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.

The species in this I&S occur in aquatic habitats and were predicted by EPA to experience similar levels of exposure to atrazine from agricultural uses. Most of these species have low exposure to atrazine due to the factors described in the tables or individual rationales below, in combination with reductions in atrazine spray drift and runoff resulting from implementation of conservation measures added to the product label (including those developed during this consultation through the Herbicide Strategy[1]; see Conservation Measures section below). We anticipate that these measures will reduce exposure from agricultural uses to a level where no more than low level adverse effects are anticipated for many listed crustacean species.

Vulnerability

For the crustacean species that we or EPA determined are "likely to be adversely affected" by the proposed action, we considered several factors for each species to determine the current vulnerability of that species to additional stressors. This effort allows us to consider whether a species' current condition is stable, moving toward recovery, or moving toward further decline. In general, we expect the species' vulnerability to additional stressors to be higher if they are near extinction, far from recovery, or moving toward further decline than if their condition is stable or 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 of the Species and Critical Habitat section of this biological opinion (Appendix B).

Our assessment of vulnerability focuses on six factors (as currently understood and available): (1) the species listing status and recent 5-year status review recommendation (if available), (2) distribution, (3) number of populations[2], (4) species population trends, (5) if pesticides have been

[1] https://www.regulations.gov/docket/EPA-HQ-OPP-2023-0365

[2] The number will vary in value and importance by species and in some cases is unknown. In general, species with a greater number of populations have greater representation, will be more resilient, and when distributed geographically, will have greater redundancy. Conversely, species with fewer populations, in general, have less representation, are less resilient, and have less redundancy.

noted as a threat, and (6) current and projected future 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), overarching Environmental Baseline section of this Opinion, five-year species status reviews, species recovery plans, species status assessments, range and critical habitat information from our ECOS[3] repository, 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 high, a mixture of medium and high, or if a threatened species was recommended for uplisting to endangered status in the most recent 5-year status review or proposed rule. We assigned a medium vulnerability ranking if a species' scores were all medium, a mix of high, medium, and low, or a mix of high and low (unless the species has been recommended for uplisting or delisting). We assigned a low vulnerability ranking to species with only low scores, a mixture of low and medium scores, or if the species was recommended for delisting. Considerations regarding specific aspects of the species' vulnerability or beyond what was included in the vulnerability ranking were applicable in our jeopardy analyses for some species depending on unique aspects of their vulnerability factors, recovery needs, or life history. This information is reflected in the rationales for conclusion below.

Exposure

We anticipate that the main route of exposure for crustaceans is contact through the water. Atrazine is moderately mobile in water and is relatively persistent in the environment relative to other pesticides on the market, indicating that off-site transport, particularly through runoff, may result in exposure to listed species in areas far from use sites.

Exposure to Agricultural Uses

Atrazine has several registered agricultural uses (see Appendix 1-4 of EPA's Biological Evaluation) in the conterminous United States. We characterize the expected level of exposure using overlaps between the species' ranges and agricultural areas where atrazine is registered for use (i.e., overlap data; including a 305-m off-site transport area adjacent to use sites), past atrazine usage data (when available; the amount and location where atrazine has been used in the past), any species-specific considerations such as life history information (e.g., habitat preferences, dietary needs, 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 atrazine use sites are assigned a high overlap score, species with 5-10% overlap are assigned a medium overlap score, and

[3] https://ecos.fws.gov/ecp/

species with less than 5% overlap are assigned a low overlap score. In addition to range overlaps with atrazine use sites, we considered past atrazine usage data within a species' range to determine how much of a species' range we expect to be treated with each year of the proposed action. Except where otherwise noted, usage data is provided by EPA applying data from their National and State Summary Use and Usage Matrix, as described in the Usage Analysis section of this Opinion. Species with usage data that indicate a large portion of their range (>10%) is treated with atrazine each year are assigned a high usage score. Species that have a medium portion of their range (5-10%) treated with atrazine each year are assigned a medium usage score, and species where data indicate a low portion of their range (<5%) is treated with atrazine each year are assigned a low usage score.

We determine the agricultural 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 agricultural exposure ranking the same score (e.g., if both overlap and usage is high, the agricultural 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 agricultural exposure ranking of medium. For species where there are additional exposure considerations, we adjust the overall exposure ranking to reflect this additional information, as appropriate.

Agricultural uses of atrazine include labeled uses for corn, vegetables and ground fruit (i.e., sweet corn), sod, orchards (i.e., guava and macadamia nut), other grains (including sugarcane and sorghum), and fallow fields only within the coterminous United States.

Exposure to Non-Agricultural Uses

In addition to agricultural uses, atrazine is registered for use on non-agricultural turf, including residential lawns and golf course turf. UDLs for non-agricultural uses sites that represent turf tend to be less defined than those for agricultural UDLs and are less likely to accurately represent the actual footprint of these use sites on the landscape. As such, we assess exposure of species to all non-agricultural uses of atrazine in a qualitative manner, considering the life history of species, methods of application, atrazine usage, and any existing conservation measures to reduce drift and runoff or otherwise limit exposure to species. To facilitate this analysis, for every species in this Appendix, we reviewed species' documents (e.g., Status of the Species (Appendix B), 5-year reviews, Species Status Assessments, recovery plans, listing rules) to determine if the species could occur on or near non-agricultural atrazine use sites (i.e., residential areas where lawns or golf courses are likely present) and the manner in which they may rely on these sites.

Depending on region, cool-season, warm-season, or a combination of turf grass species are managed on golf courses and lawns. Cool-season grasses grow best in cooler conditions, and warm-season grasses thrive in hot, dry weather (USDA, 2004); there is a transition zone across the U.S. where either category of turf grasses may be planted based on microclimate conditions. Exposure to triazines will kill cool-season grasses, but warm-season grasses can tolerate exposure to atrazine. As such, EPA estimated where in the U.S. only cool-season grasses are exclusively used in turf based on the U.S. Department of Agriculture's plant hardiness zone map as atrazine use is not expected in these areas (USDA, 2023). Because hardiness zones will change over time with environmental conditions, EPA created a static map based on the hardiness zones where they expect warm- and cool-season grasses are grown based on the most recent data mapped (i.e., 1991-2020). EPA determined zones 1a-6a represent cool-season grasses (i.e., white areas) and zones 6b-13b may include warm-season grasses (i.e., black areas) (Figure 1). We expect the cool- and warm-season grass assessment to apply to all turf, including residential, commercial, and golf course turf. We refer to EPA's cool-season map in species assessments where relevant, particularly if a species occurs exclusively in the cool-season zone where we expect atrazine will not be used on turf and no exposure will occur from this use.

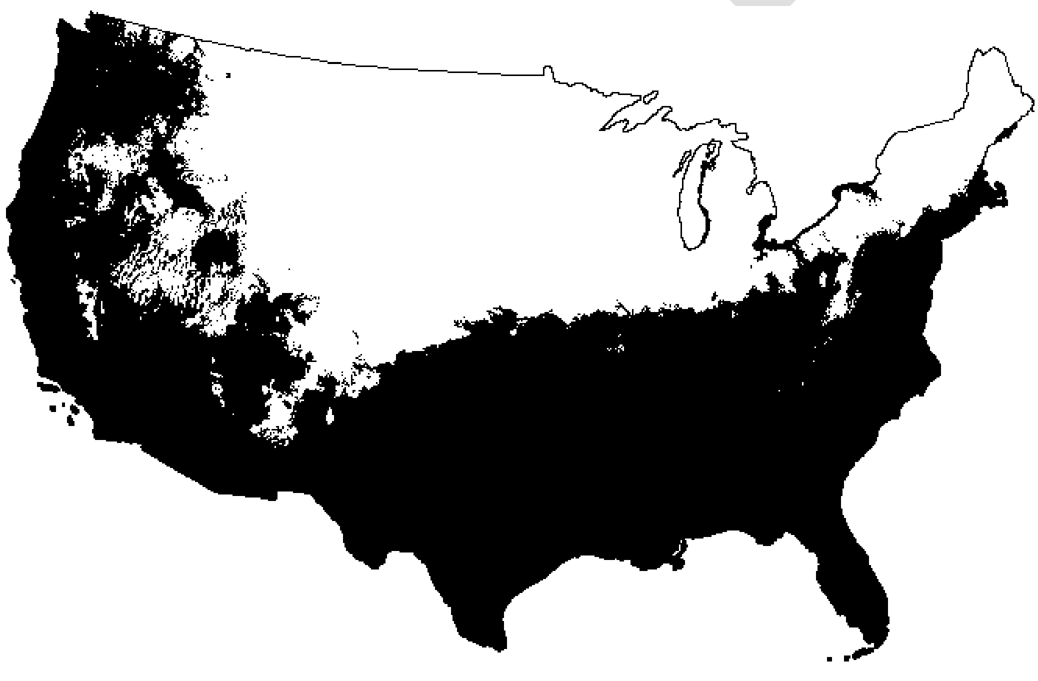

Figure 1. Map showing where cool-season grasses (white areas) and warm-season grasses (black areas) are used on turf across the continental U.S.

Particularly for residential and commercial turf uses, qualitative usage information obtained by EPA from the National Association of Landscape Professionals (NALP) indicate that atrazine is no longer commonly used on residential or commercial turf due to preferential use of newer herbicides. If atrazine were used on residential or commercial turf, it would be applied during the fall and spring as a pre-emergent. In addition, commercial and residential applicators typically apply herbicides with hand-held equipment that release course droplets, limiting the potential for spray drift.

Particularly for golf course turf uses, we obtained qualitative usage information directly from the Golf Course Superintendents Association of America (GCSAA) and an academic turf scientist that indicate that atrazine is used to control winter annual broadleaf and annual bluegrass weeds on golf courses. They are applied as a pre-emergent in early fall and early winter to fairways and roughs, which make up approximately 30% of a golf course's acreage. Triazines are not applied to tee boxes or greens, which make up an additional 6% of golf course acreage. Most applications are made at rates lower than what is on the label (i.e., 1-1.5 lbs a.i./acre). These applications are made only once or twice a year, 45-60 days apart. In general, golf courses typically apply herbicides using dedicated ground equipment with a low boom height (as per the label), and golf course superintendents make use of several tools to monitor soil moisture before any applications are made to help ensure turf and soil conditions do not lead to off-target movement of herbicides. In addition, riparian buffer zones are often used on golf courses between all water features to reduce off target movement (Golf Course Superintendents Association of America [GCSAA], pers. comm., 2025). The no-till methodology and continuous cover of a turf grass area inherent in managing golf course turf are equivalent to additional run-off mitigations (i.e., equivalent to six points on EPA's mitigation menu), and we considered them in our assessment.

For most species in this Appendix, we anticipate that non-agricultural uses will not meaningfully add to the overall level of anticipated exposure considered in our analysis of agricultural uses. Due to runoff and spray drift considerations described above, off-site exposure is not expected to result in effects to most species in this Appendix. In addition, we expect most listed species' habitat requirements preclude them from occupying non-agricultural use sites where atrazine may be used. For species whose habitat is known or presumed to occur in non-agricultural use sites of atrazine, we consider, individually and qualitatively, the extent and manner of non-agricultural atrazine 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 atrazine.

References:

GCSAA (Golf Course Superintendents Association of America). 2025. Personal communication with USFWS HQ staff.

USDA. 2004. Comparing warm-season and cool-season grasses for erosion control, water quality, and wildlife habitat. Natural Resources Conservation Service, U.S. Department of Agriculture. 5 pp.

USDA. 2023. Plant Hardiness Zone Map. Agricultural Research Service, U.S. Department of Agriculture. Accessed from https://planthardiness.ars.usda.gov/ on August 20, 2025.

Toxicity

We characterize the expected toxic effect to species based on the anticipated level of direct and indirect[4] adverse effects to individuals. Our analysis of toxicity assumes individuals are exposed to atrazine 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) 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 dietary items like plankton, other crustaceans, or detritus are exposed to atrazine and experience adverse effects.

We consider estimated concentrations of atrazine 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 atrazine can vary greatly depending on where exposure takes place. For instance, exposures on or near atrazine use sites are at higher levels than exposures that occur in areas far away from atrazine use sites. Based on available toxicity data, we anticipate crustaceans are somewhat sensitive to atrazine at estimated environmental concentrations and are not likely to die, even in habitats that only accumulate low levels. However, sublethal effects, such as reduced growth and reproduction, are possible with atrazine exposure for crustaceans at some estimated environmental concentrations (EECs).

We anticipate species that only rely on plant-based resources, such as aquatic vegetation for food or habitat, are likely to experience some indirect adverse effects. Available toxicity data in plants indicate a reduction in plant growth ultimately impacting survival of the plant is likely to occur with atrazine exposure. However, we do not anticipate that it will eliminate all aquatic vegetation within a water body and will replenish over time in any dynamic aquatic system (flowing or non-flowing) based on several mesocosm and microcosm studies discussed in the main body of the Opinion. In contrast, species that rely on terrestrial arthropods for food resources may not experience high levels of indirect adverse effects as atrazine exposure will not likely reduce the abundance and availability of terrestrial arthropod prey. However, atrazine may impact aquatic arthropod dietary resources, similarly as it would impact the species itself.

We determine the overall toxicity ranking for crustaceans by qualitatively assessing both the expected levels of direct adverse effects (e.g., reproduction) and indirect effects (e.g., prey or habitat loss). Given that mortality is the most adverse of direct effects to an individual of a

[4] 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 sometimes continue to use these terms to link back to the analysis in EPA's BE.

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 somewhat sensitive to atrazine; they are likely to experience sublethal effects if exposed, even in habitats that only accumulate low levels, and mortality is unlikely even at the highest estimated concentrations.

Conservation Measures

The technical registrants have previously agreed to substantial conservation measures that were incorporated into EPA’s 2021 BE. These conservation measures include the following:

- Prohibit use in Hawaii, Alaska, and the Territories,
- Prohibit use on roadsides, shelterbelts, Conservation Reserve Program (CRP) land, conifers (including Christmas tree plantings), timber and forestry, and miscanthus and other perennial bioenergy crops,
- Prohibit application via mechanically pressurized handguns to macadamia nuts, sweet corn, and guava,
- Restrict “fallow” uses on all labels to the following scenarios and geographies only:
    - Wheat-corn-fallow and wheat-fallow-wheat in CO, KS, ND, NE, SD, and WY,
    - Wheat-sorghum-fallow in AR, CO, GA, IL, KS, LA, MS, MO, NE, NM, NC, OK, SD, and TX
- Reduce the single maximum application rate of turf, granular formulations to 2.0 lbs. AI/A, and reduce the single maximum application rate of turf, sprays to 1.0 lb. AI/A,
- Restrict applications made by backpack-spray to landscape turf to spot treatments only,
- Restrict applicators from applying atrazine products to the same sorghum acre,
- Require all applications to use coarse or coarser droplet sizes,
- Require an in-field downwind buffer of 15-ft for all ground applications (from the edge of all streams and rivers as well as the high-tide line for all estuarine/marine environments, and from threatened and endangered species critical habitat and/or species locations)
- Prohibit all ground applications when wind speeds exceed 10 miles per hour at the application site,
- For ground boom applications, only apply with the release height recommended by the manufacturer, but no more than 4-ft above the ground or crop canopy,
- Require an in-field downwind buffer of 150-ft for all aerial applications (from the edge of all streams and rivers as well as the high-tide line for all estuarine/marine environments, and from threatened and endangered species critical habitat and/or species locations),
- If the windspeed is 10 miles per hour or less, applicators must use ½ swath displacement upwind at the downwind edge of the field. When the windspeed is between 11-15 miles per hour, applicators must use ¾ swath displacement upwind at the downwind edge of the field,

- If the windspeed is greater than 10 mph, the boom length must be 65% or less of the wingspan for fixed wing aircraft and 75% or less of the rotor diameter for helicopters. Otherwise, the boom length must be 75% or less of the wingspan for fixed-wing aircraft and 90% or less of the rotor diameter for helicopters,
- Prohibit all aerial applications when wind speeds exceed 15 miles per hour at the application site,
- Restrict aerial applications from releasing spray at a height greater than 10-ft above the ground or vegetative canopy unless a greater application height is necessary for pilot safety,
- Prohibit aerial applications of non-liquid formulations,
- Prohibit all applications during temperature inversions.

While these conservation measures are impactful and contribute to reducing the level of exposure and adverse effects to listed species, EPA and the Service anticipate substantial risk of adverse effects to many listed species remain after incorporating these measures into the proposed action.

Herbicide Strategy Conservation Measures

As part of the atrazine ESA consultation with the Service, EPA is implementing the final Herbicide Strategy to inform and identify any necessary conservation measures where EPA's analysis indicated there was a risk of population level effects to listed species. The measures identified by EPA, and committed to by the technical registrants, include:

- a standard 170-foot wind-directional spray drift buffer for aerial applications[5] (not in addition to the buffers the technical registrants committed to previously), and
- a minimum of three runoff mitigation points[6] necessary in all areas where atrazine is used, as well as additional runoff mitigation points (i.e., six points total) for certain atrazine uses limited to certain geographic areas when required to protect specific listed species.

In addition to the conservation measures identified through EPA's Herbicide Strategy, in the course of this consultation the technical registrants have also committed to additional measures for specific registered uses of atrazine to reduce exposure to listed species, including:

- Reduce the maximum annual application rate for field corn from 2.5 lbs. AI/A to 2.0 lbs. AI/A,

[5] Note: The 170-foot aerial buffer replaces the 150-foot aerial buffer agreed to before implementation of the Herbicide Strategy.

[6] Ecological Mitigation Support Document to Support Endangered Species Strategies

- For sweet corn uses, adopt one of the following:
  - Do not apply atrazine to sweet corn from August 15th to November 1st; when applied during other times of the year, use as a pre-emergent up to 2.0 lbs ai/acre.
  - With no timing restrictions for use, use as pre-emergent up to 1.25 lbs ai/acre followed by post-emergent 0.75 lbs ai/acre.
- Restrict "corn" in wheat-corn-fallow rotations to "field corn" meaning "wheat-field corn-fallow rotations",
- Off-label all uses in California except for Imperial County, and
- Add the restriction "Do not apply atrazine products during rain or when soils are saturated or above field capacity" to all formulations.

The spray drift buffers will be placed on the general label and will apply to all uses of atrazine. EPA's Herbicide Strategy provides applicators with options to reduce the distance of this buffer by using other spray drift reduction strategies that we anticipate will result in an equivalent reduction in spray drift entering non-target habitats as stated buffers. These measures and the degree to which applicators can reduce buffers by employing them are described in EPA's Herbicide Strategy and EPA's Ecological Mitigation Support Document to Support Endangered Species Strategies. These documents are provided in Appendix A-1.

Based on EPA's analyses, the required spray drift conservation measures described above (from the current label, those from implementation of the Herbicide Strategy, and additional measures committed to through consultation for specific registered atrazine uses) will reduce spray drift from entering species' habitats by >95%. The Service anticipates that this reduction will minimize off-site transport of atrazine from spray drift to a level where no more than low levels of effects are likely to occur to most species.

As stated above, all agricultural labels will include a requirement for applicators to achieve three points of runoff mitigation, as described in the Herbicide Strategy, for all agricultural uses. EPA's Herbicide Strategy provides applicators with various options to reduce runoff and erosion and assigns points to each option based on its effectiveness. Applicators must implement sufficient mitigation points to meet the label requirement. Applicators can achieve the required points using the conservation measures identified on EPA's Mitigation Menu website[7]. The menu provides a suite of options, including relief points for certain field characteristics and likelihood for pesticide transport.

We expect implementation of the required runoff and erosion reduction measures to minimize off-site transport of atrazine to habitats of listed species. EPA's analyses indicated that the general label requirement of three runoff mitigation points will reduce estimated environmental

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[7] Mitigation Menu website: https://www.epa.gov/pesticides/mitigation-menu

concentrations of atrazine in runoff by up to an order of magnitude (i.e., up to 90% reduction, in other words reduce pesticide loading to one-tenth of pre-runoff mitigation levels).

In cases where EPA has identified additional runoff measures are needed, additional points (up to six points total) will be required. EPA will communicate where additional runoff mitigation points are needed and for what specific atrazine uses through their Bulletins Live! Two online platform, which all applicators are required to check before making pesticide applications. In areas requiring up to six runoff mitigation points total, EPA expects estimated environmental concentrations of atrazine will decrease by up to two orders of magnitude (i.e., reduce pesticide loading to one-one hundredth of pre runoff mitigation levels; 99% reduction).

For all the species in this document, we expect that the runoff and conservation measures will reduce exposure concentrations to within one order of magnitude of the exposure level where individuals exposed to atrazine in areas off-site will not accumulate more than low levels of atrazine and are not likely to experience more than low levels of sublethal adverse effects to growth or reproduction (if any). Additionally, we anticipate these agricultural measures will reduce exposure to plant species, resulting in no more than low levels of adverse effects to plants that provide food or habitat features for listed species.

Summary of Conclusions for Crustaceans

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the proposed registration of atrazine with conservation measures, and the cumulative effects, it is the Service's biological opinion that the registration of atrazine, as proposed, is not likely to jeopardize the continued existence of at least 21 of the 22 crustacean species in this Appendix. For the remaining one crustacean in this appendix, we plan to continue coordination with EPA and the technical registrants to further assess this species.

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, would have had an individual discussion to provide additional explanation; we did not have any species that warranted individual discussions in this appendix. This approach allowed us to streamline our discussion in this Opinion by avoiding repeating our findings when we expected species in the respective groupings would 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 detailed process for each species-specific analysis remained the same, including for species for which we summarized our findings in tables below.

Species with low exposure informed by low overlap with agricultural areas and low likelihood of non-agricultural exposure

For the species in Table 1, we expect low exposure as informed by low overlap between the species' range and agricultural lands where atrazine is registered for use. Therefore, our concern for adverse effects is low. 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. Species with low exposure informed by low overlap with agricultural areas and low likelihood of non-agricultural exposure.

Common Name	Scientific Name	Vulnerability Ranking	Exposure Ranking	Toxicity Ranking	Total Action Area Overlap (% Range)	Determination
Benton County cave crayfish	*Cambarus aculabrum*	High	Low	High	0.5	No Jeopardy
Big Creek crayfish	*Faxonius peruncus*	High	Low	High	1.6	No Jeopardy
Big Sandy crayfish	*Cambarus callainus*	High	Low	Medium	<0.1	No Jeopardy
Black Creek crayfish	*Procambarus pictus*	High	Low	High	1.4	No Jeopardy
Guyandotte River crayfish	*Cambarus veteranus*	High	Low	Medium	0.0	No Jeopardy
Hay's Spring amphipod	*Stygobromus hayi*	High	Low	High	0.2	No Jeopardy
Hell Creek Cave crayfish	*Cambarus zophonastes*	High	Low	Medium	0.1	No Jeopardy
Lee County cave isopod	*Lirceus usdagalun*	High	Low	High	1.0	No Jeopardy
Nashville crayfish	*Orconectes shoupi*	Low	Low	Medium	1.0	No Jeopardy
Panama City crayfish	*Procambarus econfinae*	High	Low	High	0.3	No Jeopardy
St. Francis River crayfish	*Faxonius quadruncus*	High	Low	High	1.6	No Jeopardy

The species in Table 1 have high and low vulnerabilities. These species have low exposure after incorporating mitigation measures and subsequent reductions in off-target transport from agricultural use areas.

The species in Table 1 have high or medium toxicity because the species may occur in smaller, low-flow waterbodies where pesticide concentrations could be higher and cause adverse effects to these crustaceans or their aquatic invertebrate prey, but the combined effect of drift buffers, runoff controls, and reduced application rates is expected to prevent most exceedances of toxicity thresholds for agricultural uses.

In addition, the species in Table 1 have low extents of overlap between their ranges and agricultural atrazine use sites (<0.1-1.6%), including associated off-site transport areas. The total overlap metric we use is a conservative estimate of exposure as it does not fully account for redundancy between registered use sites, assumes exposure is occurring in all possible overlapping areas, assumes spray drift will occur in all directions during treatment of fields, and does not consider information on past atrazine usage. As such, we expect that exposure of these species to atrazine from agricultural uses will occur in even smaller portions of the species' ranges than the overlaps shown in Table 1.

In addition to agricultural exposure, species in Table 1 may be exposed to atrazine from non-agricultural (i.e., turf) uses. In addition, given our understanding of atrazine usage on use sites such as golf courses and residential lawns (see *Exposure to Non-Agricultural Uses*, above), we expect atrazine usage within the ranges of these species to be limited. In addition, if applied, we anticipate off-site transport of atrazine will be minimal as characteristics of the use sites (i.e., continuous cover, no till) are expected to result in little runoff. Furthermore, commercial and residential applicators typically apply herbicides with hand-held equipment that release course droplets, limiting the potential for spray drift from these specific uses. Therefore, we expect atrazine exposure from non-agricultural uses to be low for these species.

Most crustaceans are omnivores and rely on a variety of dietary items including aquatic plants, fish, amphibians, fish eggs, algae, detritus, and dead plant and animal material. We expect atrazine exposure will result in adverse effects to plant food sources, particularly a reduction in plant growth. However, we anticipate some aquatic vegetation will withstand atrazine exposure and replenish over time in flowing or non-flowing dynamic aquatic systems based on several mesocosm and microcosm studies discussed in the main body of the Opinion. Atrazine may also impact aquatic arthropod dietary resources. We do not expect atrazine exposure will impact detritus, woody plant material, animal material, or dead plant food resources. We do not expect exposed crustaceans to die, even at the highest estimated concentrations of atrazine.

In summary, we expect a small number of individuals of the species in Table 1 will experience exposure to atrazine over the project duration. Exposure will be limited to small portions of the species' ranges that overlap with agricultural or non-agricultural use sites and areas of off-site transport, and the few exposed individuals may experience adverse effects to reproduction and indirect effects through some prey loss. Therefore, we determine the overall risk of adverse effects to these species is low. After reviewing the current status of the species, environmental baseline for the action area, cumulative effects, and effects of the action (including general label conservation measures), we have determined the proposed action is not likely to appreciably reduce the survival and recovery of these species in the wild. Thus, it is our biological opinion that the registration of atrazine, as proposed, is not likely to jeopardize the continued existence of the species in Table 1.

Species with low agricultural exposure achieved through conservation measures and low likelihood of non-agricultural exposure

For the species in Table 2, we expect they will have low exposure after incorporating general label measures (e.g., measures already on the label, three runoff points and a ground and aerial buffers determined through implementation of the Herbicide Strategy, and rate reductions and other restrictions to particular registered uses) and, where applicable, species-specific measures accessed through EPA's Bulletins Live! Two. Therefore, our concern for adverse effects is low. While we present some specific information about the species 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. Species with low agricultural exposure achieved through spray drift and runoff conservation measures and low likelihood of non-agricultural exposure.

Common Name	Scientific Name	Vulnerability Ranking	Agricultural Exposure Ranking	Toxicity Ranking	Conservation Measures	Determination
Brawleys Fork crayfish	*Cambarus williami*	High	Low	Medium	General label measures	No Jeopardy
Noel's amphipod	*Gammarus desperatus*	High	Low	High	General label measures	No Jeopardy
Vernal pool fairy shrimp	*Branchinecta lynchi*	High	Low	High	General label measures + six pts for all uses	No Jeopardy
Vernal pool tadpole shrimp	*Lepidurus packardi*	High	Low	High	General label measures + six pts for all uses	No Jeopardy

The species in Table 3 has high vulnerability. The species has low exposure after incorporating mitigation measures and subsequent reductions in off-target transport from agricultural use areas.

Most crustaceans are omnivores and rely on a variety of dietary items including aquatic plants, fish, amphibians, fish eggs, algae, detritus, and dead plant and animal material. We expect atrazine exposure will result in adverse effects to plant food sources, particularly a reduction in plant growth. However, we anticipate some aquatic vegetation will withstand atrazine exposure and replenish over time in flowing or non-flowing dynamic aquatic systems based on several mesocosm and microcosm studies discussed in the main body of the Opinion. Atrazine may also impact aquatic arthropod dietary resources. We do not expect atrazine exposure will impact detritus, woody plant material, animal material, or dead plant food resources. We do not expect exposed crustaceans to die, even at the highest estimated concentrations of atrazine.

We anticipate the species in this group are not likely to occur in agricultural atrazine use sites. We expect the general label measures for agricultural uses described above (e.g., reduced application rates, 15-foot spray drift buffer for ground application, 170-foot spray drift buffer for aerial applications, three runoff mitigation points, reduction in application rates) will reduce off-field exposures by an order of magnitude (i.e., a 90% reduction), which we expect will not cause more than low levels of adverse effects to exposed individuals and will not result in more than low levels of adverse effects to the plant communities that provide habitat and food resources to individuals for the Brawleys Fork crayfish and Noel's amphipod. For the vernal pool fairy shrimp and vernal pool tadpole shrimp, atrazine concentrations remain high enough after the general label measures to cause adverse direct and indirect effects to the species, so an additional three runoff mitigation points are included to further reduce the concentrations of atrazine reaching their habitats for a total of six runoff mitigation points.

In addition to agricultural exposure, the species in Table 2 may be exposed to atrazine from non-agricultural (i.e., turf) uses. However, these non-agricultural use sites do not provide the species' necessary habitat. Even though Noel's amphipod occurs near urban areas where atrazine may be used on turf, most individuals are on National Wildlife Refuge lands where we do not expect atrazine will be used (i.e., atrazine has not been reported for use on refuges since at least 2013). In addition, given our understanding of atrazine usage on use sites such as golf courses and residential lawns (see *Exposure to Non-Agricultural Uses*, above), we expect atrazine usage within the ranges of these species to be limited. In addition, if applied, we anticipate off-site transport of atrazine will be minimal as characteristics of the use sites (i.e., continuous cover, no till) are expected to result in little runoff. Furthermore, commercial and residential applicators typically apply herbicides with hand-held equipment that release course droplets, limiting the potential for spray drift from these specific uses. Therefore, we expect atrazine exposure from non-agricultural uses to be low for these species.

In summary, with implementation of conservation measures on product labels, we expect that few individuals will be exposed to atrazine via off-site transport from agricultural or non-agricultural areas. Those few exposed individuals will experience no more than low level of adverse effects to reproduction and may experience indirect effects through some prey loss. Therefore, we determine the overall risk of adverse effects to these species is low. After reviewing the current status of the species, environmental baseline for the action area, cumulative effects, and effects of the action (including general label and specific conservation measures), we have determined the proposed action is not likely to appreciably reduce the survival and recovery of these species in the wild. Thus, it is our biological opinion that the registration of atrazine, as proposed, is not likely to jeopardize the continued existence of the species in Table 2.

Species that occur in caves with low agricultural exposure achieved through conservation measures and low likelihood of non-agricultural exposure

The species in Table 3 are grouped together because we anticipate all of these species are at low risk of adverse effects from the proposed action as a result of conservation measures included in the description of the action, including general label measures (e.g., measures already on the label, three runoff points and a ground and aerial buffers determined through implementation of the Herbicide Strategy, and rate reductions and other restrictions to particular registered uses), and their primary habitat is in cave systems. 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. Species that occur in caves with low agricultural exposure achieved through spray drift and runoff conservation measures and low likelihood of non-agricultural exposure.

Common Name	Scientific Name	Vulnerability Ranking	Agricultural Exposure Ranking	Toxicity Ranking	Determination
Alabama cave shrimp	*Palaemonias alabamae*	High	Low	High	No Jeopardy
Illinois cave amphipod	*Gammarus acherondytes*	High	Low	High	No Jeopardy
Kentucky cave shrimp	*Palaemonias ganteri*	High	Low	High	No Jeopardy
Madison Cave isopod	*Antrolana lira*	High	Low	High	No Jeopardy
Miami Cave crayfish	*Procambarus milleri*	High	Low	High	No Jeopardy
Peck's cave amphipod	*Stygobromus (=Stygonectes) pecki*	High	Low	High	No Jeopardy
Squirrel Chimney Cave shrimp	*Palaemonetes cummingi*	High	Low	High	No Jeopardy

The species in Table 3 have high vulnerability rankings. These species have low exposure rankings after incorporating conservation measures and subsequent reductions in off-target transport from agricultural use areas and accounting for the modeling of karst systems.

EPA's Herbicide Strategy requires a minimum of three runoff mitigation points and standard a 15-foot ground and standard 170-foot aerial spray drift buffer on all agricultural atrazine applications, which will reduce estimated environmental concentrations of atrazine from agricultural uses by up to 90% (or an order of magnitude) for the species in this group. Applicators must select runoff and erosion control practices from EPA's mitigation menu, which is designed to be flexible while ensuring site-level risk is reduced. These general conservation measures will both reduce the number of individuals exposed (by reducing the extent of off-site transport of atrazine residues) and reduce the level of adverse effects that will occur to exposed individuals (by reducing estimated exposure concentrations).

The crustaceans in Table 3 may be exposed to pesticides in water from over land flow or leaching from soil from land use practices over or near sinkholes, karst systems, or other porous features near the surface of cave habitats. The environmental fate, transport, and physicochemical properties of atrazine are such that it is quite mobile in soil matrices and water. Atrazine is persistent enough in the environment that it could run-off of agricultural fields and remain at levels toxic enough to impact cave species. Karst systems are known to have enhanced porosity and permeability and are therefore susceptible to pesticide contamination that could be present in run-off water. Karst cave systems recharge (i.e., the process of aboveground water reaching the groundwater supply) every several days to months, and atrazine is not known to degrade in that time frame (see *Exposure* section in this Opinion) so atrazine could be present in water that enters the cave. However, the karst system watersheds specific to where these different crustaceans occur (Alabama, Kentucky, Illinois, Texas, Virginia, and Florida) are such that the dilution of off-field run off of atrazine in combination with the conservation measures provided, will not frequently reach concentrations that will impact these cave crustaceans or their dietary resources (aquatic arthropods, algae, detritus, etc.). Thus we expect effects to growth and/or reproduction for these crustaceans and their dietary resources (e.g., aquatic arthropods, algae) will be infrequent and of low magnitude due to the reduction in atrazine exposure. Likewise, estimated environmental concentrations from non-agricultural exposure are not likely to reach levels where we would observe mortality or sub-lethal effects to these species.

In summary, we expect these crustaceans are likely to experience no more than low levels of exposure to atrazine based on the low atrazine EECs we expect after implementation of the conservation measures. We also expect non-agricultural exposure is low. A small number of exposed individuals may have fewer offspring, reduced growth, and temporary reduced food availability, but we do not expect mortality or high levels of sublethal effects to these crustaceans. After reviewing the current status of the species, environmental baseline for the action area, cumulative effects, and effects of the action (including the conservation measures that are incorporated into the proposed action), we have determined the proposed action 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 the species listed in Table 3.

Species requiring further analysis

In our draft Biological Opinion, we focused our analyses on 1) species with low expected exposure to atrazine (due to low overlap, usage, or conservation measures adopted prior to consultation), and 2) species with more than low levels of exposure that benefited from conservation measures identified through the Herbicide Strategy that aimed to reduce off-site transport of atrazine (i.e., listed plants and listed animals that depend on plant resources). For the species in Table 4, we identified the need for further coordination. We expect Herbicide Strategy conservation measures to reduce pesticide loading into aquatic habitats by up to 90% (i.e., one order of magnitude) compared to unmitigated runoff. While the conservation measures are expected to reduce the extent of off-field exposure and reduce exposure concentrations, we anticipate atrazine residues could remain at levels high enough to cause greater than low levels of adverse direct and/or indirect effects to these species. We intend to continue coordinating with EPA and atrazine registrants between the release of this draft Opinion and the transmission of the final Opinion to gain information regarding the exposure and effects of each species to atrazine. As such, we have not yet made a determination for this species.

Table 4. Crustaceans needing further mitigation.

Common Name	Scientific Name	Vulnerability Ranking	Exposure Ranking	Toxicity Ranking
Slenderclaw crayfish	*Cambarus cracens*	High	High	High