect effects (e.g., prey or habitat loss). Given that mortality is the most adverse of direct effects to an individual of a species, we assign the most weight to direct adverse effects resulting in mortality when determining the toxicity ranking. As mentioned previously, available toxicity data indicate crustaceans are highly sensitive to carbaryl and are likely to experience high levels of mortality, even in habitats that only accumulate low levels. As such, all crustaceans will have a high toxicity ranking.

Conservation Measures

As part of the 2022 proposed interim decision for carbaryl, the technical registrants committed to a number of conservation measures for the protection of listed species, including a 48-hour rain restriction and mandatory 25-foot and 150-foot application buffers from aquatic habitats for all outdoor ground and aerial applications, respectively. We anticipate these measures will contribute to the protection of listed crustacean species by reducing the amount of carbaryl residue that is transported off use sites and into the habitat of listed species.

Additionally, an existing letter of concurrence issued by the Service to USDA APHIS regarding carbaryl use in their rangeland grasshopper and Mormon cricket suppression program requires the implementation of numerous conservation measures for the protection of listed species. The USDA APHIS biological assessment considered grasshopper and Mormon cricket program

activities in states where their program is active, which include the implementation of conservation measures, and as a surrogate for usage in states where no programs exist greatly reducing the likelihood of exposure to the species from rangeland uses of carbaryl. Crustacean mitigations from the USDA-APHIS grasshopper and Mormon cricket consultation are the following: a 2,500-foot buffer for all ultra-low volume aerial applications of carbaryl and a 300-foot buffer for all ground applications of carbaryl. For carbaryl bait aerial applications all crustaceans are protected by a 750-foot buffer for aerial applications and a 100-foot buffer for ground applications. These specific buffers apply for the following species that fall in the action area for the USDA-APHIS consultation: Noel's amphipod and Socorro isopod. For the remaining crustaceans in this biological opinion that are outside of the action area for the grasshopper and Mormon cricket program, we anticipate there is a low likelihood of the need to apply these program measures as grasshopper and Mormon cricket populations do not reach the level where they would need to be suppressed in these areas. However, we anticipate the standard aquatic habitat buffers (500-foot buffer for aerial sprays, 200-foot buffer for ground sprays, and a 50-foot buffer for bait application) and other mitigation measures outlined in the USDA APHIS biological assessment would be applied if there were a need to use carbaryl applications for this reason within the remaining crustacean species' habitats.

Summary of Crustaceans Conclusions

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is our biological opinion that the registration of carbaryl is not likely to jeopardize the continued existence of the 30 crustacean species in this Appendix.

In our analysis below, some species that had the same or very similar rationales for their conclusions were grouped together, to increase efficiency and avoid repetition. Relevant information and data unique to each individual species was considered when assigning species to groups and incorporated into the rationales as appropriate. Species-specific information (e.g., environmental baseline, cumulative effects, status of the species, exposure, and toxicity) was considered for all species, including those species in the grouped analyses, and are presented in full in Appendices B and E. Species with rationales that did not fit in a group, or warranted a separate rationale because of their life history, conservation status, or other information indicated that effects could be different, have an individual discussion to provide additional explanation. This approach allowed us to streamline our discussion in this Opinion by avoiding repeating our findings when species in the respective groupings would be expected to be affected similarly. The use of these groupings, therefore, does not mean that our evaluation failed to evaluate each individual species. On the contrary, our process and analysis for each species remained the same, regardless of the format of the discussion presented below.

Species with low concern of adverse effects

We group species together that have low concern of adverse effects due to low exposure and low toxicity with high vulnerability (Table 1). For crustaceans, only one species, the Nashville crayfish, meets the criteria for this group based on low exposure and low toxicity with high vulnerability. While we present some specific information about the species in Table 1 below, we provide additional information on vulnerability (including environmental baseline and cumulative effects), exposure, and toxicity in Appendix E. The status of the species accounts can be found in Appendix B.

Table 1. Crustacean species with low exposure, low vulnerability, and high toxicity if exposed.

Scientific Name	Common Name	Vulnerability Ranking	Exposure Ranking	Toxicity Ranking	Determination
Orconectes shoupi	Nashville crayfish	Low	Low	High	No Jeopardy

The Nashville crayfish is listed as endangered, and it only occurs in the Mill Creek watershed of Tennessee. Nashville crayfish have been found in stream reaches in metropolitan Nashville, and juveniles are found more commonly on stream margins in slower flowing water with aquatic vegetation cover. The species was proposed for delisting due to recovery in 2019 (85 FR 59732 59734) because it currently persists in high numbers and exhibits a high degree of resistance to disturbance, indicating that the species has a low susceptibility to threats and high degree of stability. Pesticides are a noted threat to the species, with herbicide and pesticide run-off included as contributing factors to habitat degradation.

The Nashville crayfish has a high toxicity ranking for carbaryl, indicating that mortality is likely when exposure occurs. However, we anticipate very few individuals are likely to experience adverse effects as the exposure ranking for the Nashville crayfish is low. Total overlap of the species' range with agricultural use sites is 1.7% and agricultural carbaryl usage is expected to occur in 1.6% of the species' range annually. The low level of carbaryl usage within the Nashville crayfish range is corroborated by the USDA's Census of Agriculture (CoA) data that indicate that low usage of insecticides (of any type) occurred in the past in the counties where this species' range occurs (0.5% of the species' range treated). In addition to low exposure from agricultural uses, we expect low exposure from non-agricultural carbaryl uses because the species occurs near developed spaces where carbaryl use is limited. Available application information and past usage data indicates that carbaryl treatments in these non-agricultural areas will be limited to small areas that are treated infrequently over the duration of the proposed action. Furthermore, we anticipate carbaryl treatments in developed areas, such as residential uses, will be made using spot and crack-and-crevice treatments, which we anticipate will result in minimal off-site transport and exposure to listed crustaceans. Thus, despite the high level of toxicity exposed individuals are likely to experience, we anticipate no more than a small number of individuals are likely to be adversely affected.

In summary, we expect a small number of individuals of the Nashville crayfish will likely experience exposure to carbaryl in up to 1.6% of its range over the project duration. This low level of exposure is evidenced by the low annual carbaryl usage and CoA data indicating any use of insecticides within the range of the Nashville crayfish is low. Although we expect a small number of Nashville crayfish will die, we do not expect that this level of mortality will cause species-level effects due to the species' stable status and ability to withstand current levels of stressors in its environment. After adding the effects of the action and cumulative effects to the environmental baseline, and in light of the status of the species, we have determined the proposed action is not expected to appreciably reduce the likelihood of survival and recovery of the species in the wild. Thus, it is our biological opinion that the proposed action is not likely to jeopardize the continued existence of the Nashville crayfish.

Species with low exposure (informed by low overlap with agriculture)

The species in Table 2 are grouped together as they all have low exposure informed by low overlap between the species' range and agricultural sites where carbaryl is registered for use. While we present some specific information about the species in Table 2 below, we provide additional information on vulnerability (including environmental baseline and cumulative effects), exposure, and toxicity in Appendix E. The status of the species accounts can be found in Appendix B.

Table 2. Crustacean species with low exposure (informed by low overlap with agriculture), high vulnerability, and high toxicity.

Scientific Name	Common Name	Vulnerability Ranking	Exposure Ranking	Toxicity Ranking	Total Agricultural Use Overlap (% Range)	Determination
Branchinecta sandiegonensis	San Diego fairy shrimp	High	Low	High	0.9	No Jeopardy
Cambarus aculabrum	Benton County cave crayfish	High	Low	High	0.6	No Jeopardy
Cambarus callainus	Big Sandy crayfish	High	Low	High	0.0	No Jeopardy
Cambarus veteranus	Guyandotte River crayfish	High	Low	High	0.0	No Jeopardy
Cambarus zophonastes	Hell Creek Cave crayfish	High	Low	High	0.2	No Jeopardy
Faxonius peruncus	Big Creek Crayfish	High	Low	High	2.5	No Jeopardy
Faxonius quadruncus	St. Francis River Crayfish	High	Low	High	2.5	No Jeopardy
Gammarus hyalleloides	Diminutive Amphipod	High	Low	High	3.3	No Jeopardy
Gammarus pecos	Pecos amphipod	High	Low	High	1.4	No Jeopardy
Lirceus usdagalun	Lee County cave isopod	High	Low	High	1.4	No Jeopardy
Pacifastacus fortis	Shasta crayfish	High	Low	High	1.4	No Jeopardy

Scientific Name	Common Name	Vulnerability Ranking	Exposure Ranking	Toxicity Ranking	Total Agricultural Use Overlap (% Range)	Determination
Procambarus econfinae	Panama City crayfish	High	Low	High	0.7	No Jeopardy
Streptocephalus woottoni	Riverside fairy shrimp	High	Low	High	2.0	No Jeopardy
Stygobromus hayi	Hay's Spring amphipod	High	Low	High	0.2	No Jeopardy
Thermosphaeroma thermophilus	Socorro isopod	High	Low	High	2.4	No Jeopardy

All species listed in Table 2 have high vulnerability rankings, indicating that they may be especially susceptible to species-level impacts from additional stressors in their environment, such as adverse effects to individuals from carbaryl exposure. Specifically, pesticides are a noted threat to the Lee County cave isopod, Hell Creek cave crayfish, Benton County cave crayfish, Riverside fairy shrimp, San Diego fairy shrimp, diminutive amphipod, and Panama City crayfish. The species listed in Table 2 also have high toxicity rankings as available toxicity data indicate that many aquatic invertebrates, including crustaceans, are highly sensitive to carbaryl exposure and are likely to experience high levels of mortality if exposed even at low concentrations.

Even though these species are highly vulnerable, individuals are likely to die if exposed, and many are known to be threatened by pesticides, we anticipate, at most, a very small number of individuals are likely to be exposed to carbaryl. The species listed in Table 2 have a low extent of overlap between agricultural use sites and their ranges, including associated off-site transport areas (total overlaps range from <0.1%-3.3%). The total overlap metric we use is a conservative estimate of exposure as it does not fully account for redundancy between use site layers, assumes exposure is occurring in all possible overlapping areas, and does not consider information on past carbaryl usage. As such, we expect that exposure of these species to carbaryl will occur in even smaller portions of the species' ranges.

Where available, additional data describing past carbaryl usage generally supports this expectation. For all species Table 2, excluding the Panama City crayfish for which no CoA data are available, CoA usage data corroborates our conclusion of low likelihood of exposure because very little insecticide usage has occurred within the counties where these species occur (i.e., all insecticide usage indicates 0-1.6% of these species' ranges are likely to be treated with any insecticides). Additional usage data from the California Department of Pesticide Regulations California Pesticide Use Report (CalPUR) indicate that little to no carbaryl has been used within the ranges of the Shasta crayfish, Riverside fairy shrimp, and the San Diego fairy shrimp, with up to only 0.1% of the ranges treated for these species annually from 2013-2022. While we expect that some of these species may occur on or near non-agricultural use sites, we anticipate

no more than a small number of individuals of each species will be exposed to carbaryl and killed from non-agricultural uses. None of the species in Table 2 occur exclusively or disproportionately near non-agricultural carbaryl use sites; though some individuals or populations may occur near non-agricultural use sites, we expect that most individuals or populations will not be exposed to carbaryl through non-agricultural uses. Available application information and past usage data indicate that non-agricultural usage of carbaryl is generally low in the areas where these species are found and are limited to small areas that are infrequently treated, suggesting that any exposures that may occur will be limited in extent. For example, the Panama City crayfish inhibits shallow, ephemeral, freshwater wetlands, and may occur in utility rights of way when habitat conditions are met. However, available usage information indicates that carbaryl is used infrequently in rights of ways, with less than 500 pounds of carbaryl applied to roadways nationally on an annual basis. While this may result in a large treatment footprint if all rights of way usage were concentrated in one location or within one species' range, we expect this is highly unlikely to occur and rather expect rights of way usage is likely to be sporadic across the national landscape and only small amounts of carbaryl, if any, will be used within the Panama City crayfish's range for this use. Therefore, we only expect a few individuals to die as a result of these non-agricultural uses of carbaryl under the proposed action.

In addition, there is a specific conservation measure for the Socorro isopod related to rangeland use of carbaryl for the USDA APHIS grasshopper and Mormon cricket suppression program, which requires the implementation of a 2,500-foot and 300-foot buffer from the range for the species for aerial ultra-low volume and ground applications, respectively. For aerial and ground bait applications, a 750-foot buffer and 100-ft buffer are required, respectively. The USDA APHIS BA considered grasshopper and Mormon cricket program activities in states where their program is active, which include the implementation of conservation measures. For states that were not included in the USDA APHIS BA, we expect the need for carbaryl use on rangelands to be unlikely; if carbaryl use is needed for grasshopper or Mormon cricket control outside of the 17 states included in the APHIS BA, buffers (500-foot buffer for aerial sprays, 200-foot buffer for ground sprays, and 50-foot buffer for bait) from aquatic areas are required for any applications. We expect these mitigation measures will be sufficient to result in no adverse effects or incidental take from future uses of carbaryl within rangeland areas that occur in the species' range.

Given the low level of overlap between the species' ranges with agricultural use sites within the action area and low level of exposure associated with non-agricultural use sites, we anticipate only low levels of exposure will occur for the species in this group. Thus, while these species' vulnerabilities and toxicity rankings are high, we have high confidence that no more than small numbers of individuals of these species are likely to be exposed to carbaryl and die, and exposure will be limited to small portions of the species' ranges that overlap with use sites. Therefore, we determine the overall risk of adverse effects to these species is low. After adding the effects of the action and cumulative effects to the environmental baseline, and in light of the status of the species, we have determined the proposed action is not expected to result in the death of more than small numbers of individuals and is not expected to appreciably reduce the likelihood of survival and recovery of these species in the wild. Thus, it is our biological opinion

that the proposed action is not likely to jeopardize the continued existence of these crustacean species.

Species with low exposure (informed by low past usage from the California Department of Pesticide Regulation Pesticide Use Reporting Data)

The species in Table 3 are grouped together because they all occur completely within California and have low exposure confirmed by low levels of past carbaryl usage within their ranges (% range treated), as informed by the California Department of Pesticide Regulation Pesticide Use Report (CalPUR) data. While we present some specific information about the species in Table 3 below, we provide additional information on vulnerability (including environmental baseline and cumulative effects), exposure, and toxicity in Appendix E. The status of the species accounts can be found in Appendix B.

Table 3. Crustacean species with low exposure informed by low past usage from California Department of Pesticide Regulation Pesticide Use Reporting Data

Scientific Name	Common Name	Vulnerability Ranking	Exposure Ranking	Toxicity Ranking	% Range Treated (CalPUR)	Determination
Branchinecta conservatio	Conservancy fairy shrimp	High	Low	High	0.3	No Jeopardy
Branchinecta longiantenna	Longhorn fairy shrimp	High	Low	High	0.5	No Jeopardy
Syncaris pacifica	California freshwater shrimp	High	Low	High	0.0	No Jeopardy

All species in Table 3 have high vulnerability rankings, indicating that they may be especially susceptible to species-level impacts from additional stressors in their environment, such as adverse effects to individuals from carbaryl exposure. Specifically, pesticides are noted as a threat to the California freshwater shrimp and the conservancy fairy shrimp but not the longhorn fairy shrimp. The species in Table 3 also have high toxicity rankings because available toxicity data indicate that many aquatic invertebrates, including crustaceans, are highly sensitive to carbaryl exposure and are likely to experience high levels of mortality if exposed even at low concentrations.

While species in Table 3 are highly vulnerable and individuals are likely to die if exposed, we anticipate only a small number of individuals are likely to be exposed to carbaryl given that CalPUR data indicate low usage within their species' ranges. These species have high percent overlap between agricultural use sites and their ranges (approximately 5.1 to 32%), but mandatory pesticide usage reporting data collected by the state of California indicates very little carbaryl has been used in the agricultural areas where these species' ranges occur. Up to 0.5% of the ranges (conservancy fairy shrimp: 0.3% and longhorn fairy shrimp: 0.5%) have been treated with carbaryl annually from 2013-2022. CalPUR data indicates that no carbaryl has been used

within the range of the California freshwater shrimp between 2013-2022. Given that usage reporting is mandated by the state of California and that this data is provided regularly at a fine spatial resolution (i.e., at the section level, which is per square mile), we have high confidence that only a small percentage of the species' ranges have been (and are likely to be) exposed to carbaryl.

While we expect that some of these species may occur on or near non-agricultural use sites, we do anticipate no more than a small number of individuals of each species will be exposed to carbaryl and killed from non-agricultural uses. None of the species in Table 3 occur exclusively or disproportionately near non-agricultural carbaryl use sites; though some individuals or populations may occur near non-agricultural use sites, we expect that most individuals or populations will not be exposed to carbaryl through non-agricultural uses. While CalPUR data include all agricultural usage, it is also inclusive of certain non-agricultural uses, such as those performed by professional commercial applicators. While these data no not capture all non-agricultural usage, such as residential applications by consumers, given our broad understanding of carbaryl usage, general information on non-agricultural use practices, and existing conservation measures we expect limited exposure from these uses of carbaryl. As such, we anticipate no more than small numbers of individuals of these species will be exposed and die from non-agricultural uses of carbaryl.

We have high confidence that there is a low extent of exposure for these species and only a small number of individuals will be exposed and die. After adding the effects of the action and cumulative effects to the environmental baseline, and in light of the status of these species, we have determined the proposed action is not expected to appreciably reduce the survival and recovery of these species in the wild. Thus, it is our biological opinion that the proposed action is not likely to jeopardize the continued existence of these crustacean species.

Species with low exposure (informed by low past usage from USDA Census of Agriculture)

The species in Table 4 are grouped together because we expect low exposure (% range treated) confirmed by low levels of past insecticide usage within their ranges, as informed by the USDA's Census of Agriculture (CoA) data. While we present some specific information about the species in Table 4 below, we provide additional information on vulnerability (including environmental baseline and cumulative effects), exposure, and toxicity in Appendix E. The status of the species accounts can be found in Appendix B.

Table 4. Species with low exposure (confirmed by low past usage from USDA Census of Agriculture), high vulnerability, and high toxicity.

Scientific Name	Common Name	Vulnerability Ranking	Exposure Ranking	Toxicity Ranking	% Range Treated (CoA)	Determination
Antrolana lira	Madison Cave isopod	High	Low	High	2.9	No Jeopardy
Gammarus desperatus	Noels amphipod	High	Low	High	3.1	No Jeopardy
Stygobromus (=Stygonectes) pecki	Peck's cave amphipod	High	Low	High	1.8	No Jeopardy

The species listed in Table 4 have high vulnerability rankings, indicating that they may be especially susceptible to species-level impacts from additional stressors in their environment, such as adverse effects to individuals from carbaryl exposure. Additionally, pesticides are noted as a threat to both species in this group. All three species have a high toxicity ranking because available toxicity data indicate that many aquatic invertebrates, including crustaceans, are highly sensitive to carbaryl exposure and are likely to experience high levels of adverse effects (e.g., mortality) if exposed even at low concentrations.

While species in Table 4 are highly vulnerable, are specifically threatened by pesticides, and are likely to experience high levels of adverse effects if individuals are exposed to carbaryl, we anticipate only a small number of individuals are likely to be exposed to carbaryl. All three species have low levels of insecticide usage within the counties where these species occur as reported by the USDA CoA (1.8-3.1% of the species' ranges were treated with any insecticides annually in the past). Given that this reporting broadly includes all insecticide usage, we consider CoA data to be conservative estimates of carbaryl usage that indicate very little of the species' ranges are likely to be treated. In addition, the Madison Cave isopod and Peck's Cave amphipod occur primarily in cave systems. For Madison Cave isopod, we do not expect adverse effects through groundwater penetration due to carbaryl's low persistence in water. We expect most carbaryl residues will degrade within a few days to weeks at conditions environmentally relevant

to living organisms (e.g., neutral pH, presence of microorganisms, etc.). We expect recharge of karst cave systems, or the process of aboveground water reaching the groundwater supply, will often take weeks to months, at which point we expect carbaryl to be degraded and no longer present in the water as it enters the cave. For Peck's cave amphipod, we do not expect adverse effects to its subterranean habitat, and we expect minimal effects while its feeding from surface waters due to low past usage of carbaryl in its range. Noel's amphipod is extant in only isolated locations on Bitter Lake National Wildlife Refuge in New Mexico (USFWS 2020) where we expect carbaryl usage is unlikely to occur. Its population numbers are unknown, although the species has remained stable at known occupied sites.

None of the species in Table 4 occur exclusively or disproportionately near non-agricultural carbaryl use sites. Available application information and past usage data indicate that non-agricultural usage of carbaryl is generally low in the areas where these species are found and are limited to small areas that are infrequently treated, suggesting that any exposures that may occur will be limited in extent and not likely to result in the exposure and death of individuals. Therefore, we expect non-agricultural uses of carbaryl will not result in adverse effects or incidental take of these species.

We anticipate few, if any, individuals are likely to experience exposure as the CoA indicates very low amounts of insecticides are used within the ranges of these species. Additionally, we anticipate cave habitats are not likely to accumulate more than low levels of carbaryl as we expect the majority of carbaryl residues will degrade before entering the cave systems occupied by these species. Thus, given that we only anticipate small numbers of individuals will die as exposure is low, we determine the overall risk of adverse effects of carbaryl is low. After adding the effects of the action and cumulative effects to the environmental baseline, and in light of the status of the species, we have determined the proposed action is not expected to appreciably reduce the survival and recovery of these species in the wild. Thus, it is our biological opinion that the proposed action is not likely to jeopardize the continued existence of these species.

References:

U.S. Fish and Wildlife Service. 2020. Noel's amphipod (*Gammarus desperatus*), Koster's springsnail (*Juturnia kosteri*), Roswell springsnail (*Pyrgulopsis roswellensis*), and Pecos assiminea (*Assiminea pecos*) 5-Year Review: Summary and Evaluation. Albuquerque, New Mexico. 13 pp.

Species with low exposure (based on habitat characteristics)

The species in Table 5 are grouped together because we expect the cave systems that these species occupy are not likely to accumulate more than low levels of carbaryl. While we present some specific information about the species in Table 5 below, we provide additional information on vulnerability (including environmental baseline and cumulative effects), exposure, and toxicity in Appendix E. The status of the species accounts can be found in Appendix B.

Table 5. Species with low exposure (based on the characteristics of their preferred habitat)

Scientific Name	Common Name	Vulnerability Ranking	Exposure Ranking	Toxicity Ranking	Determination
Gammarus acherondytes	Illinois cave amphipod	High	Low	High	No Jeopardy
Palaemonetes cummingi	Squirrel Chimney Cave shrimp	High	Low	High	No Jeopardy
Palaemonias alabamae	Alabama cave shrimp	High	Low	High	No Jeopardy
Palaemonias ganteri	Kentucky cave shrimp	High	Low	High	No Jeopardy

All species in Table 5 have high vulnerability rankings, indicating that they may be especially susceptible to species-level impacts from additional stressors in their environment, such as adverse effects to individuals from carbaryl exposure. Additionally, pesticides are noted as a threat to the Kentucky cave shrimp and the Illinois cave amphipod. The species in this group have high toxicity rankings as available toxicity data indicate that many aquatic invertebrates, including crustaceans, are highly sensitive to carbaryl exposure and are likely to experience high levels of mortality if exposed even at low concentrations.

Despite having high vulnerability and toxicity rankings, we anticipate only a small number of individuals, at most, are likely to be exposed to carbaryl based on the unique characteristics of the habitat these species occupy. All four of these species live exclusively in cave ecosystems. We expect most carbaryl residues will likely degrade within a few days to weeks at conditions environmentally relevant to living organisms (e.g., neutral pH, presence of microorganisms) as carbaryl has low persistence in water. In contrast, we expect recharge of karst cave systems from surface water, or the process of aboveground water reaching the groundwater supply, likely takes weeks to months, at which point we expect carbaryl to be degraded and no longer present in the water as it enters the cave. As such, we anticipate only a small number of individuals, if any, are likely to be exposed to carbaryl from both agricultural and non-agricultural uses.

We anticipate the cave habitats are not likely to accumulate more than low levels of carbaryl as we expect the majority of carbaryl residues will degrade before entering the cave systems that these species occupy. Thus, while individuals are likely to die when exposed, and while

pesticides are noted as a threat to the species in this group, we anticipate few, if any, individuals are likely to be exposed and die. We determine the overall risk of adverse effects of carbaryl to these species is low. After adding the effects of the action and cumulative effects to the environmental baseline, and in light of the status of the species, we have determined the proposed action is not expected to appreciably reduce the survival and recovery of these species in the wild. Thus, it is our biological opinion that the proposed action is not likely to jeopardize the continued existence of these crustacean species.

Species with Individual Integration and Synthesis summaries

For species in Table 6, our preliminary exposure and toxicity rankings indicated that the proposed action may result in moderate to high adverse effects. As such, we discuss each species in more detail in individual Integration and Synthesis summaries below. In some cases, we modified initial exposure and toxicity rankings due to additional information regarding exposure and effects for individual species, as described below. For species that had a jeopardy determination in the draft Opinion, EPA incorporated species-specific conservation measures that the registrants agreed to incorporate into the description of the action to minimize exposure to the species. When relevant, we retained our evaluation that led to our Preliminary Conclusion and the need for species-specific measures and added an updated Final Conclusion to reflect the impacts of these species-specific measures.

Additional information on vulnerability (including environmental baseline and cumulative effects), exposure, and toxicity can be found in Appendix E. The status of the species accounts can be found in Appendix B.

Table 6. Crustaceans with moderate to high adverse effects anticipated from the proposed action. We addressed each species in individual Integration and Synthesis summaries.

Scientific Name	Common Name	Determination
Branchinecta lynchi	Vernal pool fairy shrimp	No Jeopardy
Lepidurus packardi	Vernal pool tadpole shrimp	No Jeopardy
Cambarus cracens	Slenderclaw crayfish	No Jeopardy
Cambarus williami	Brawleys Fork crayfish	No Jeopardy

Integration and Synthesis Summary: Vernal pool fairy shrimp

Scientific Name:	Common Name:	Entity ID:
Branchinecta lynchi	Vernal pool fairy shrimp	493

Species Overview

In reviewing the status of the species, the environmental baseline for the action area, cumulative effects, and the effects of the action, we determined that the species' vulnerability is high, anticipated exposure to carbaryl is low (based on usage information from the California Department of Pesticide Regulation), and toxicity is high within the action area across the species' range (Figure 1), as described in the following sections. After adding the effects of the action and cumulative effects to the environmental baseline, and in light of the status of the species, we have determined the proposed action is not expected to appreciably reduce the survival and recovery of the species in the wild. Thus, it is our biological opinion that the proposed action is not likely to jeopardize the continued existence of the vernal pool fairy shrimp.

Species range

Based on range map dated: 12-17-2019; Wherever found; *States within the range:* CA, OR

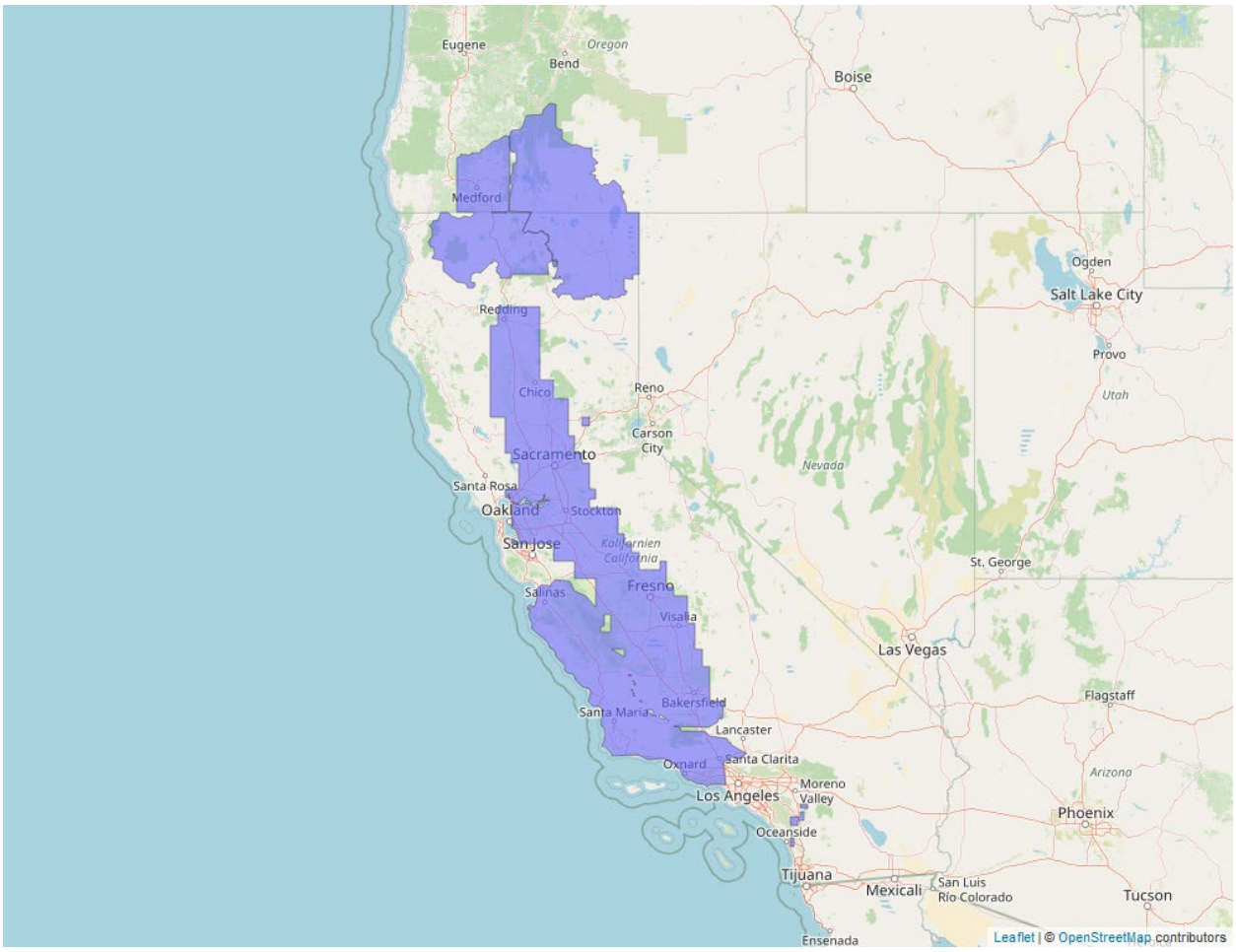

Figure 1. Range map of vernal pool fairy shrimp (blue polygons). Range map accessed at https://ecos.fws.gov/ecp/species/498.

Vulnerability

As mentioned above, vulnerability considers the present and likely future condition of the species to determine its vulnerability to additional stressors. In making our jeopardy determination, vulnerability of the species is a function not only of its status, but also the environmental baseline and cumulative effects. These are summarized below for this species.

Summary of status

Listing status: Threatened

Most recent 5-Year Status Review recommendation: No change in Status

Most recently completed 5-Year Status Review: 5/9/2024

Distribution: Species/Populations neither constrained nor widespread

Number of populations: Multiple populations (numerous)

Species trends: Unknown population trends

Pesticides noted in Service documents as a threat to the species: yes

Environmental Baseline/Cumulative Effects (EB/CE) Summary

The vernal pool fairy shrimp is a small freshwater crustacean endemic to California and the Agate Desert of southern Oregon. It is seldom abundant where found and only exists in vernal pools or similar habitats with cool water; it is not found in permanent bodies of water. They have no predatory defenses and cannot survive where fish are present. As of 2007, 400 species records were present in the California Natural Diversity Database and approximately 53% were located on private lands and 15% were on Federal lands: 13% on Department of Defense installations and 2% on public lands managed by the U.S. Forest Service, U.S. Bureau of Reclamation, U.S. Bureau of Land Management, and Western Area Power Administration (USFWS 2007). The most recent 5-Year Review (USFWS 2024) indicates that the vernal pool fairy shrimp has a very weak phylogeological structure, making determining genetic variation amongst the different geographic areas difficult to assess.

Loss and modification of vernal pool habitat continues to be the primary threat to the vernal pool fairy shrimp and is expected to continue in the future. Even in areas where habitat is protected, urbanization of lands surrounding conserved areas fragments protected habitats, likely preventing dispersal of the shrimp within and between populations and causing increased edge effects to pool complexes. Some vernal pool habitats are protected through conservation easements, but vernal pool habitat loss has continued. Remaining habitat fragments often exhibit different hydrological conditions, invasion by non-native plants and other species, increased vegetation growth, and other conditions (such as cessation of grazing or overgrazing) that reduce the suitability of the land as habitat for the shrimp. Water quality in vernal pools can be degraded by pesticide overspray and residues entering across the Central Valley, where agriculture is a common land use. Eight counties where vernal pool fairy shrimp are found are among the ten counties in California with the highest pesticide usage: Fresno, Tulare, San Joaquin, Madera, Monterey, Merced, Ventura, and Kings Counties (USFWS 2007).

Overall Vulnerability: High

Effects of the Action: Exposure

Overlap with Agricultural Use Sites

We do not expect listed crustacean species will occur on-field, and thus expect exposure will only result from off-field transport via spray drift or runoff. Given that the ranges for listed aquatic species are generally delineated using the relevant HUC 12 watersheds, we anticipate that all residues that leave use sites will be collected in the waterbodies within the species' range where individuals occur regardless of how residues leave treated sites or where in the range they are deposited. As such, we do not extend overlap metrics off-field as this will not functionally change the expected exposures that listed aquatic species are likely to experience. We use on-field overlaps with the species' range without a buffer as an estimate of the extent of exposure that's likely to occur. We expect up to 25.7% of the species' range contains agricultural carbaryl use sites (Table 7).

Table 7. Agricultural use overlap and annual usage data (% Range Treated) for the vernal pool fairy shrimp.

Use Layer	Use Site Overlap (% range)	% Range Treated
Alfalfa	2.8	0.1
Citrus	0.7	<0.1
Corn[2]	2.3	0.1
Grapes	2.3	0.1
Other Crops	6.3	6.3
Other Grains	2.9	<0.1
Other Orchards[3]	8.3	2.1
Other Row Crops	0.5	<0.1
Soybeans	<0.1	0
Vegetables and Ground Fruit	2.7	0.8
Total	**25.7**	**9.5**

[2] We expect corn and soybean use sites are highly redundant with each other and only use the higher of the two layers in our calculation of total percent overlap and total percent treated range.

[3] We expect 'other orchards' and 'citrus' use sites are highly redundant with each other and only use the higher of the two layers in our calculation of total percent overlap and total percent treated range.

Usage

Past statewide usage data indicate that up to 9.5% of the species' range has been treated with carbaryl for agriculture annually. However, because the majority of the species' range is in California (Figure 1), we consider CalPUR data for this species, which indicates that 0.39% of the range was treated with carbaryl between 2013-2022. Given that usage reporting is mandated by the state of California and that this data is provided regularly at a fine spatial resolution (i.e., at the section level, which is per square mile), we have high confidence that only a small percentage of the species' range in California has been (and is likely to be in the future) exposed to carbaryl. As we have no indication that carbaryl usage would differ in the small part of the range extending into Oregon, and because most occurrences of this species are in California, we consider CalPUR usage data to be the best measures of usage within the entire range of the vernal pool fairy shrimp.

Non-agricultural Uses

In addition to agricultural use sites, we anticipate some non-agricultural carbaryl use sites also occur within the species' range, including developed, open space developed, nurseries, managed forests, and rights of way areas. They do not occur in or near rangeland.

U.S. Forest Service usage data indicate that 322 acres of managed forests within the general regions overlapping the vernal pool fairy shrimp's range have been treated with carbaryl over a 5-year period (2016-2020). We do not anticipate all treated acres of managed forests occur in a single location or are all concentrated within the fairy shrimp's range. Furthermore, treatments are made using ground-based sprayers directed to lower parts of the tree (i.e., the trunk) (which will limit the extent of off-site transport and exposure to individuals) and are made to protect plantings of oak trees in Southern California (which would limit exposure to only the southernmost portions of the range). As such, we anticipate a low likelihood of carbaryl usage in the range, and that if usage did occur, exposure to the vernal pool fairy shrimp would be minimal. Some exposure through nurseries, developed, rights of way, and open space developed uses may occur. Available usage data from USDA APHIS indicate that no carbaryl has been used in rangelands located in the state of California, indicating a low likelihood of exposure through this use. Similarly, available usage data indicate very little carbaryl usage is likely to occur in rights of way, with less than 500 pounds of carbaryl applied to roadways nationally on an annual basis. While this may result in a large treatment footprint if all rights of way usage were concentrated in one location or within one species' range, we expect this is highly unlikely to occur and rather expect rights of way usage is likely to be sporadic across the national landscape, with only small amounts, if any, used within the species' range. Available usage data indicate only low levels of past carbaryl usage in open space developed areas (including golf courses) within the vernal pool fairy shrimp's range, with, at most, up to 2.5% of the species' range likely to be treated each year. In addition, while CalPUR data include all agricultural usage, it is also inclusive of certain non-agricultural uses, such as those performed by professional commercial applicators. While these data no not capture all non-agricultural usage,

such as residential applications by consumers, we expect that this reporting would be inclusive of a portion of the usage within the rights of way and open space developed land use categories, providing another line of evidence of low usage. As such, we do not anticipate rights of way or open space developed uses will result in exposure to more than a few individuals of the species.

Conservation Measures

As part of the 2022 proposed interim decision for carbaryl, the technical registrants committed to a number of conservation measures for the protection of listed species, including a 48-hour rain restriction and mandatory 25-foot and 150-foot application buffers from aquatic habitats for all outdoor ground and aerial applications, respectively. We anticipate these measures will contribute to the protection of listed crustacean species by reducing the amount of carbaryl residues that is transported off use sites and into the habitat of listed species. However, despite the incorporation of the rain restriction and mandatory application buffers, exposure remains high for this species.

Exposure Summary

There is a high extent of overlap between agricultural use sites and the species' range (25.7% overlap). Based on CalPUR data, we anticipate a low level of usage within the range, as <1% has been treated annually for agricultural uses. Thus, based on our confidence in the CalPUR data, we determine the overall exposure ranking is low. As such, we anticipate a small number of individuals are likely to experience exposure.

Individuals may occasionally occur near non-agricultural use sites, including developed, open space developed, nurseries, and rights of way areas. However, based on the low likelihood of exposure from usage within the range of the vernal pool fairy shrimp for these non-agricultural uses, we do not anticipate more than a few individuals will be exposed from non-agricultural uses.

Overall Exposure: Low

Effects of the Action: Toxicity

Direct Effects:

Based on toxicity data for crustaceans, we expect that exposure to carbaryl from runoff or spray drift deposition will result in mortality of any individuals exposed.

Indirect Effects:

Vernal pool fairy shrimp are opportunistic filter feeders. We do not expect that carbaryl exposure will result in adverse effects to algae, bacteria, protozoa, rotifers, and bits of waste from other plants and animals present in their environments that provide food for the species.

Toxicity Summary

Given the high sensitivity of crustaceans to carbaryl at estimated environmental concentrations, we anticipate any individuals exposed to carbaryl will die. As such, the species has a high toxicity ranking.

Overall Toxicity: High

Effects of the Action Summary

There is a high level of overlap between the species' range and agricultural use sites and associated off-field areas (25.7% total overlap) and a low level of past usage (<1.0 % range treated annually with carbaryl). Based on our confidence in the CalPUR data, we expect a small number of individuals are likely to be exposed to carbaryl over the duration of the proposed action. Although crustacean species are highly sensitive to carbaryl, we expect that only a small number of individuals will die due to low exposure. Similarly, based on available usage data on non-agricultural uses and existing conservation measures, we do not anticipate more than a small number of individuals will be exposed and die from non-agricultural uses. We do not anticipate these deaths will result in species-level effects and expect the overall risk to the species is low.

Conclusion

The vernal pool fairy shrimp is a threatened, species native to California and the Agate Desert of southern Oregon found only in specialized vernal pool habitats. Several populations exist, all occurring in small numbers that inhabit temporary water bodies across the species range. Most occurrences of the species have been found on private lands (85%). The vernal pool fairy shrimp is an opportunistic filter feeder that subsist on algae, bacteria and protozoa, but the species has no predator defenses of its own leaving it vulnerable. Threats to the species include habitat loss and fragmentation (mostly from development) and changes to water quality from pesticide use, runoff, and atmospheric deposition from nearby agricultural land uses. The species has a high vulnerability ranking.

The vernal pool fairy shrimp has a high toxicity ranking because we expect any direct exposure to result in mortality. A high percentage (25.7%) of agricultural use sites overlap with the species' range in the action area, but past annual carbaryl usage for agriculture occurred on a very small percentage of the range (0.39%). Because CalPUR usage data has a high spatial resolution and is based on a robust dataset of usage reporting for each chemical, including

carbaryl specifically, we expect low exposure for the vernal pool fairy shrimp over the duration of the action from agricultural uses. Due to the low levels of carbaryl usage in non-agricultural areas within the range of the vernal pool fairy shrimp and existing conservation measures for most residential uses, we expect non-agricultural uses to result in exposure and death of no more than a very small number of individuals.

In summary, exposure to carbaryl runoff is anticipated to occur in a very small portion of the range as usage data from the state of California indicate very little of the range is likely to be treated with carbaryl. As such, we expect only a small number of individuals will be exposed and die over the duration of the action. After adding the effects of the action and cumulative effects to the environmental baseline, and in light of the status of the species, we have determined the proposed action is not expected to appreciably reduce the survival and recovery of the species in the wild. Thus, it is our biological opinion that the proposed action is not likely to jeopardize the continued existence of the vernal pool fairy shrimp.

References

U.S. Fish and Wildlife Service. 2024. Vernal Pool Fairy Shrimp (*Branchinecta lynchi*) 5-Year Review: Summary and Evaluation. Sacramento, California. 135 pp.

U.S. Fish and Wildlife Service. 2007. Vernal Pool Fairy Shrimp (*Branchinecta lynchi*) 5-Year Review: Summary and Evaluation. Sacramento, California. 76 pp.

Integration and Synthesis Summary: Vernal pool tadpole shrimp

Scientific Name:	Common Name:	Entity ID:
Lepidurus packardi	Vernal pool tadpole shrimp	494

Species Overview

In reviewing the status of the species, the environmental baseline for the action area, cumulative effects, and the effects of the action, we determined that the species' vulnerability is high, anticipated exposure to carbaryl is low (based on past usage data from the California Department of Pesticide Regulation), and toxicity is high within the action area across the species' range (Figure 2), as described in the following sections. After adding the effects of the action and cumulative effects to the environmental baseline, and in light of the status of the species, we have determined the proposed action is not expected to appreciably reduce the survival and recovery of the species in the wild. Thus, it is our biological opinion that the proposed action is not likely to jeopardize the continued existence of the vernal pool tadpole shrimp.

Species range

Based on range map dated: 03-19-2018; Wherever found; *States within the range:* CA, OR

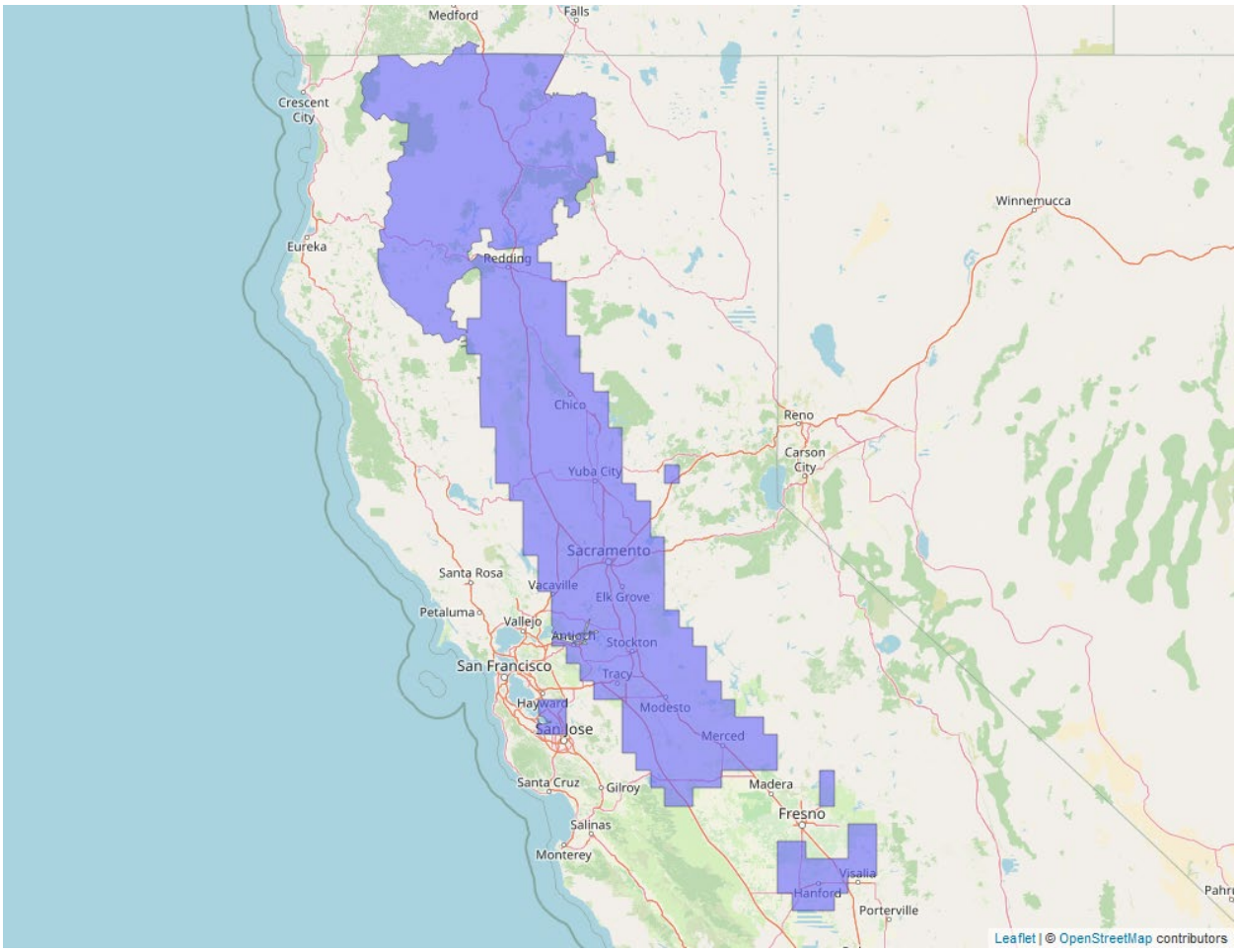

Figure 2. Range map of vernal pool tadpole shrimp (blue polygons). Range map accessed at https://ecos.fws.gov/ecp/species/2246.

Vulnerability

As mentioned above, vulnerability considers the present and likely future condition of the species to determine its vulnerability to additional stressors. In making our jeopardy determination, vulnerability of the species is a function not only of its status, but also the environmental baseline and cumulative effects. These are summarized below for this species.

Summary of status

Listing status: Endangered

Most recent 5-Year Status Review recommendation: No change in Status

Most recently completed 5-Year Status Review: 5/9/2024

Distribution: Small, endemic, constrained, and/or isolated population(s)

Number of populations: Multiple populations (numerous)

Species trends: Unknown population trends

Pesticides noted in Service documents as a threat to the species: yes

Environmental Baseline/Cumulative Effects (EB/CE) Summary

Vernal pool tadpole shrimp are found in ephemeral freshwater habitats, including alkaline pools, clay flats, vernal lakes, vernal pools, vernal swales, and other seasonal wetlands, in California. They are found across a wide range large proportion of northern California, but their habitat is highly fragmented and they are uncommon where they are found. As of 2007, the California Natural Diversity Database reported 226 species occurrences in the following 19 counties: Alameda, Butte, Colusa, Contra Costa, Fresno, Glenn, Kings, Merced, Placer, Sacramento, San Joaquin, Shasta, Solano, Stanislaus, Sutter, Tehama, Tulare, Yolo, and Yuba. The greatest number of occurrences (28%) was found in Sacramento County (USFWS 2007). Recent findings (USFWS 2024) indicate that populations of the vernal pool tadpole shrimp are for the most part genetically distinct from each other, despite the ability of individuals to be transported from one vernal pool to another from the ingestion and excretion of shrimp cysts by waterfowl.

Modification, fragmentation, and destruction of habitat caused largely by urban development and conversion of natural lands to agriculture continue to cause the greatest threat to the species. Additionally, altered site hydrology, inappropriate levels of grazing, contaminant runoff into vernal pools, stochastic extirpation, invasive plants, mosquito fish (*Gambusia affinis*) predation, climate change, and prolonged drought are also major threats. Petroleum products, pesticides, herbicides, and other chemicals can be conveyed into the vernal pool habitats by overland runoff during the rainy season, thereby adversely affecting water quality and chemistry of vernal pools and reducing the suitability for tadpole shrimp. Many of these chemical compounds are thought to have adverse effects on listed vernal pool crustaceans and/or their cysts, with individuals being killed directly or suffering reduced fitness through physiological stress or a reduction in their food base. Fertilizer contamination can lead to vernal pool eutrophication, which can reduce dissolved oxygen and kill vernal pool crustaceans. Vernal pools are hydrated by winter precipitation, which often includes pesticides (e.g., herbicides, insecticides, fungicides) that have volatized and are atmospherically transported. Concentrations of the pesticide diazinon, found in vernal pools on National Wildlife Refuge complexes in the Sacramento and San Joaquin Valleys, have been measured at levels that could have adverse effects on the vernal pool tadpole shrimp. Endosulfan, hexazinone, trifluralin, and simazine were also present in sampled pools at levels that could be toxic to the shrimp. The Central Valley, where this shrimp lives, is dominated by agricultural land uses and we expect pesticide use to be high. Biocides, which are pesticides or disinfectants used against microorganisms, may cause a threat, but the magnitude of this threat is unknown (USFWS 2007).

Overall Vulnerability: High

Effects of the Action: Exposure

Overlap with Agricultural Use Sites

We do not expect listed crustacean species will occur on-field, and thus expect exposure will only result from off-field transport via spray drift or runoff. Given that the ranges for listed aquatic species are generally delineated using the relevant HUC 12 watersheds, we anticipate that all residues that leave use sites will be collected in the waterbodies within the species' range where individuals occur, regardless of how residues leave treated sites or where in the range they are deposited. As such, we do not extend overlap metrics off-field as this will not functionally change the expected exposures that listed aquatic species are likely to experience. We use on-field overlaps with the species' range without a buffer as an estimate of the extent of exposure that's likely to occur. We expect up to 33.1% of the species' range contains agricultural carbaryl use sites (Table 8).

Table 8. Agricultural use overlap and annual usage data (% Range Treated) for the vernal pool tadpole shrimp.

Use Layer	Use Site Overlap (% range)	% Range Treated
Alfalfa	3.8	0.2
Citrus	0.5	0.2
Corn[4]	3.7	0.3
Grapes	2.7	0.3
Other Crops	7.1	7.1
Other Grains	3.3	<0.1
Other Orchards[5]	11.2	4.6
Other Row Crops	1.1	<0.1
Soybeans	<0.1	0
Vegetables and Ground Fruit	2.9	1.7
Total	**33.1**	**13.9**

[4] We expect corn and soybean use sites are highly redundant with each other and only use the higher of the two layers in our calculation of total percent overlap and total percent treated range.

[5] We expect 'other orchards' and 'citrus' use sites are highly redundant with each other and only use the higher of the two layers in our calculation of total percent overlap and total percent treated range.

Usage

Past statewide usage data indicate that up to 13.9% of the species' range has been treated with carbaryl annually for agriculture. However, because the vast majority of the species' range is in California (Figure 2), we consider CalPUR data for this species, which indicates that 0.33% of the range was treated with carbaryl from 2013-2022. Given that usage reporting is mandated by the state of California and that this data is provided regularly at a fine spatial resolution (i.e., at the section level, which is per square mile), we have high confidence that only a small percentage of the species' range in California has been (and is likely to be in the future) exposed to carbaryl. As we have no indication that carbaryl usage would differ in the small part of the range extending into Oregon, and because most occurrences of this species are in California, we consider CalPUR usage data to be the best measures of usage within the entire range of the vernal pool tadpole shrimp.

Non-agricultural Uses

In addition to agricultural use sites, we anticipate some non-agricultural carbaryl use sites also occur within the species' range, including developed, open space developed, nurseries, and rights of way areas. Given that the vernal pool tadpole shrimp is restricted to vernal pool habitat, we do not anticipate individuals are likely to be exposed to developed or nursery uses of carbaryl. Some exposure through rights of way and open space developed uses may occur. Available usage data from USDA APHIS indicate that no carbaryl has been used in rangelands located in the state of California, indicating a low likelihood of exposure through this use.

U.S. Forest Service usage data indicate that 322 acres of managed forests within the general regions overlapping the vernal pool fairy shrimp's range have been treated with carbaryl over a 5-year period (2016-2020). We do not anticipate all treated acres of managed forests occur in a single location or are all concentrated within the fairy shrimp's range. Furthermore, treatments are made using ground-based sprayers directed to lower parts of the tree (i.e., the trunk) (which will limit the extent of off-site transport and exposure to individuals) and are made to protect plantings of oak trees in Southern California (which would limit exposure to only the southernmost portions of the range). Similarly, available usage data indicate very little carbaryl usage is likely to occur in rights of way, with less than 500 pounds of carbaryl applied to roadways nationally on an annual basis. While this may result in a large treatment footprint if all rights of way usage were concentrated in one location or within one species' range, we expect this is highly unlikely to occur and rather expect rights of way usage is likely to be sporadic across the national landscape, with only small amounts, if any, used within the species' range. Available usage data indicate only low levels of past carbaryl usage in open space developed areas (including golf courses) within the vernal pool tadpole shrimp's range, with, at most, up to 2.5% of the species' range likely to be treated each year. In addition, while CalPUR data include all agricultural usage, it is also inclusive of certain non-agricultural uses, such as those performed by professional commercial applicators. While these data no not capture all non-agricultural usage, such as residential applications by consumers, we expect that this reporting would be

inclusive of a portion of the usage within the rights of way and open space developed land use categories, providing another line of evidence of low usage. As such, we expect individuals are unlikely to be exposed to carbaryl through usage on open space developed areas. In summary, we anticipate no more than small numbers of individuals are likely to be exposed through non-agricultural uses of carbaryl.

Conservation Measures

As part of the 2022 proposed interim decision for carbaryl, the technical registrants committed to a number of conservation measures for the protection of listed species, including a 48-hour rain restriction and mandatory 25-foot and 150-foot application buffers from aquatic habitats for all outdoor ground and aerial applications, respectively. We anticipate these measures will contribute to the protection of listed crustacean species by reducing the amount of carbaryl residues that is transported off use sites and into the habitat of listed species. However, despite the incorporation of the rain restriction and mandatory application buffers, exposure remains high for this species.

Exposure Summary

There is a high extent of overlap between agricultural use sites and the species' range (33.1% overlap). Based on CalPUR data, we anticipate a low level of usage within the range, as <1% has been treated annually for agricultural uses. Given our confidence in the CalPUR data, we determine the overall exposure ranking is low. As such, we anticipate a small number of individuals are likely to experience exposure.

Individuals may occasionally occur near non-agricultural use sites, including open space developed and rights of way areas. However, based on the low likelihood of exposure from usage within the range of the vernal pool tadpole shrimp for these non-agricultural uses, we do not anticipate non-agricultural uses of carbaryl will expose more than a small number of individuals. Therefore, we anticipate an overall low likelihood of exposure and subsequent adverse effects from non-agricultural uses of carbaryl.

Overall Exposure: Low

Effects of the Action: Toxicity

Direct Effects:

Based on toxicity data for crustaceans, we expect that exposure to carbaryl from runoff or spray drift deposition will result in mortality of any individuals exposed.

Indirect Effects:

The vernal pool tadpole shrimp is a very aggressive omnivore. We expect that carbaryl exposure will result in adverse effects to insects, other fairy shrimp including the conservancy fairy shrimp, and tadpoles, but not the algae, bacteria, protozoa, rotifers, or aquatic earthworms that provide food for the species.

Toxicity Summary

Given the high sensitivity of crustaceans to carbaryl at estimated environmental concentrations, we anticipate any individuals exposed to carbaryl will die. Additionally, we anticipate other aquatic invertebrate species it may rely on for food will also die with exposure to carbaryl.

Overall Toxicity: High

Effects of the Action Summary

There is a high level of overlap between the species' range and agricultural use sites and associated off-field areas (33.1% total overlap) and a high level of past usage (<1.0% range treated annually). Given our confidence in the CalPUR data, we expect a small number of individuals are likely to be exposed over the duration of the proposed action. We expect crustacean species are highly sensitive to carbaryl, indicating a small number of individuals are likely to experience mortality. Similarly, based on available usage data on non-agricultural uses and existing conservation measures, we do not anticipate more than a small number of individuals will be exposed and die from non-agricultural uses. We do not anticipate these deaths will result in species-level effects. As such, the overall risk of adverse effects to the vernal pool tadpole shrimp is low.

Conclusion

The vernal pool tadpole shrimp is an endangered species found in specialized vernal pool habitats in the Central Valley of California. There are several populations, all of which occur in small numbers in temporary water bodies. Many occurrences of the species are found on private lands. The vernal pool tadpole shrimp is an omnivore that feeds on other aquatic invertebrates, algae, and microorganisms. Their threats include habitat loss and fragmentation (mostly from development and conversion to agriculture) and changes to water quality, including use, runoff, and atmospheric deposition of pesticides from nearby agricultural lands. The species has a high vulnerability ranking.

The vernal pool tadpole shrimp has a high toxicity ranking because we expect any direct exposure to result in mortality. A high percentage (33.1%) of agricultural use sites overlap with the species' range in the action area, but past annual carbaryl usage for agriculture occurred on a very small percentage of the range (0.33%). Because CalPUR usage data has a high spatial

resolution and is based on a robust dataset of usage reporting for each chemical, including carbaryl specifically, we expect low exposure for the vernal pool tadpole shrimp over the duration of the action from agricultural uses. Due to the low levels of usage of carbaryl in non-agricultural areas within the range of the vernal pool tadpole shrimp, we expect non-agricultural uses to result in the exposure and death of no more than, at most, a very small number of individuals.

In summary, exposure to carbaryl runoff is anticipated to occur in a very small portion of the range, and we expect only a small number of individuals will be exposed and die over the duration of the action. Even though the species is highly vulnerable and the overlap with potential carbaryl use sites is high, past carbaryl usage in the range is very low and we expect similarly low usage in the future. Therefore, we expect a small number of individuals will die, and we do not expect species-level effects. After adding the effects of the action and cumulative effects to the environmental baseline, and in light of the status of the species, we have determined the proposed action is not expected to appreciably reduce the survival and recovery of the species in the wild. Thus, it is our biological opinion that the proposed action is not likely to jeopardize the continued existence of the vernal pool tadpole shrimp.

References

U. S. Fish and Wildlife Service. 2024. Vernal Pool Tadpole Shrimp (*Lepidurus packardi*) 5-Year Review: Summary and Evaluation. Sacramento, California. 135 pp.

U. S. Fish and Wildlife Service. 2007. Vernal Pool Tadpole Shrimp (*Lepidurus packardi*) 5-Year Review: Summary and Evaluation. Sacramento, California. 50 pp.

Integration and Synthesis Summary: Slenderclaw crayfish

Scientific Name:	Common Name:	Entity ID:
Cambarus cracens	Slenderclaw crayfish	10757

Species Overview

In reviewing the status of the species, the environmental baseline for the action area, cumulative effects, and the effects of the action, we determined that the species' vulnerability is high, anticipated exposure to carbaryl is medium, and toxicity is high within the action area across the species' range (Figure 4), as described in the following sections. As such, we expected a moderate number of individuals were likely to die from the proposed action.

Because of the effects described in our preliminary evaluation and conclusion, EPA and the applicant agreed to incorporate the species-specific conservation measures as part of the action. We now expect exposure for the slenderclaw crayfish to be low. After incorporating conservation measures into the proposed action, adding the effects of the action and cumulative effects to the environmental baseline, and in light of the status of the species, we have determined the proposed action is not likely to appreciably reduce the survival and recovery of the species. Thus, it is our biological opinion that the proposed action is not likely to jeopardize the continued existence of the slenderclaw crayfish.

Species range

Based on range map dated: 04-14-2021; Wherever found; *States within the range:* AL

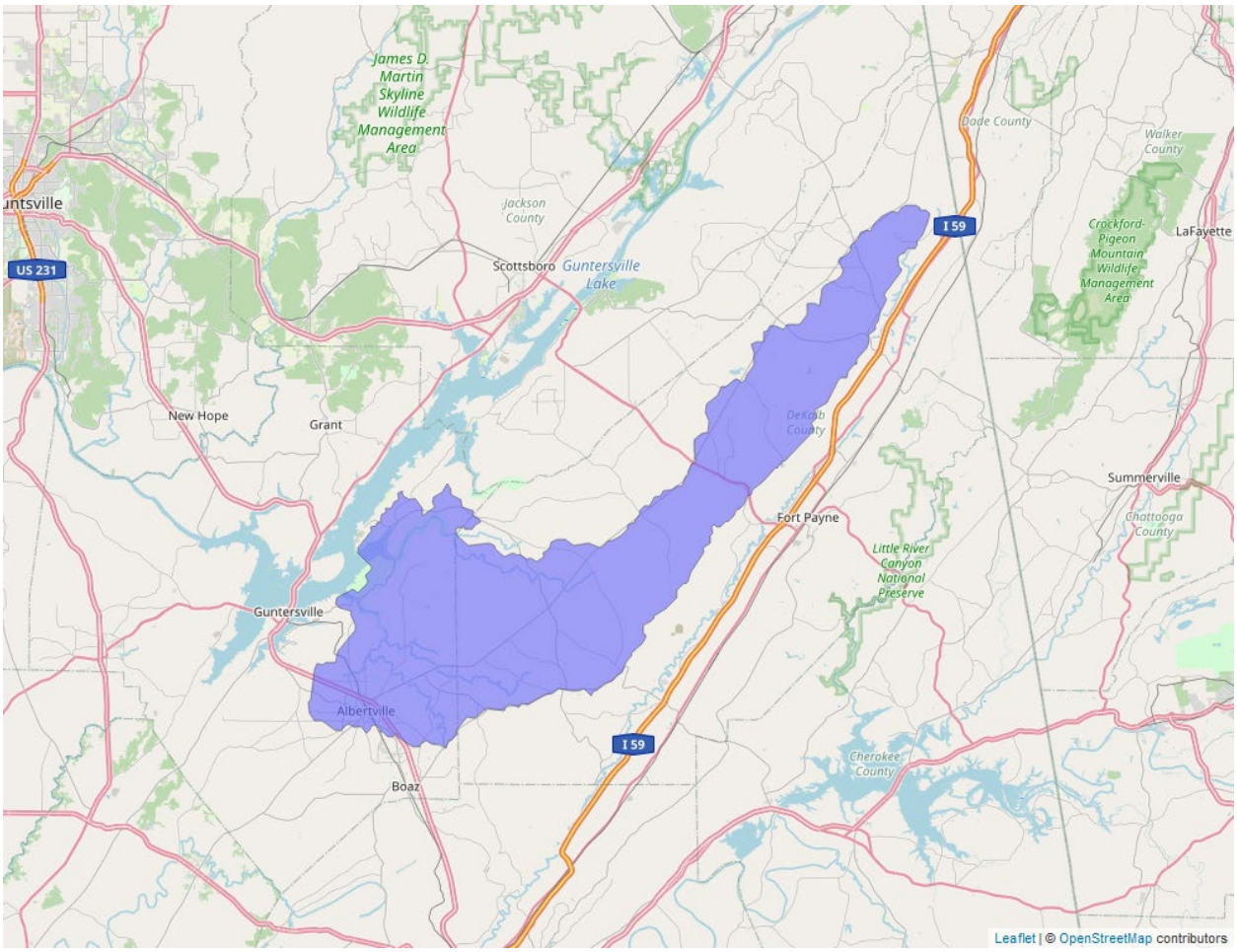

Figure 3. Range map of slenderclaw crayfish (blue polygons). Range map accessed at https://ecos.fws.gov/ecp/species/9792.

Vulnerability

As mentioned above, vulnerability considers the present and likely future condition of the species to determine its vulnerability to additional stressors. In making our jeopardy determination, vulnerability of the species is a function not only of its status, but also the environmental baseline and cumulative effects. These are summarized below for this species.

Summary of status

Listing status: Endangered

Most recent 5-Year Status Review recommendation: N/A

Most recently completed 5-Year Status Review: N/A

Distribution: Small, endemic, constrained, and/or isolated population(s)

Number of populations: Multiple populations (few)

Species trends: Unknown population trends

Pesticides noted in Service documents as a threat to the species: yes

Environmental Baseline/Cumulative Effects (EB/CE) Summary

The slenderclaw crayfish is a relatively small, freshwater crustacean with a comparatively elongate, slender front claw. It is cryptic, stream-dwelling, and endemic to Sand Mountain in DeKalb and Marshall counties, Alabama on the Cumberland Plateau in the Tennessee River Basin. They occur in small to medium flowing streams (usually 20 ft wide or smaller with depths of 2.3 ft or shallower). One population occurs where there are large boulders, fractured bedrock, and no turbidity and another occurs where there are small substrates (i.e., mix of sand, gravel, and cobble) and no turbidity. They need abundant interstitial space within each habitat type and adequate seasonal water flows to maintain benthic habitats and connectivity. They likely feed on aquatic macroinvertebrates as juveniles and shift toward omnivory as adults. As of 2019, there were two extant populations: Short Creek (three extant sites) and Town Creek (two extant sites) (USFWS 2019).

Hydrologic alteration (precipitation change), land-use change, and non-native virile crayfish were identified as factors affecting slenderclaw crayfish and coupled with low abundance and water quality concerns, the slenderclaw crayfish at risk of extinction within the next 10 to 20 years. The invasive virile crayfish is the biggest threat against the species; it has been documented in areas in the slenderclaw crayfish's range. The Short Creek population has low resiliency and the species' range within the Town Creek population may become highly restricted to the headwaters due to the expansion of virile crayfish and urban areas. In addition, the slenderclaw crayfish exhibits low natural redundancy given its narrow range. Pesticides, specifically those related to poultry farming, were mentioned as a threat to water quality and the species. Acreage of pastureland, poultry production, and row crop production in some of the species' range (i.e., Alabama) has decreased (USFWS 2019).

Overall Vulnerability: High

Effects of the Action: Exposure

Overlap with Agricultural Use Sites

We do not expect listed crustacean species will occur on-field, and thus expect exposure will only result from off-field transport via spray drift or runoff. Given that the ranges for listed aquatic species are generally delineated using the relevant HUC 12 watersheds, we anticipate

that all residues that leave use sites will be collected in the waterbodies within the species' range where individuals occur regardless of how residues leave treated sites or where in the range they are deposited. As such, we do not extend overlap metrics off-field as this will not functionally change the expected exposures that listed aquatic species are likely to experience. We use on-field overlaps with the species' range without a buffer as an estimate of the extent of exposure that's likely to occur. We expect up to 8.6% of the species' range contains agricultural carbaryl use sites (Table 10).

Table 9. Agricultural use overlap and annual usage data (% Range Treated) for the slenderclaw crayfish.

Use Layer	Use Site Overlap (% range)	% Range Treated
Alfalfa	<0.1	<0.1
Citrus	<0.1	<0.1
Corn	6.8	3.9
Grapes	0	0
Other Crops	0.5	0.5
Other Grains	0.4	0.1
Other Orchards[6]	<0.1	<0.1
Other Row Crops	0.1	0.1
Soybeans[7]	7.4	3.5
Vegetables and Ground Fruit	0.1	0.1
Total	**8.6**	**4.8**

Usage

Past usage data indicate that up to 4.8% of the species' range has been treated with carbaryl annually.

Non-agricultural Uses

In addition to agricultural use sites, we anticipate some non-agricultural carbaryl use sites also occur within the species' range, including developed, open space developed, nurseries, managed forests, rangeland, and rights of way areas. The species occurs in streams that may occur near

[6] We expect 'other orchards' and 'citrus' use sites are highly redundant with each other and only use the higher of the two layers in our calculation of total percent overlap and total percent treated range.

[7] We expect corn and soybean use sites are highly redundant with each other and only use the higher of the two layers in our calculation of total percent overlap and total percent treated range.

pasturelands, but acreage of pasture has decreased in recent years. Some of their occupied streams occur near roadways and other developed uses as well. Exposure through rangeland, rights of way, and open space developed uses may occur. However, we anticipate no more than, at most, a small number of individuals will be exposed to carbaryl and killed from non-agricultural uses.

Alabama is not included in the USDA APHIS grasshopper/Mormon cricket suppression program because it is not one of the 17 states within the action area for this program, indicating that carbaryl usage on rangelands is not expected to occur in Alabama. Similarly, available usage data indicate very little carbaryl usage is likely to occur in rights of way, with less than 500 pounds of carbaryl applied to roadways nationally each year. While this may result in a large treatment footprint if all rights of way usage were concentrated in one location or within one species' range, we expect this is highly unlikely to occur and rather expect rights of way usage is likely to be sporadic across the national landscape, with only small amounts, if any, used within the species' range. Available usage data indicate only low levels of past carbaryl usage in open space developed areas (including golf courses) within the slenderclaw crayfish's range, with, at most, up to 2.5% of the species' range likely to be treated each year.

Given this available information, we do not anticipate more than a small number of individuals are likely to be exposed to carbaryl through non-agricultural uses over the duration of the proposed action.

Conservation Measures

As part of the 2022 proposed interim decision for carbaryl, the technical registrants committed to a number of conservation measures for the protection of listed species, including a 48-hour rain restriction and mandatory 25-foot and 150-foot application buffers from aquatic habitats for all outdoor ground and aerial applications, respectively. We anticipate these measures will contribute to the protection of listed crustacean species by reducing the amount of carbaryl residues that is transported off use sites and into the habitat of listed species. However, despite the incorporation of the rain restriction and mandatory application buffers, exposure remains high for this species.

Label measures limit many residential uses of carbaryl to spot, crack-and-crevice, or narrow perimeter bands around urban structures (from 1 inch to 6 feet in width), which we expect will substantially reduce the likelihood of exposure to the species from developed uses.

Exposure Summary

There is a moderate extent of overlap between agricultural use sites and the species' range (8.6% overlap). We anticipate up to 4.8% of the species' range will likely be treated annually from agricultural uses, which we consider a low level of usage. We do not anticipate more than small numbers of individuals are likely to be exposed through non-agricultural uses. Based on the

moderate level of overlap, we determine the overall exposure ranking is medium. As such, we anticipate a moderate number of individuals are likely to experience exposure.

Overall Exposure: Medium

Effects of the Action: Toxicity

Direct Effects:

Based on toxicity data for crustaceans, we expect that exposure to carbaryl from runoff or spray drift deposition will result in mortality of any individuals exposed.

Indirect Effects:

Based on the best available information from other crayfishes, slenderclaw crayfish likely eat aquatic macroinvertebrates in the juvenile stage and shift toward eating both plant and animals in the adult stage. We expect that carbaryl exposure will result in adverse effects to macroinvertebrates that provide food for juveniles but will not adversely affect plant food sources that adults consume.

Toxicity Summary

Given the high sensitivity of crustaceans to carbaryl at estimated environmental concentrations, we anticipate any individuals exposed to carbaryl will die. Additionally, we anticipate other aquatic invertebrate species it may rely on for food in its juvenile stage will also die with exposure to carbaryl.

Overall Toxicity: High

Effects of the Action Summary

There is a medium level of overlap between the species' range and agricultural use sites and associated off-field areas (8.6% total overlap) and a low level of past usage (up to 4.8% range treated annually), indicating a moderate number of individuals are likely to be exposed over the duration of the proposed action. We expect crustacean species are highly sensitive to carbaryl, indicating a moderate number of individuals are likely to die. Based on available usage data and existing conservation measures for non-agricultural uses, we do not anticipate more than a small number of individuals will be exposed and die from non-agricultural uses. Given the impact agricultural uses will have on the species, the overall risk of adverse effects to the slenderclaw crayfish is high.

Preliminary Conclusion

The slenderclaw crayfish is an endangered, narrow endemic crustacean found in two populations on Sand Mountains in DeKalb and Marshall counties of Alabama. They are found in small to medium flowing streams and likely feed on macroinvertebrates and vegetation. Both populations have low abundance, low resiliency, and are at risk of extinction from threats like habitat loss, non-native and invasive crustacean species (i.e., virile crayfish), and changes in precipitation.

Past annual carbaryl usage occurred on a low percentage of the range (4.8%) and a moderate percentage of agricultural use sites overlap with the species' range (8.6%), indicating that more of the range could receive treatment in the future. In the 2019 Species Status Assessment, we mentioned concern about pesticides, specifically from agriculture and poultry farming, and effects to water quality. Though the species occurs in areas near some non-agricultural use sites (i.e., pasturelands), we did not expect these routes of exposure to meaningful add to the overall level of anticipated exposure and nor would they contribute to the overall risk of adverse effects from agricultural uses.

In our draft opinion, before incorporating species-specific conservation measures, we determined the species had a medium exposure ranking and we anticipated that a moderate number of individuals would experience exposure from the proposed action. Slenderclaw crayfish have a high toxicity ranking because we expect any direct exposure to result in mortality.

We anticipated exposure to carbaryl runoff would affect a moderate number of individuals over the duration of the proposed action. Even though past usage in the species' range was low, the species occurs in low abundance in only two populations; a moderate portion (8.6%) of the range is on potential carbaryl use sites, which we expected would result in a moderate number of individuals being exposed and dying over the duration of the proposed action without the conservation measures subsequently adopted as part of the action, as discussed below.

Final Conclusion (with Species-Specific Conservation Measures)

Because of the effects described in our preliminary conclusion above (Preliminary Conclusion), EPA and the applicant agreed to incorporate the following measures as part of the action. Within the Pesticide Use Limitation Area (PULA) for the slenderclaw crayfish:

1) *For agricultural uses, carbaryl must be applied using a 105 foot buffer for ground applications and a 160 foot buffer for airblast applications. Based on AgDRIFT modeling, the buffers will reduce spray drift from entering terrestrial habitat for the slenderclaw crayfish by >95%. These buffer distances may be reduced using other measures identified as equivalent mitigations (i.e., reducing spray drift by similar magnitude) as specified in EPA's Draft Insecticide Strategy and as described in Appendix A-1 of this Opinion.*

2) *For agricultural uses, applicators need 9 points of mitigation as outlined in EPA's Draft Insecticide Strategy. This will reduce carbaryl loads in the habitat of the slenderclaw crayfish by three orders of magnitude (i.e., a 1000-fold reduction).*

The PULA for the slenderclaw crayfish will be developed as described in the Description of the Proposed Action section of the main Opinion and Appendix A-1. EPA is currently considering public comments received on the Draft Insecticide Strategy. If additional mitigation options become available during finalization of the Insecticide Strategy or in the future, this might warrant re-initiation to incorporate those measures into the action (i.e., additional options and mitigations for end users). In that case, EPA will provide documentation that these measures provide equivalent conservation for listed species, including reduction in off-site transport. Upon confirmation by the Service, those options will be added to the acceptable mitigations listed for end users of carbaryl.

We anticipate that with the measures described above that carbaryl entering the habitat of the slenderclaw crayfish will be greatly limited and result in exposure of very low numbers of individuals over the course of the action. After reviewing the current status of the species, environmental baseline for the action area, cumulative effects, and effects of the action (including the species-specific conservation measures that are now incorporated into the proposed action), we determined the proposed action is not likely to appreciably reduce the survival and recovery of the species. Thus, it is our biological opinion that the registration of carbaryl, as proposed, is not likely to jeopardize the continued existence of the slenderclaw crayfish.

References

U.S. Fish and Wildlife Service. 2019. Species Status Assessment Report for the Slenderclaw Crayfish (*Cambarus cracens*), Version 1.4. Atlanta, Georgia. 73 pp.

Integration and Synthesis Summary: Brawleys Fork crayfish

Scientific Name:	Common Name:	Entity ID:
Cambarus williami	Brawleys Fork crayfish	10771

Species Overview

In reviewing the status of the species, the environmental baseline for the action area, cumulative effects, and the effects of the action, we determined that the species' vulnerability was high, anticipated exposure to carbaryl was high, and toxicity was high within the action area across the species' range (Figure 5), as described in the following sections. As such, we expected a large number of individuals were likely to die from the proposed action.

Because of the effects described in our preliminary evaluation and conclusion, EPA and the applicant agreed to incorporate the species-specific conservation measures as part of the action. We now expect exposure for the Brawleys Fork crayfish to be low. After incorporating conservation measures into the proposed action, adding the effects of the action and cumulative effects to the environmental baseline, and in light of the status of the species, we have determined the proposed action is not likely to appreciably reduce the survival and recovery of the species. Thus, we anticipate that the proposed action will not jeopardize the continued existence of the Brawleys Fork crayfish.

Species range

Based on range map dated: 08-20-2015; Wherever found; *States within the range:* TN

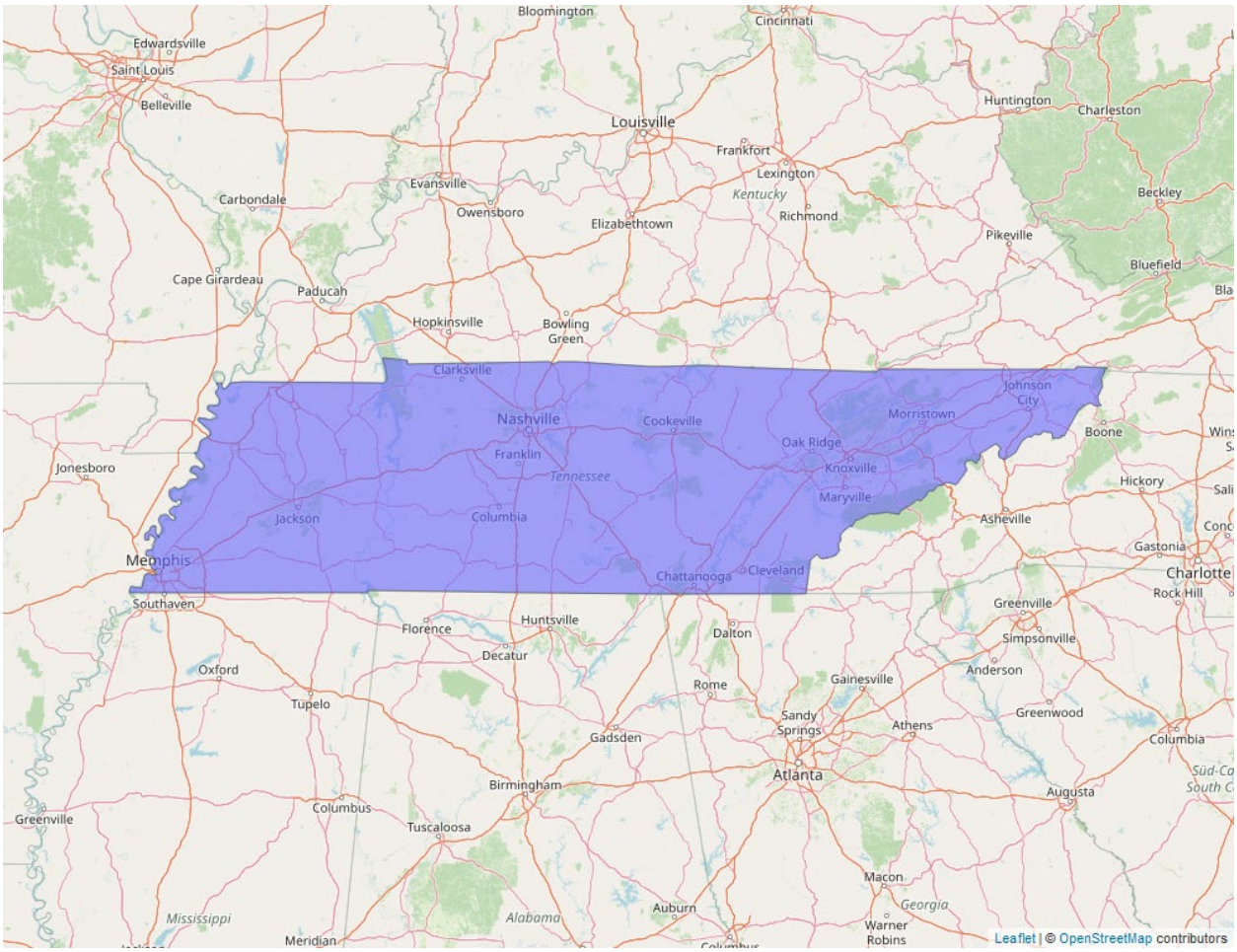

Figure 4. Range map of Brawleys Fork crayfish (blue polygons). Range map accessed at https://ecos.fws.gov/ecp/species/9806.

Vulnerability

As mentioned above, vulnerability considers the present and likely future condition of the species to determine its vulnerability to additional stressors. In making our jeopardy determination, vulnerability of the species is a function not only of its status, but also the environmental baseline and cumulative effects. These are summarized below for this species.

Summary of status

Listing status: Proposed Threatened

Most recent 5-Year Status Review recommendation: N/A

Most recently completed 5-Year Status Review: N/A

Distribution: Small, endemic, constrained, and/or isolated population(s)

Number of populations: Multiple populations (few)

Species trends: Unknown population trends

Pesticides noted in Service documents as a threat to the species: yes

Environmental Baseline/Cumulative Effects (EB/CE) Summary

Brawleys Fork crayfish is a small, freshwater crayfish endemic to the Nashville Basin and Eastern Highland Rim ecoregions of central Tennessee. They primarily occur in small- to medium-sized streams of the Stones and Collins River systems and one medium-sized river and are found across 20 streams in five Hydrologic Unit Code (HUC) watersheds. They occupy runs and riffles with moderate to fast flow and layered cherty gravel substrate and cobble with ample interstitial space. Habitat condition for all occupied areas is low. Out of 15 streams with abundance data, eight of them had low or very low abundance. Available information indicates no loss of populations or analysis units over time and the current known range of the species is wider than the historical range (USFWS 2023).

The primary threat to Brawleys Fork crayfish is sedimentation (e.g., agricultural and horticultural practices, gravel dredging, stream impoundment, and urban growth). Sediment fills interstitial spaces that the crayfish needs for feeding, breeding, and sheltering. Other threats include water quality degradation, channel modifications, and effects of climate change. A common grub control product contains pesticides including imidacloprid, clothianidin, and thiamethoxam (i.e., neonicotinoids). Some crayfish have shown behavioral changes that suggest they are more susceptible to predation after pesticide exposure (USFWS 2023).

Overall Vulnerability: High

Effects of the Action: Exposure

Overlap with Agricultural Use Sites

We do not expect listed crustacean species will occur on-field, and thus expect exposure will only result from off-field transport via spray drift or runoff. Given that the ranges for listed aquatic species are generally delineated using the relevant HUC 12 watersheds, we anticipate that all residues that leave use sites will be collected in the waterbodies within the species' range where individuals occur regardless of how residues leave treated sites or where in the range they are deposited. As such, we do not extend overlap metrics off-field as this will not functionally change the expected exposures that listed aquatic species are likely to experience. We use on-field overlaps with the species' range without a buffer as an estimate of the extent of exposure

that's likely to occur. We expect up to 13.5% of the species' range contains agricultural carbaryl use sites (Table 11).

Table 10. Agricultural use overlap and annual usage data (% Range Treated) for the Brawleys Fork crayfish.

Use Layer	Use Site Overlap (% range)	% Range Treated
Alfalfa	<0.1	<0.1
Citrus	<0.1	<0.1
Corn	9.1	0.7
Grapes	<0.1	<0.1
Other Crops	0.9	0.1
Other Grains	0.1	<0.1
Other Orchards[8]	<0.1	<0.1
Other Row Crops	0.2	<0.1
Soybeans[9]	12.3	5
Vegetables and Ground Fruit	<0.1	<0.1
Total	**13.5**	**5.2**

Usage

Past usage data indicate that up to 5.2% of the species' range has been treated with carbaryl annually.

Additional Exposure Considerations

The species occurs primarily in small- to medium-sized streams and one medium-sized river. Brawleys Fork crayfish become sexually mature by one year and live for three years (USFWS 2023).

[8] We expect 'other orchards' and 'citrus' use sites are highly redundant with each other and only use the higher of the two layers in our calculation of total percent overlap and total percent treated range.

[9] We expect corn and soybean use sites are highly redundant with each other and only use the higher of the two layers in our calculation of total percent overlap and total percent treated range.

Non-agricultural Uses

In addition to agricultural use sites, we anticipate some non-agricultural carbaryl use sites also occur within the species' range, including developed, open space developed, nurseries, managed forests, rangeland, and rights of way areas. However, we anticipate no more than, at most, a small number of individuals will be exposed to carbaryl and killed from non-agricultural uses.

Tennessee is not included in the USDA APHIS grasshopper/Mormon cricket suppression program because it is not one of the 17 states within the action area for this program, indicating that carbaryl usage on rangelands is not expected to occur in Tennessee. Similarly, available usage data indicate very little carbaryl usage is likely to occur in rights of way, with less than 500 pounds of carbaryl applied to roadways nationally each year. While this may result in a large treatment footprint if all rights of way usage were concentrated in one location or within one species' range, we expect this is highly unlikely to occur and rather expect rights of way usage is likely to be sporadic across the national landscape, with only small amounts, if any, used within the species' range. Available usage data indicate only low levels of past carbaryl usage in open space developed areas (including golf courses) within the Brawleys Fork crayfish's range, with, at most, up to 2.5% of the species' range likely to be treated each year. As such, we expect no more than small numbers of individuals are expected to be exposed to carbaryl through these non-agricultural uses. In contrast, we expect there is a large presence of ornamental plant nurseries that occur within the species' range, including areas directly adjacent to waterbodies where individual Brawleys Fork crayfish have been observed occurring. While available usage data generally indicate low levels of usage are likely to occur in nurseries, given this close proximity to known habitat and the high prevalence of this specific use site within the range, we anticipate a large number of individuals are expected to be exposed to carbaryl through this non-agricultural use.

Conservation Measures

As part of the 2022 proposed interim decision for carbaryl, the technical registrants committed to a number of conservation measures for the protection of listed species, including a 48-hour rain restriction and mandatory 25-foot and 150-foot application buffers from aquatic habitats for all outdoor ground and aerial applications, respectively. We anticipate these measures will contribute to the protection of listed crustacean species by reducing the amount of carbaryl residues that is transported off use sites and into the habitat of listed species. However, despite the incorporation of the rain restriction and mandatory application buffers, exposure remains high for this species.

Label measures limit many residential uses of carbaryl to spot, crack-and-crevice, or narrow perimeter bands around urban structures (from 1 inch to 6 feet in width), which we expect will substantially reduce the likelihood of exposure to the species from developed uses.

Exposure Summary

There is a high extent of overlap between agricultural use sites and the species' range (13.5% overlap). We anticipate up to 5.2% of the species' range will likely be treated annually from agricultural uses, which we consider a medium level of usage. Based on available usage data and existing conservation measures for non-agricultural uses, we anticipate no more than small numbers of individuals will be exposed through non-agricultural uses of carbaryl. Based on the high overlap with agricultural use areas and moderate level of past agricultural usage, we determine the overall exposure ranking is high, and we anticipate a large number of individuals are likely to experience exposure.

Overall Exposure: High

Effects of the Action: Toxicity

Direct Effects:

Based on toxicity data for crustaceans, we expect that exposure to carbaryl from runoff or spray drift deposition will result in mortality of any individuals exposed.

Indirect Effects:

While the specific diet of this species is unknown, we anticipate the species likely consumes smaller invertebrates, periphyton, and/or plant and detritus. We expect that carbaryl exposure will result in adverse effects to macroinvertebrates that individuals feed on, but will not adversely affect the periphyton, plants, and detritus food resources.

Toxicity Summary

Given the high sensitivity of crustaceans to carbaryl at estimated environmental concentrations, we anticipate any individuals exposed to carbaryl will die. Additionally, we anticipate other aquatic invertebrate species it may rely on for food will also die with exposure to carbaryl.

Overall Toxicity: High

Effects of the Action Summary

There is a high level of overlap between the species' range and agricultural use sites and associated off-field areas (13.5% total overlap) and a medium level of past usage (up to 5.2% range treated annually), indicating a large number of individuals are likely to be exposed over the duration of the proposed action. We expect crustacean species are highly sensitive to carbaryl, indicating a large number of individuals are likely to experience mortality. Based on available usage data and existing conservation measures for non-agricultural uses, we do not anticipate

more than a small number of individuals will be exposed and die from non-agricultural uses. However, based on the high level of exposure and toxicity from agricultural uses, we anticipate there will be a high risk of adverse effects to the Brawleys Fork crayfish.

Preliminary Conclusion

The Brawleys Fork crayfish is a proposed threatened, narrow endemic crustacean found in five HUC watersheds in central Tennessee. They are found in small to medium flowing streams and a medium-sized river, particularly runs and riffles with moderate to fast flow and ample interstitial space in substrate. All populations have low abundance and low resiliency, and habitat conditions at all occupied sites are considered low. Threats to the species include sedimentation, primarily loss of interstitial space, effects of climate change, decreased water quality, and channel modifications.

Past annual carbaryl usage occurred on a moderate percentage of the range (5.2%) and a high percentage of agricultural use sites overlap with the species' range (13.5%), indicating that more of the range could receive treatment in the future. We determined the species had a high exposure ranking, and without the conservation measures subsequently adopted as part of the action, as discussed below, we anticipated that a large number of individuals would experience exposure from the proposed action. Brawleys Fork crayfish have a high toxicity ranking because we expect any direct exposure to result in mortality.

In our draft opinion, before incorporating species-specific conservation measures, we anticipated exposure to carbaryl runoff would result in the exposure and death of a large number of individuals over the duration of the proposed action. The species occurs in populations with low abundance, low resiliency, and low habitat condition (e.g., low riparian canopy cover, high agricultural or urban development, frequent drought).

Final Conclusion (with Species-Specific Conservation Measures)

Because of the effects described in our preliminary conclusion above (Preliminary Conclusion), EPA and the applicant agreed to incorporate the following measures as part of the action. Within the Pesticide Use Limitation Area (PULA) for the Brawleys Fork crayfish:

1) *For agricultural uses, carbaryl must be applied using a 105-foot buffer for ground applications and a 160-foot buffer for airblast applications.*
2) *For agricultural uses, applicators need 9 points of mitigation as outlined in EPA's Draft Insecticide Strategy. This will reduce carbaryl loads in the habitat of the Brawleys Fork crayfish by three orders of magnitude (i.e., a 1000-fold reduction).*
3) *For applications to nurseries, carbaryl must be applied using a 160-foot buffer for airblast applications.*

Based on AgDRIFT modeling, the buffers will reduce spray drift from entering terrestrial habitat for the slenderclaw crayfish by >95%. These buffer distances may be reduced using other

measures identified as equivalent mitigations (i.e., reducing spray drift by similar magnitude) as specified in EPA's Draft Insecticide Strategy and as described in Appendix A-1 of this Opinion.

The PULA for the Brawleys Fork crayfish will be developed as described in the Description of the Proposed Action section of the main Opinion and Appendix A-1. EPA is currently considering public comments received on the Draft Insecticide Strategy. If additional mitigation options become available during finalization of the Insecticide Strategy or in the future, this might warrant re-initiation to incorporate those measures into the action (i.e., additional options and mitigations for end users). In that case, EPA will provide documentation that these measures provide equivalent conservation for listed species, including reduction in off-site transport. Upon confirmation by the Service, those options will be added to the acceptable mitigations listed for end users of carbaryl.

We anticipate that with the measures described above carbaryl entering the habitat of the Brawleys Fork crayfish will be greatly limited and result in exposure of very low numbers of individuals over the course of the action. After reviewing the current status of the species, environmental baseline for the action area, cumulative effects, and effects of the action (including the species-specific conservation measures that are now incorporated into the proposed action), we determined the proposed action is not likely to appreciably reduce the survival and recovery of the species. Thus, it is our biological opinion that the registration of carbaryl, as proposed, is not likely to jeopardize the continued existence of the Brawleys Fork crayfish.

References

U.S. Fish and Wildlife Service. 2023. Species Status Assessment Report for the Brawleys Fork Crayfish (*Cambarus williami*), Version 1.1. Atlanta, Georgia. 73 pp.