FINAL PERFORMANCE REPORT

Federal Aid Grant No. F14AF01228 (T-81-1)

Mapping Priority Areas for Oklahoma's Ozark Karst Species of Greatest Conservation Concern

Oklahoma Department of Wildlife Conservation

October 1, 2014 through September 30, 2016

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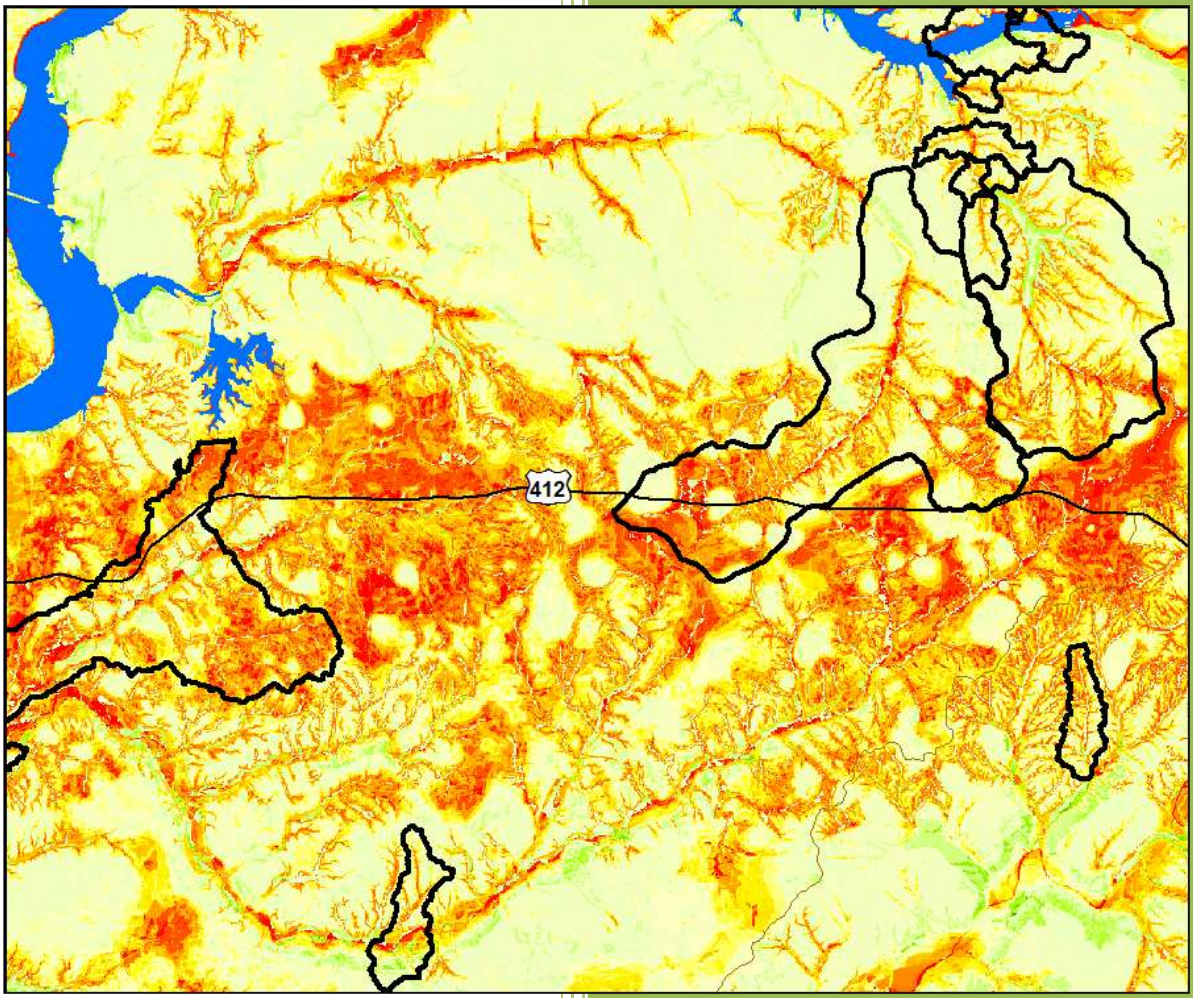

Final Report for
Oklahoma State Wildlife Grant
Number T-81-1

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and Jay Pruett
The Nature Conservancy
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FINAL REPORT

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Jay Pruett – The Nature Conservancy, Oklahoma Field Office

A. ABSTRACT

Priority areas were mapped for 28 species using information from 216 occurrence records at 94 sites, and updated range maps were created for each species. Many of the species (n=22) are known from less than 10 sites in Oklahoma. Six species are endemic to caves in the Oklahoma Ozarks: *Caecidotea mackini, Cambarus subterraneaus, Cambarus tartarus, Pygmarrhopalites jay, Stygobromus bowmani, Trigenotyla blacki*. An additional 15 species are Ozark endemics with populations occurring in Arkansas and Missouri. The remaining seven species (*Dendrocoelopsis americana, Myotis grisescens, Myotis sodalis, Myotis septentrionalis, Porrhomma cavernicola, Spelobia tenebrarum, Stygobromus alabamensis*) have additional populations that occur outside of the Ozarks. In addition to assessing locations where conservation actions could be focused to benefit populations and species, a priority ranking for species was developed to assist with future implementation projects.

B. INTRODUCTION

Karst species are important components of species conservation planning efforts in the Oklahoma Comprehensive Wildlife Conservation Strategy, and these habitats are considered Very High Priority Conservation Landscapes in the Strategy (pp 277–293: Oklahoma Department of Wildlife Conservation 2005). Karst is a terrain, generally underlain by limestone or dolomite, in which the topography is chiefly formed by the dissolving of rock, and which may be characterized by sinkholes, losing streams, closed depressions, subterranean drainage, and caves. Often, species living in karst habitats are uniquely adapted to rigorous environmental conditions that occur there. Because light is absent and food is limited, many species exhibit morphological, physiological, and behavioral characteristics that make them well suited for existence in subterranean habitats. These organisms are often among the rarest and most unique species inhabiting karst regions.

To effectively protect karst species and the groundwater resources they use, information is needed concerning the threats these species may be experiencing (Tercafs 2001). For some Oklahoma caves and karst species, information such as surface water contribution, potential impacts from human visitation and alteration, or groundwater vulnerability is available (Bidwell et al. 2010, Graening et al. 2011, Graening 2005, Aley 2005, Gillip et al. 2009). Recharge area for some Oklahoma populations of Ozark cavefish (*Amblyopsis rosae*) were delineated by Ozark Underground Laboratory, and these studies included characterizations of the habitat into groundwater vulnerability categories and the identification of potential point source contaminants (Aley and Aley 1990, Aley and Aley 1991, Aley 2005). These delineations and threat assessments have been critical in assisting with the recovery efforts associated with Ozark cavefish populations in Oklahoma. However, for a majority of Oklahoma's cave species, little information is available about possible threats, and detailed threat analyses, such as those associated with Ozark cavefish populations, are not feasible due to the large number of species habitats that would need to be assessed. An alternative to site-specific analyses of threat would be to use a spatial approach that assessed threat across the entire distribution of Oklahoma karst species and used spatial information that was currently available. The Nature Conservancy has developed an approach that assessed threat across a karst landscape (Inlander et al. 2011) and has used this approach to assess threat for karst species in Arkansas (Figure 1). The purpose of this study was to develop a spatially-based threat assessment for 29 karst species of greatest conservation concern identified in the Strategy that occur in the caves and springs of the Oklahoma Ozarks (Table 1).

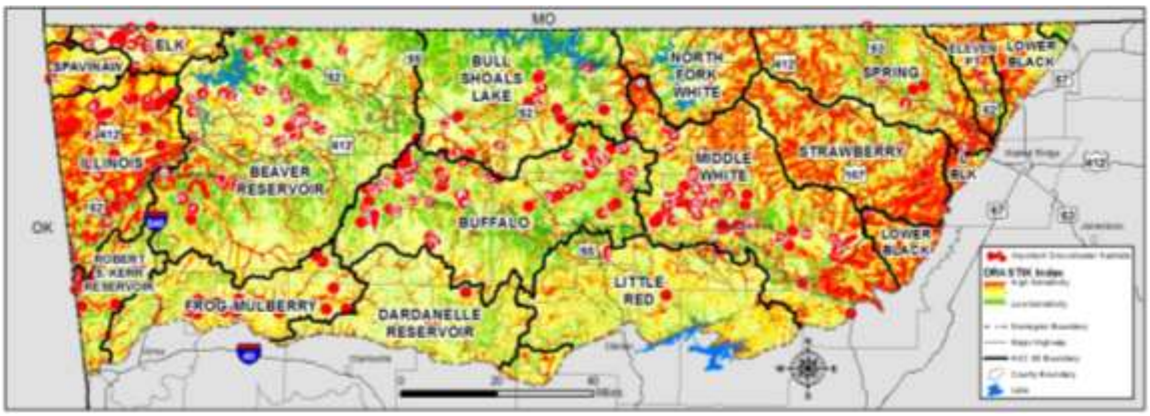

Figure 1. Threat map for Arkansas karst species of greatest concern overlaid on a groundwater vulnerability map for northern Arkansas (Inlander et al. 2011).

Table 1. List of rare karst dependent species found in the Oklahoma Ozarks. *Eight Oklahoma karst dependent species not included in the Strategy were included in the threat assessment.

Class	Common Name	Scientific Name	SGCN status*
Amphibians	Grotto Salamander	*Eurycea spelaea*	Included
	Ozark Salamander	*Plethodon angusticlavius*	Included
Crayfish	Cave Crayfish	*Cambarus subterraneaus*	Included
	Oklahoma Cave Crayfish	*Cambarus tartarus*	Included
Fish	Ozark Cavefish	*Amblyopsis rosae*	Included
Insect	Ozark Cave Silverfish	*Speleonycta ozarkensis*	Not Included
	Cave Dung Fly	*Spelobia tenebrarum*	Not Included
	Cave Springtail	*Pseudosinella dubia*	Included
	Cave Springtail	*Pygmarrhopalites jayi*	Included
Invertebrates Other	Cave Flatworm	*Dendrocoelopsis americana*	Not Included
	Cave Isopod	*Caecidotea ancyla*	Included
	Cave Isopod	*Caecidotea antricola*	Included
	Cave Isopod	*Caecidotea macropropoda*	Included
	Cave Isopod	*Caecidotea mackini*	Included
	Cave Isopod	*Caecidotea simulator*	Included
	Cave Isopod	*Caecidotea steevesi*	Not Included
	Cave Isopod	*Caecidotea stiladactyla*	Included

	Kansas Well Amphipod	*Bactrurus hubrichti*	Included
	Alabama Cave Amphipod	*Stygobromus alabamensis*	Not Included
	Bowman's Cave Amphipod	*Stygobromus bowmani*	Included
	Onondaga Cave Amphipod	*Stygobromus onondagaensis*	Not Included
	Ozark Cave Amphipod	*Stygobromus ozarkensis*	Included
	Appalachian Cave Spider	*Porrhomma cavernicola*	Not Included
	Cave False Scorpion	*Hesperochernes occidentalis*	Not Included
	Black's Cave Millipede	*Trigenotyla blacki*	Included
Mammals	Gray Myotis	*Myotis grisescens*	Included
	Indiana Myotis	*Myotis sodalis*	Included
	Northern Long-eared Myotis	*Myotis septentrionalis*	Included
	Ozark Big-eared Bat	*Corynorhinus townsendii ingens*	Included

C. OBJECTIVES

- Generate updated species range maps for each of the 20 Oklahoma species by integrating data from multiple sources.
- Assess the current status of threats associated with each of these 20 species.

D. APPROACH

Study Area

The study area for this project was limited to the portion of the state considered part of the Ozarks Ecoregion (Figure 2). This portion included sections of the Boston Mountains and the Ozark Plateau as designated by EPA Level 3 ecoregional mapping effort.

Figure 2. The study area for this project included all Oklahoma lands within the Ozarks Ecoregion boundary and includes the Boston Mountains and the Ozarks Plateau.

Species Range Maps

To provide updated information to the Oklahoma Comprehensive Wildlife Conservation Strategy, we developed species range maps for 29 karst-associated species found in the Ozark portion of Oklahoma. Not included in this analysis are karst species found in the Arbuckle Mountains or in the gypsum karst areas of western Oklahoma. The maps reflect species ranges within Oklahoma, but do not reflect the entire range of any species that occurs in adjacent areas of Arkansas, Kansas, or Missouri.

We used a Microsoft Access database structure to characterize descriptions and locations of karst species. The location data used in this project were derived from a pre-existing, proprietary database that was created by The Nature Conservancy independently from this grant. This karst database includes occurrence information for the 29 karst species included in this study, as well as many other groundwater and karst-dependent species occurring elsewhere in the Ozarks ecoregion. Species information is continually updated with the latest species and location information collected through inventory efforts by TNC and its partners. Collectively, the 29 species examined in this project are known from 94 sites in Oklahoma that include caves, sinkholes, crevices, seeps and springs.

For the purposes of this project, the 29 karst species were split into three biological community groups: terrestrial, bat, and aquatic communities. Terrestrial species use in-cave terrestrial habitats. Bat species use caves and crevices for hibernation, raising their young and other life functions. Bats also forage beyond these karst features. Aquatic species primarily or solely use the aquatic habitats of caves, springs, and seeps. The grotto salamander (*Eurycea spelaea*) was placed in the aquatic community group though it uses both terrestrial and aquatic karst habitats. A range map was generated for *Stygobromus bowmani* based on the general location information (single seep at a Girl Scout Camp 3.2 miles south of Locust Grove, Mayes County) available in Holsinger (1967).

Threat Assessment

GIS-based threat models were designed and implemented for each of the three biological community groups. These models were developed to assess and compare the relative level of threat from human land uses and activities at each species occurrence site, and also to determine the relative threat to each species across its range in Oklahoma.

The threat models varied in content and complexity with each biological community group. The threat model for the terrestrial group was the simplest of all the community threat models, only accounting for the risk of disturbance at the site by human visitation (Risk: Visitation, or RVI). The

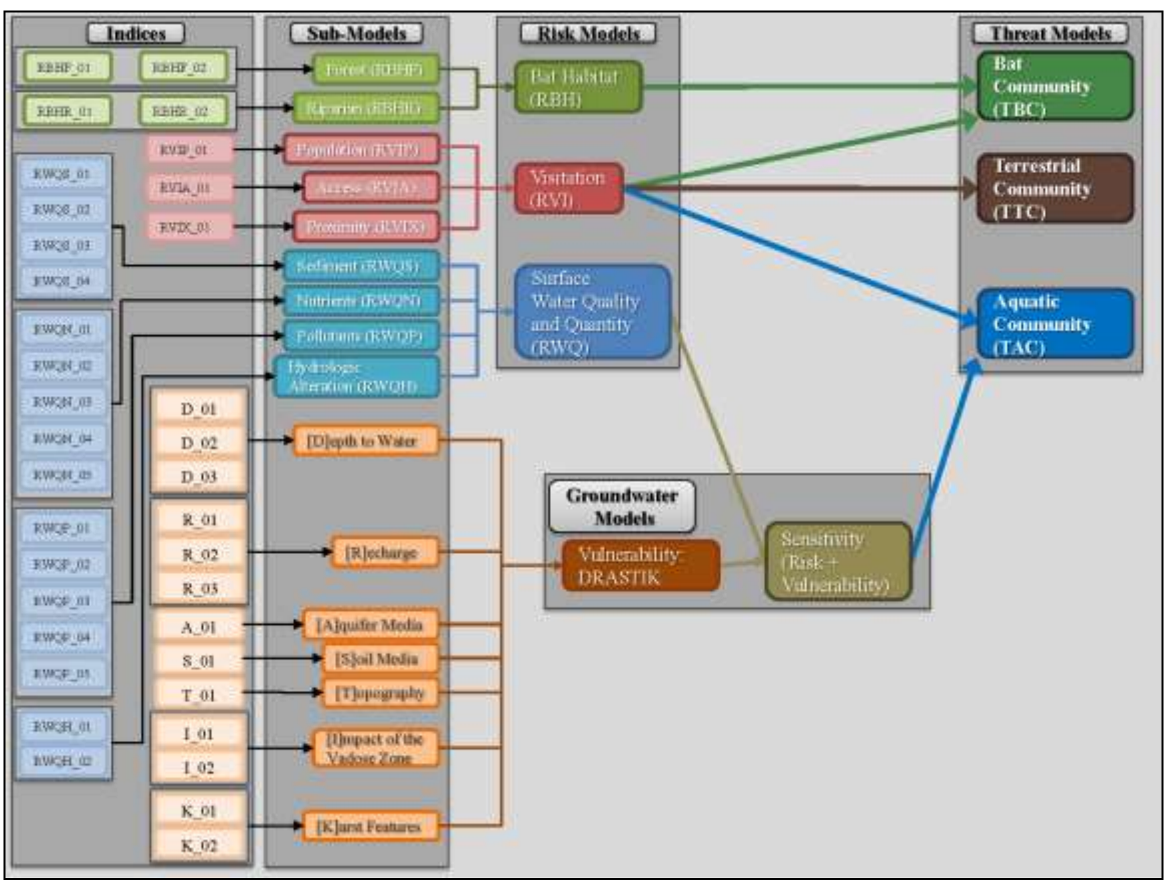

Figure 3. Generalized schematic of three community threat models.

threat model for the bat community accounted for the risk of visitation (RVI) , as well as the riparian and upland forest habitat characteristics near the site (Risk: Bat Habitat, or RBH). The threat model for the aquatic community was the most complex of the threat models. It accounted for site visitation (RVI), but also accounted for groundwater sensitivity. Groundwater sensitivity had two sub-models: The risk to water quality and quantity (RWQ), and the groundwater vulnerability, which describes the ability of the landscape and subsurface to filter and attenuate the factors assessed in RWQ. Figure 3 is a generalized schematic of the criteria for each threat model.

Terrestrial Community Group

The threat model for the terrestrial community group assumed that the primary threat to terrestrial karst species is from human visitation to the sites where the species occurs. Impacts from human visitation can include trampling, collection of animals, disturbance, destruction of habitat, vandalism, introduction of pollutants, and others. A GIS model was developed using available GIS data to measure the relative risk of visitation (RVI) across sites.

Sites and Assessment Areas

All site points with known occurrences of terrestrial species were selected as a subset from the master occurrences GIS layer and were designated as the terrestrial site layer. A total of 18 sites were included for this analysis. For each site point, a GIS assessment area (AA) for calculating RVI indices was defined as a circular area with a 10-mile radius from the site. This visitation assessment area (VAA) was intended to describe the human activities and likelihood of visitation in proximity to the site.

Risk Model: Visitation (RVI)

As described earlier and shown in Figure 3, the terrestrial community threat model was based solely on the visitation risk model (RVI). The RVI model was developed with the assumption that the likelihood that a particular site will be visited is dependent on the proximate human population, the available access to the site, and the proximity of the site to a road. Therefore, RVI was comprised of three sub-models: population (RVIP), access (RVIA), and proximity (RVIX), as shown in Figure 4 below. Figure 4 also shows the indices that comprise each of these sub-models.

Visitation Sub-Model: Population (RVIP)

An index is the result of a specific GIS analysis. For example, the visitation sub-model for population (RVIP) is comprised of a single index called RVIP_01. RVIP_01 is based on a count of the total human population in the VAA for each site.

Data from the 2010 US Census were used to calculate RVIP_01. A "raw" index value was first calculated for each site which represented the human population count of the census blocks that occurred within the VAA. The raw values ranged from 6,615 people for a cave in a rural part of a county to 34,830 people for a site in a more urban area. Raw index values are referred to in GIS layers and tables accompanying this document with a "_R" as a suffix. The raw index in this example is RVIP_01_R.

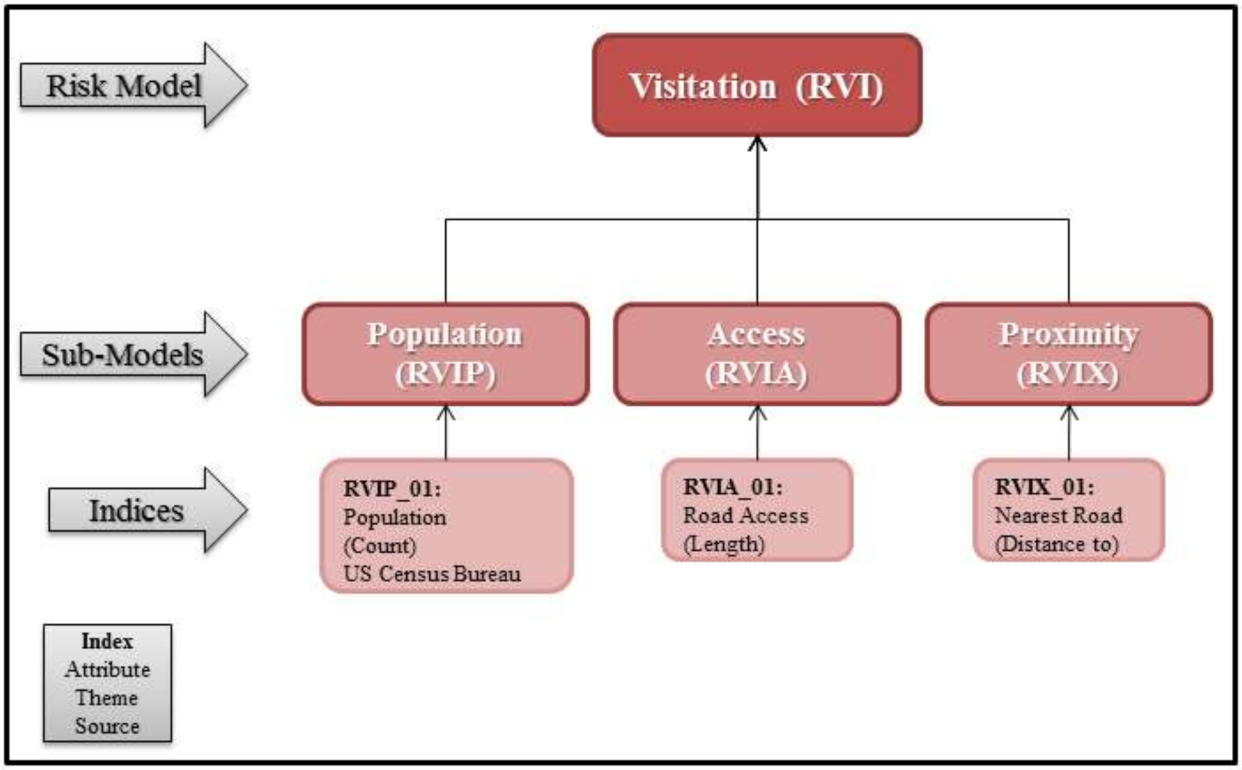

Figure 4. Visitation risk model schematic.

In the above example, and for all threat models, raw index values were re-scaled and normalized to have a maximum value of 1.0 and a minimum possible value of 0. Regardless of what attribute the index was measuring, the site with a final rescaled value of 1.0 indicated the best ecological condition for that index.

The process for rescaling an index included dividing the raw index value at each site by the highest raw value at any site. In the example above the result of this first rescaling calculation would give the urban site a 1.0 since it was the site with the highest raw value. The values for this index were inverted so the site with the lowest human population within the VAA would be assigned a 1.0. Final scaled index values are referred to in GIS layers and tables accompanying this document with a "_S" as a suffix. The scaled index in this example is RVIP_01_S. For more specific information about the modeling process and data sources for this and all other indices, see Appendix A.

Visitation Sub-Model: Access (RVIA)

The second sub-model comprising the Visitation risk model was developed to assess the likelihood of visitation based on the access (RVIA) that the proximate road network provides. RVIA was comprised of a single index, RVIA_01, which summarized the amount of roads within the VAA. See Appendix A for more information about this index.

Visitation Sub-Model: Proximity (RVIX)

The third sub-model comprising the visitation risk model was developed to assess the likelihood of visitation based on the proximity (RVIX) of the site to a road. The logic of the index is that the closer a site is to a road; the more likely it would be disturbed. RVIX was comprised of a single index, RVIX_01, which indicated the distance of the site to the nearest road. The assessment area was the site itself. See Appendix A for more information about this index.

Calculation of the Visitation Risk Model

Because the sub-models for the RVI risk model were each only comprised of a single index, the sub-model scores were the same as the index that they included. The raw RVI score was simply the summation of the RVIP, RVIA, and RVIX sub-models. The raw sum RVI_R was then rescaled from 0 to 1 to determine the final RVI_S score.

Calculation of the Terrestrial Community Threat Model

Because it is comprised solely of the RVI risk model, the terrestrial community threat model scores were calculated directly from the RVI_S score.

Bat Community Group

Bats use caves, crevices, and other karst sites as habitat. Visitation and disturbance by humans to these sites is a primary threat to multiple bat species. Bats also use forest and riparian lands near these sites to forage for food. As shown in Figure 3, the bat community threat model is based on both the visitation risk model (RVI) described above as well as the bat habitat risk model (RBH), which characterizes the condition of these foraging habitats.

Sites and Assessment Areas

All site points with known occurrences of bat species were selected as a subset from the master occurrences GIS layer and were saved separately as the bat site layer. A total of 64 sites were included for this analysis. For each site point, a GIS assessment area for calculating RVI indices was defined as a circular area with a 10-mile radius from the site (VAA), as described above for terrestrial sites. A bat foraging habitat assessment area (BAA) was also generated for assessing the indices of the RBH model. The BAA was defined as an area within a 5-mile radius to each point in the bat site layer.

Risk Model: Visitation (RVI)

The visitation risk model for bats was calculated using the same methodology as was used for terrestrial sites, described above. It was applied to the bat site layer.

Risk Model: Bat Habitat (RBH)

The bat habitat risk model (RBH) is shown in Figure 5. It was comprised of two sub-models: Forest (RBHF) and Riparian (RBHR).

Bat Habitat Sub-Model: Forest (RBHF)

RBHF consisted of two indices. RBHF_01 described the percent of the BAA that was in forested land use. In the model, it is assumed that a greater amount of forest is preferable for bats. RBHF_02 described the relative amount of forest edge in the BAA. In the model, it is assumed that a greater amount of forest edge is preferable for bats. See Appendix A for more information about these indices.

After RBHF_01 and RBHF_02 were initially calculated, their raw scores were scaled from a value of 0 to 1. These two scaled indices were summed to generate the raw RBHF score (RBHF_R), which was then also rescaled from 0 to 1 in the sub-model score RBHF_S.

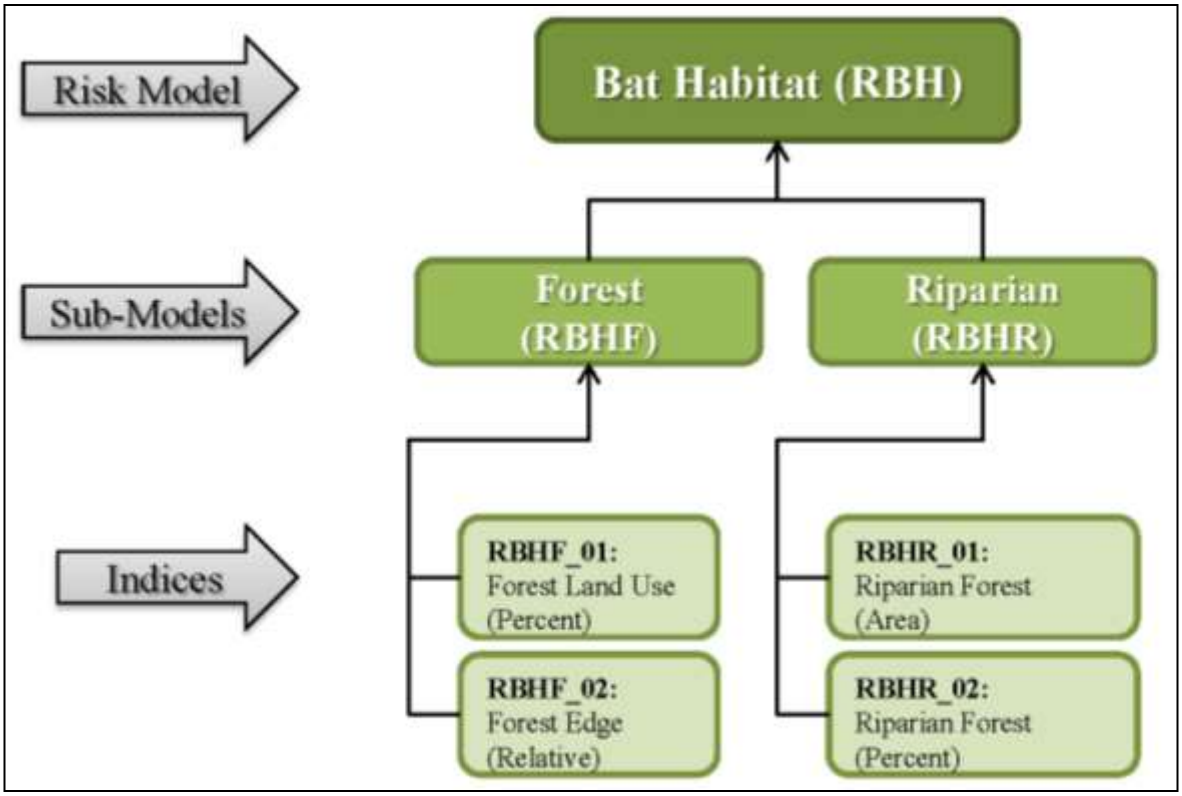

Figure 5. Bat habitat risk model schematic.

Bat Habitat Sub-Model: Riparian (RBHR)

Riparian forest is an important habitat for some bat species. RBHR accounted for the amount and condition of the riparian area within the BAA. The riparian area was defined as areas adjacent to water bodies, and was mapped in a raster GIS environment. Cells mapped as water in the land use / land cover layers were first selected. This captured water features including lakes, ponds, and larger streams and rivers. Streams mapped in the USGS high resolution National Hydrologic Dataset (NHD) were also rasterized. All analysis was run with a 30m raster cell size. The water cells from the LULC and NHD datasets were then buffered by an additional 30m cell. The results of this analysis yielded the riparian area for this project. The stream riparian area was as wide as three 30m cells because the stream was represented with one cell, and had another cell on each side. Lake and pond shorelines were one cell.

The indices for RBHR were calculated solely based on data falling within the riparian area described above. RBHR_01 described the total area of forested land use within the riparian area. RBHR_02 described the percent of the riparian area that was forested as opposed to other land use classes. See Appendix A for more information about these indices.

After RBHR_01 and RBHR_02 were initially calculated, their raw scores were scaled from a value of 0 to 1. These two scaled indices were summed to generate the raw RBHR score (RBHR_R), which was then also rescaled from 0 to 1 in the sub-model score RBHR_S.

Calculation of the Bat Habitat Risk Model

The raw RHB score was simply the summation of the scaled RBHF and RBHR sub-model scores. The raw sum RBH_R was then rescaled from 0 to 1 to determine the final RBH_S score.

Calculation of the Bat Community Threat Model

The bat community threat model score was a summation of the RBH risk model and the RVI risk model, as shown in Figure 3. Again, the two scaled values for RHB and RVI were summed and then rescaled from 0 to 1 to form the bat community threat model.

Aquatic Community Group

The threat assessment for the aquatic community group was the most complex of all three taxa groups. Similar to terrestrial and bat species, visitation to aquatic sites by humans was assumed to be a significant risk component of threat to aquatic species. However, because aquatic species are immersed in aquatic habitats for a portion or all of their life cycle, the water quality and quantity in these habitats is also a significant risk component. A water quality and quantity risk model (RWQ) was developed to characterize potential impacts from sediment, nutrients, pollutants, and hydrologic alteration, each of which was described with separate sub-models. Each of the sub-models was comprised of a variety of unique indices (), which address different measures of risk.

Risks to water quality and quantity are generated at the surface, but karst aquatic species primarily occur in subsurface habitats or spring runs that emerge from subsurface aquifers. Pollutants that enter surface waters are not delivered to subsurface aquifers uniformly.

Groundwater *vulnerability* describes the relative attenuation capacity of geologic materials between the land surface and saturated zone. Groundwater vulnerability mapping can be used as a guide in assessing which areas are more susceptible to groundwater contamination within a broader mapped area. Groundwater vulnerability mapping involves the simplification of complex geologic and hydrogeologic situations. For this effort, a groundwater vulnerability model was developed to characterize the attenuation of risks.

Groundwater *sensitivity* combines both the relative risk from surface human impact characteristics and the vulnerability that can attenuate the movement of risk factors through the subsurface to groundwater and subsurface habitats. For this effort, a groundwater sensitivity model was developed to determine how the risks are offset or augmented by vulnerability to ultimately impact the karst aquatic community.

Figure 3 shows all factors used to model threats to aquatic sites, including risk of visitation, risk to surface water quality and quantity, groundwater vulnerability, and groundwater sensitivity.

Sites and Assessment Areas

All site points with known occurrences of aquatic species were selected as a subset from the master occurrences GIS layer and were saved separately as the aquatic site layer. A total of 47 sites were included for this analysis. For each site point, a GIS assessment area for calculating RVI indices was defined as a circular area with a 10-mile radius from the site (VAA), as described above for terrestrial sites.

For each site point, a recharge assessment area (RAA) had to be delineated that estimated groundwater recharge for calculating risk, vulnerability, and sensitivity measures. For some sites, especially those harboring federal threatened or endangered species, dye traced recharge areas had already been determined through previous studies. A dye traced recharge area can be thought of as a watershed of a cave or an underground watershed. A dye traced recharge area is the best information that exists to delineate a subsurface drainage area and involves field work performing dye injection tests into sinking streams and identifying where the dye outflow exists from surrounding caves and springs. A total of 7 sites had dye traced recharge areas delineated previously, which were used as RAAs.

For sites without dye traced recharge areas, a topographic estimate of recharge area (TERA) was determined by selecting one or multiple contiguous USGS NHD Plus catchments that were likely to capture surface flow upstream of the site. This was determined by TNC karst and GIS staff. While it is acknowledged that using surface watersheds (NHD Plus catchments) wasn't entirely reflective of the underground hydrological regime, it was determined to be the best available data to define RAAs for non-dye traced sites with aquatic species for this project.

Risk Model: Visitation

The visitation risk model for the aquatic community group was calculated using the same methodology as was used for terrestrial sites, described above. It was applied to the aquatic site layer.

Risk Model: Surface Water Quality and Quantity (RWQ)

The surface water quality and quantity risk model (RWQ) is shown in Figure 6, below. It was comprised of four sub-models: Sediment (RWQS), Nutrients (RWQN), Pollutants (RWQP) and Hydrologic Alteration (RWQH). Readily available GIS layers were queried to estimate risks within each RAA. Figure 6 also shows the indices that comprise the RWQ sub-models.

Surface Water Sub-Model: Sediment (RWQS)

Sediment is a primary impairment in Ozark streams. Unpaved roads and non-forest land uses are common sources of sediment. The sediment sub-model accounts for sediment sources from unpaved roads and non-forested land-use types. RWQS_01 accounts for the total length of unpaved roads within the RAA. RWQS_02 accounts for the density of roads within the RAA. With the variation in the size of RAAs, it was important to account for both the total length of roads, and road density. RWQS_03 accounts for the total area of forested land-use (and therefore non-forested land use). See Appendix A for more information about these indices.

After all RWQS indices were initially calculated, their raw scores were scaled from a value of 0 to 1. These scaled indices were summed to generate the raw RWQS score (RWQS_R), which was then also rescaled from 0 to 1 in the sub-model score RWQS_S.

Surface Water Sub-Model: Nutrients (RWQN)

The Nutrients sub-model accounts for nutrient sources from rural septic systems, confined animal feed operations, and pasture land use. RWQN_01 counts the density of rural households in the RAA based on US Census data. The index assumes that a household outside of city limits will use a decentralized septic system. RWQN_02 and RWQN_03 characterize the count and density of CAFOs in the RAA. Though much nutrient material that is produced at CAFOs is transported and spread elsewhere, the index assumes that some nutrients produced at CAFOs will get into groundwater. RWQN_04 and RWQN_05 quantify the total area and percent of the RAA in pasture land use. It is assumed that some pastures will have cattle present, which will be a source of nutrients. It is also assumed that pastures that do not have cattle are likely to be fertilized for grass production, also a nutrient source. See Appendix A for more information about these indices.

After all RWQN indices were initially calculated, their raw scores were scaled from a value of 0 to 1. These scaled indices were summed to generate the raw RWQN score (RWQN_R), which was then also rescaled from 0 to 1 in the sub-model score RWQN_S.

Surface Water Sub-Model: Pollutants (RWQP)

The Pollutants sub-model accounts for additional pollutant sources associated with paved roads and highways, residential density, and facilities that have permitted discharges. RWQP_01 and RWQP_02 measure total paved road length and density, respectively. Paved roads, including highways, are a potential source for pollution for a few reasons. First, the risk of a chemical or fuel tanker spill is higher on these transportation corridors. Second, regular discharge and leaking of fuel and oil from vehicles is expected to be greater on paved roads. Roads and highways were weighted to account for greater surface area and traffic volume on highways. The weighting scheme is shown in Appendix A. RWQP_03 measures human population density, which is expected to account for some non-point pollution sources. RWQP_04 and RWQP_05 count the number and density of pollution point sources permitted by ADEQ. See Appendix A for more information about these indices.

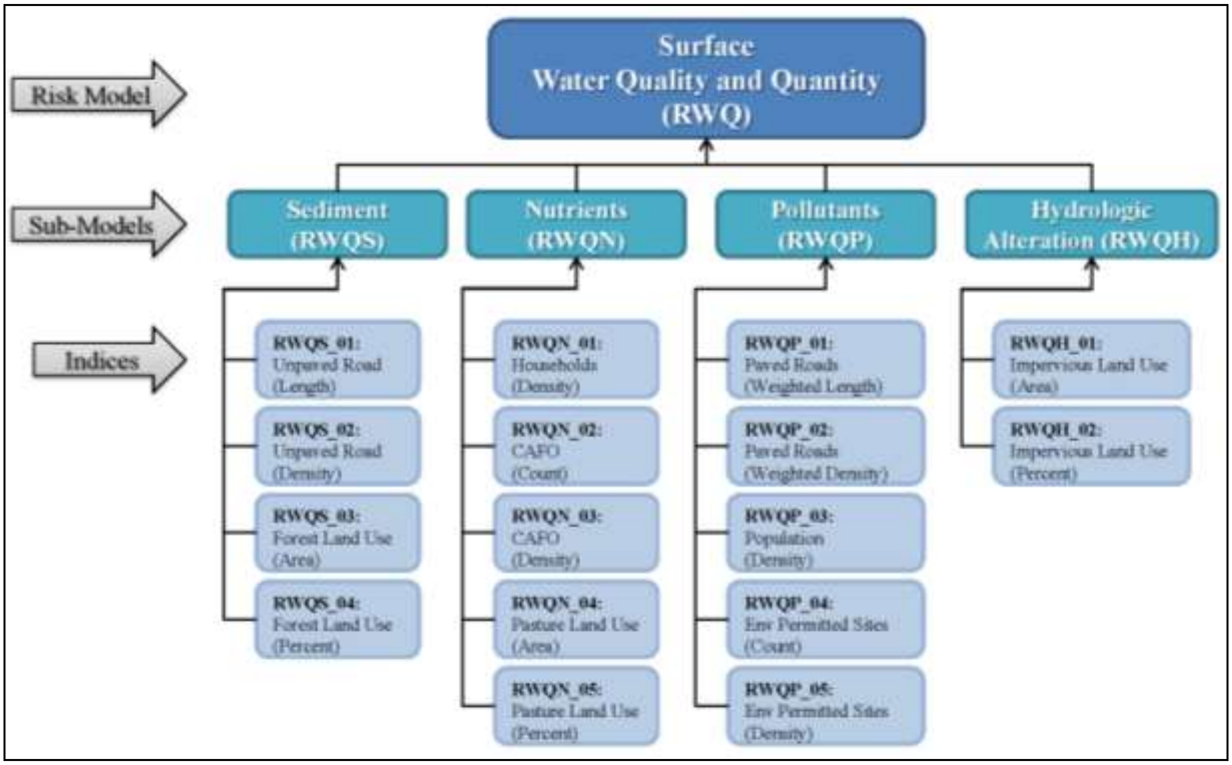

Figure 6. Surface water quality and quantity risk model schematic.

After all RWQP indices were initially calculated, their raw scores were scaled from a value of 0 to 1. These scaled indices were summed to generate the raw RWQP score (RWQP_R), which was then also rescaled from 0 to 1 in the sub-model score RWQP_S.

Surface Water Sub-Model: Hydrologic Alteration (RWQH)

The Hydrologic Alteration sub-model was intended to account for the impact of impervious surfaces on water quality, groundwater infiltration, and altered storm hydrograph. RWQH_01 and RWQH_02 account for total area and percent of the RAA with impervious surfaces. Impervious surfaces were mapped using urban and bare land uses, and paved roads. See Appendix A for more information about these indices.

After all RWQH indices were initially calculated, their raw scores were scaled from a value of 0 to 1. These scaled indices were summed to generate the raw RWQH score (RWQH_R), which was then also rescaled from 0 to 1 in the sub-model score RWQH_S.

Calculation of the Water Quality and Quantity (RWQ)

The raw RWQ score was simply the summation of the scaled RWQS, RWQN, RWQP and RWQH sub-model scores. The raw sum RWQ_R was then rescaled from 0 to 1 to determine the final RWQ_S score.

Groundwater Vulnerability Model: DRASTIK

Groundwater Vulnerability Model Selection

Groundwater vulnerability mapping can be used as a guide in assessing which areas are more susceptible to groundwater contamination within a broader mapped area. Groundwater vulnerability mapping involves the simplification of complex geologic and hydrogeologic situations and the attenuation capacity of the geologic materials between the land surface and saturated zone. Vulnerability maps are designed only as a guide and for relative comparisons and are not intended to replace specific site evaluations.

Several models exist for evaluating the vulnerability of groundwater, the models fall into one of two categories, “any aquifer” or “karst specific” models. The “any aquifer” models include DRASTIC, GOD, AVI, and SINTACS and have been mainly applied in porous aquifers. The “karst specific” models include EPIK, PI, and COP and were developed for the assessment of vulnerability in karst areas. Deciding which model to use depends on factors such as the type of aquifer, data availability, cost, and time. While EPIK, PI, and COP will all do a better job at mapping karst aquifers, the data needed to run these models includes spatial data on sinkholes, sinking streams, and other karst features.

In areas with low data availability, the DRASTIC method is a suitable model and methodology according to Foster and Hirata (1988). This method is relatively inexpensive and straightforward which makes it a popular approach in groundwater vulnerability mapping. According to Margane (2003), the model uses data that are commonly available or can be estimated to produce vulnerability maps that can be easily interpreted. A USGS publication also concurs by stating that “the index method is a popular approach to ground-water vulnerability assessments because it is relatively inexpensive, straightforward, and uses data that are commonly available or estimated, and produces an end product that is easily interpreted and incorporated into the decision-making process” (USGS 2002).

For this project, most karst spatial data were unavailable and prevented the utilization of one of these karst specific models. Therefore, DRASTIC was selected to assess groundwater vulnerability in the Ozarks in Oklahoma with slight modifications from its original design to better represent the landscape setting.

DRASTIC Model Background

The DRASTIC model was developed by the U.S. Environmental Protection Agency (US EPA) and is the most widely used index-based method for mapping groundwater vulnerability in porous aquifers. DRASTIC is a composite mapping technique designed to produce scores for different geographic locations and is an acronym for the seven hydrogeological factors considered in the method:

- D Depth to Water Table
- R (Net) Recharge
- A Aquifer Media
- S Soil Media
- T Topography (Slope)
- I Impact of Vadose Zone Media
- C Conductivity (Hydraulic) of Aquifer

Within each parameter, a rating is given between 1 and 10, with 10 being the highest degree of pollution vulnerability and 1 being the lowest degree of pollution vulnerability. The USGS states "the point rating system for DRASTIC was determined by the best professional judgment of the original method developers." (USGS 2002)

A weight is also given to each rating relative to each other in order of importance from 1 through 5. The most significant factors have weights of 5; the least significant have a weight of 1. These weights are allocated based on a parameter's contribution to the overall susceptibility of an area. Ratings for individual parameters were proposed in the DRASTIC EPA manual (Aller et al. 1987).

The DRASTIC Index (groundwater vulnerability) at any one location on the map is determined by the equation:

Vulnerability = DrDw + RrRw + ArAw + SrSw + TrTw + IrIw + CrCw
where r = rating and w = weight

In order to properly represent and overlay the multiple parameters within the DRASTIC methodology from a spatial context, a Geographic Information System (GIS) is generally used. The computed DRASTIC index identifies areas which are likely to be susceptible to groundwater contamination relative to one another. Similar hydrogeologic parameters produce similar vulnerability indices. The higher the DRASTIC index the greater the vulnerability to groundwater pollution. It must be remembered that the DRASTIC technique provides a relative evaluation tool and is not designed to provide absolute answers.

DRASTIC Model Modifications

Many modifications of the original DRASTIC model have been proposed by numerous authors in various locales throughout the world according to localized characteristics and data availability. Some of these modifications include adjusting the individual weights to emphasize or de-emphasize certain parameters, adding or removing parameters, or some combination of these procedures.

Piscopo (2001) used DRASTIC and GIS to produce a groundwater vulnerability map for the Castlereagh Catchment in Australia. In this study, the author excluded hydraulic conductivity (C) from the final DRASTIC calculation due to the lack of spatial data. Furthermore, the way the Recharge parameter (R) and Impact of vadose zone media (I) parameters were calculated was modified from how they were calculated by the US EPA. The author determined the recharge (R) parameter was more than simply a measure of rainfall; and additional environmental variables were summed together. The following equation was used to generate (R) taking into account three components:

Recharge value = Slope % + Rainfall + Soil permeability

The Impact on the vadose zone media (I) parameter was also determined by Piscopo (2001) to be more than only the geologic characteristics and was defined by the equation:

Impact of the Vadose Zone = Soil Permeability + Depth to Water Table

Lee (1996) modified DRASTIC in research in Korea because most of the aquifers there are developed in fractured rock causing groundwater to mainly move through the fault and fracture areas. Higher lineament density values may represent more potential to groundwater contamination. Therefore, by applying analysis of lineament density to the DRASTIC system, groundwater pollution susceptibility was assessed more accurately. Due to the importance of lineament density in this system, lineament density was assigned a weight of 5, the greatest value of DRASTIC system weights. The modified DRASTIC system index was calculated using the equation:

Modified DRASTIC index =
DRASTIC index + (Lineament density rating x weight = 5)

Davis et al (2001) proposed the KARSTIC method in research conducted in South Dakota, USA. This was a modification of the DRASTIC method that was designed specifically to apply to hydrogeologic properties in karst landscapes. The KARSTIC method uses nine parameters (summed into seven terms) including information on karst features such as sinkholes with surface recharge. To calculate the (K) parameter in this model, karst surface features were multiplied by fractures and other geologic structure because a greater degree of vulnerability can result from using a product.

Project Methodology

The DRASTIC model for this project was developed in a raster GIS environment in ArcGIS. The following modifications were made specific to the original DRASTIC model. Calculations of the (R) and (I) parameters were based on the methods and techniques described by Piscopo (2001). The Hydraulic Conductivity (C) parameter was excluded from the development of the DRASTIC index because detailed data were not available. A new parameter (K) was added to represent lineaments and faults in the study area. We termed our model *DRASTIK* to keep the model identity similar to the traditional model while also incorporating lineaments and the important role they play with groundwater a karst landscape.

Parameter ranges were based on a combination of sources including Hallman (1997), Klug (2009), Aller et al (1987), as well as by the Jenks classification method in ArcGIS using 10 classes. See Appendix B for specific parameter ranges.

A comprehensive collection of key datasets was compiled including SSURGO soils, USGS bedrock geology, a USGS water well database, Oregon State PRISM average rainfall data, USGS Faults, and a USGS DEM. To bring consistency to the varying scales of the input datasets, a constant scale was determined by the DEM (30 meters) and each of the layers was converted to a raster dataset in ArcGIS 10.2.1.

Each cell in the model output dataset is represented by a vulnerability value, which corresponds to the cumulative rating of all input parameters and weights. Model outputs were then classed based on their levels of vulnerability. Below is a description of each model parameter and the applied weights that were used. Figure 7 below shows the indices, data sources, and weights of the DRASTIK model.

DRASTIK Sub-Model: Depth to Water (D)

Represents the depth from the ground surface to the water table, deeper water table levels imply lesser chance for contamination to occur. This is an important feature because it determines the depth of material through which a contaminant must travel before reaching the water table. In general, attenuation capacity increases as the depth to water increases. This is because deeper water levels result in a longer travel time of a contaminant. Model weight: 5.

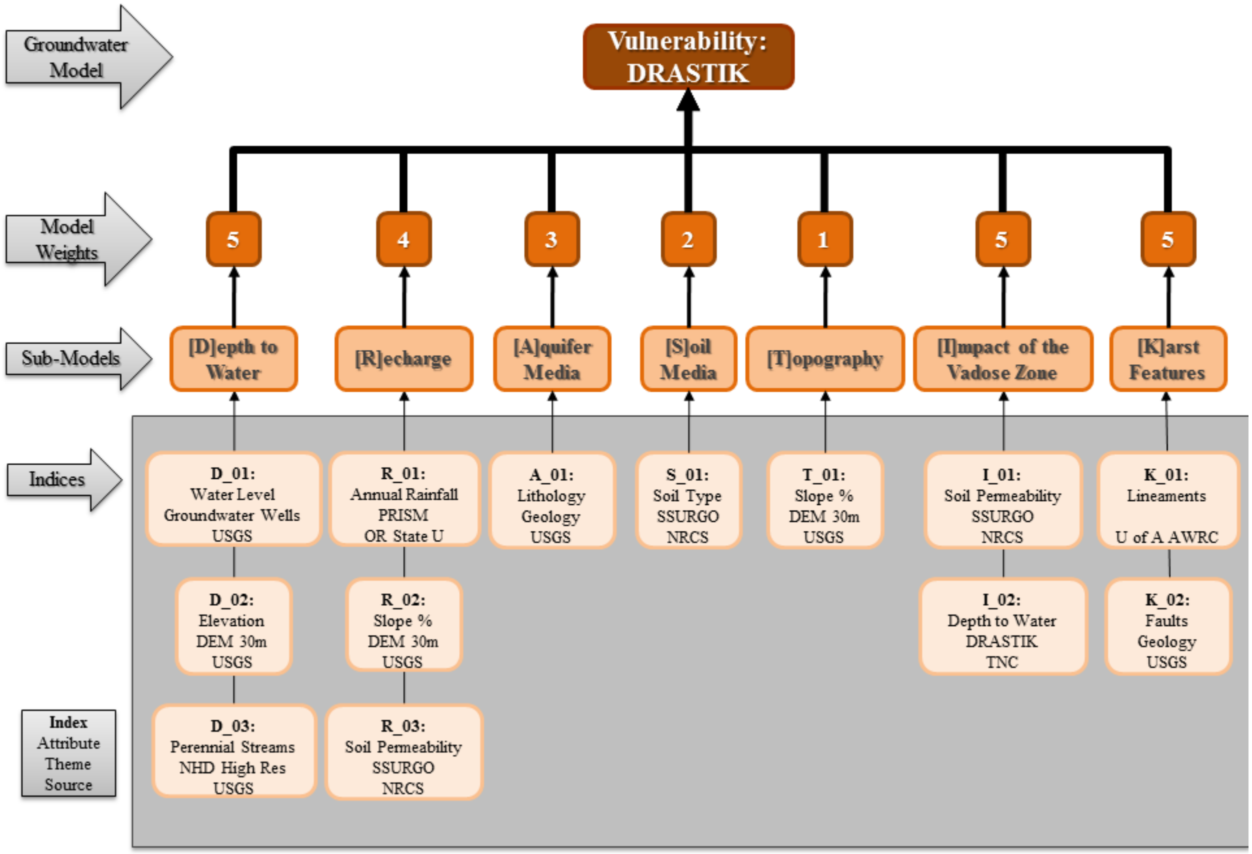

Figure 7. Schematic of DRASTIK groundwater vulnerability model.

DRASTIK Sub-Model: Recharge (R)

Represents the amount of water which penetrates the ground surface and reaches the water table, recharge water represents the vehicle for transporting pollutants. In general, the greater the recharge, the greater the potential for groundwater pollution. The components incorporated in the recharge feature for the Ozarks of Oklahoma were slope, rainfall, and soil permeability. Model weight: 4.

DRASTIK Sub-Model: Aquafer Media (A)

Refers to the saturated zone material properties, which controls the pollutant attenuation processes. Aquifer medium governs the route and path length within the aquifer. The route which a contaminant will take can be strongly influenced by fracturing, porosity, or by an interconnected series of openings which may provide preferential pathways for groundwater flow. For the Ozarks of Oklahoma, the aquifer media was defined by its geology type. Model weight: 3.

DRASTIK Sub-Model: Soil Media (S)

Represents the uppermost weathered portion of the unsaturated zone and controls the amount of recharge that can infiltrate downward into the water table. Soil media can be described in terms of its textural classification and ranked in order of pollution potential. For the Ozarks of Oklahoma, a soil permeability class "ksat_r" was used from the SSURGO dataset. This map was suitable to be used for the soil media vulnerability feature map, as well as a component map for the development of the impact of Vadose Zone media map. Model weight: 2.

DRASTIK Sub-Model: Topography (T)

Refers to the slope of the land surface, it dictates whether the runoff will remain on the surface to allow contaminant percolation to the saturated zone. Slopes that provide a greater opportunity for contaminants to infiltrate will be associated with higher groundwater pollution potential. Topography influences soil development and therefore has an effect on contaminant attenuation. Slope in percentage was calculated using Digital Elevation Model (DEM) data for the Ozarks of Oklahoma. Slope was then classified and ranked for use in the topography component map. Model weight: 1.

DRASTIK Sub-Model: Impact of the Vadose Zone (I)

Represents the unsaturated zone material above the water table. It controls the passage and attenuation of the contaminant to the saturated zone. The type of Vadose Zone media determines the attenuation characteristics of the material including the typical soil horizon and rock above the water table. The factors considered important in defining the impact of Vadose Zone in the Ozarks of Oklahoma include soil permeability and depth to the water table. Model weight: 5.

DRASTIK Sub-Model: Karst Features (K)

Lineaments are geological structures such as fractures and joints. The lineament is closely related to groundwater flow and contaminants migration. Higher lineament density values may represent more potential to groundwater contamination. Model weight: 5. (REPLACED "C" PARAMETER)

Calculation of the Groundwater Vulnerability Model: DRASTIK

The weightings used for parameters (D) (R) (A) (S) (T) and (I) was based on those in the original DRASTIC weighting method proposed by Aller et al (1987). The weighting for the (K) parameter was based on published literature from Mendoza (2006), Lee (1996), and Davis (2001).

The raw DRASTIK score at each aquatic site was rescaled from 0 to 1 to determine the scaled DRASTIK score for further analysis of threat.

Calculation of the Groundwater Sensitivity Model: RWQ + DRASTIK

Groundwater sensitivity is a function of both the surface risk factors, and the vulnerability, which characterizes the degree to which a system is susceptible to, or unable to cope with adverse risks. Assessment of groundwater vulnerability led to the creation of the DRASTIK layer. This layer is dependent on the physical hydrogeologic conditions found in a specific environment and is essentially independent of the land use. This data can be used by itself to help identify the potential areas in the Ozarks of Oklahoma where groundwater is highly vulnerable to contamination and areas that are susceptible to degradation and need further site specific investigation.

For the purpose of determining groundwater sensitivity at aquatic sites, the scaled score RWQ_S and the scaled DRASTIK scores were summed. The raw sum for groundwater sensitivity was then rescaled from 0 to 1.

Calculation of the Aquatic Community Threat Model

The raw aquatic community threat score was simply the summation of the RVI and groundwater sensitivity. The raw sum of these two scores was then rescaled from 0 to 1 to determine the final aquatic community threat score.

E.1. RESULTS

Based on 216 occurrence records at 94 sites, species range maps and threat assessment scores were generated for 28 species (Figures 9-36). A literature review determined that the species, *Bactrurus hubrichti*, which is listed in Oklahoma Comprehensive Wildlife Conservation Strategy as occurring in the Ozark Ecoregion, is not known from this region of Oklahoma. *Bactrurus hubrichti* is known from several sites in the Osage Cuestas of the Central Irregular Plains (Koenemann and Holsinger 2001). A distribution map was not created for *B. hubrichti*, and threats were not evaluated for this species. Several species were added in order to cover the complete karst-limited fauna found in the Ozarks of Oklahoma: *Caecidotea steevesi*, *Dendrocoelopsis americana*, *Hesperochernes occidentalis*, *Porrhomma cavernicola*, *Spelobia tenebrarum*, *Speleonycta ozarkensis*, *Stygobromus alabamensis*, and *Stygobromus onondagaensis*. These species were not included in the Oklahoma Comprehensive Wildlife Conservation Strategy, but are an important component of the karst-limited fauna found in the Ozarks of Oklahoma.

Many of the species (n=22) are known from less than 10 sites in Oklahoma (Table 2). The Ozark Big-eared Bat (*Corynorhinus townsendii ingens*) had the highest number of occurrences at 51; however, these sites include both essential use sites (consistently used by the species) and limited use sites (occasionally used or suspected of being used by the species). Most of the 51 sites are designated as limited use sites and may be used occasionally by Ozark Big-eared Bats during different seasons.

Limited use sites are important sites during the summer for solitary males and in the spring/fall months during migration between maternity and hibernation caves. The Ozark salamander (*Plethodon angusticlavius*) was reported from a single cave; however, the species is likely more common than cave records suggest since it also occurs in cool, damp habitats outside of caves. No attempt was made to determine the number of surface records for this salamander. Six species are endemic to caves in the Oklahoma Ozarks: *Caecidotea mackini*, *Cambarus subterraneaus*, *Cambarus tartarus, Pygmarrhopalites jay, Stygobromus bowmani, Trigenotyla blacki*. An additional 15 species are Ozark endemics with populations occurring in Arkansas and Missouri (Elliott 2007, Graening et al. 2012). The remaining seven species (*Dendrocoelopsis americana, Myotis grisescens, Myotis sodalis, Myotis septentrionalis, Porrhomma cavernicola, Spelobia tenebrarum,* and *Stygobromus alabamensis*) have additional populations that occur outside of the Ozarks.

Phylum Platyhelminthes
Order Tricladida
Family Dendrocoelidae

Dendrocoelopsis americana
(Hyman 1939) (Figure 8)

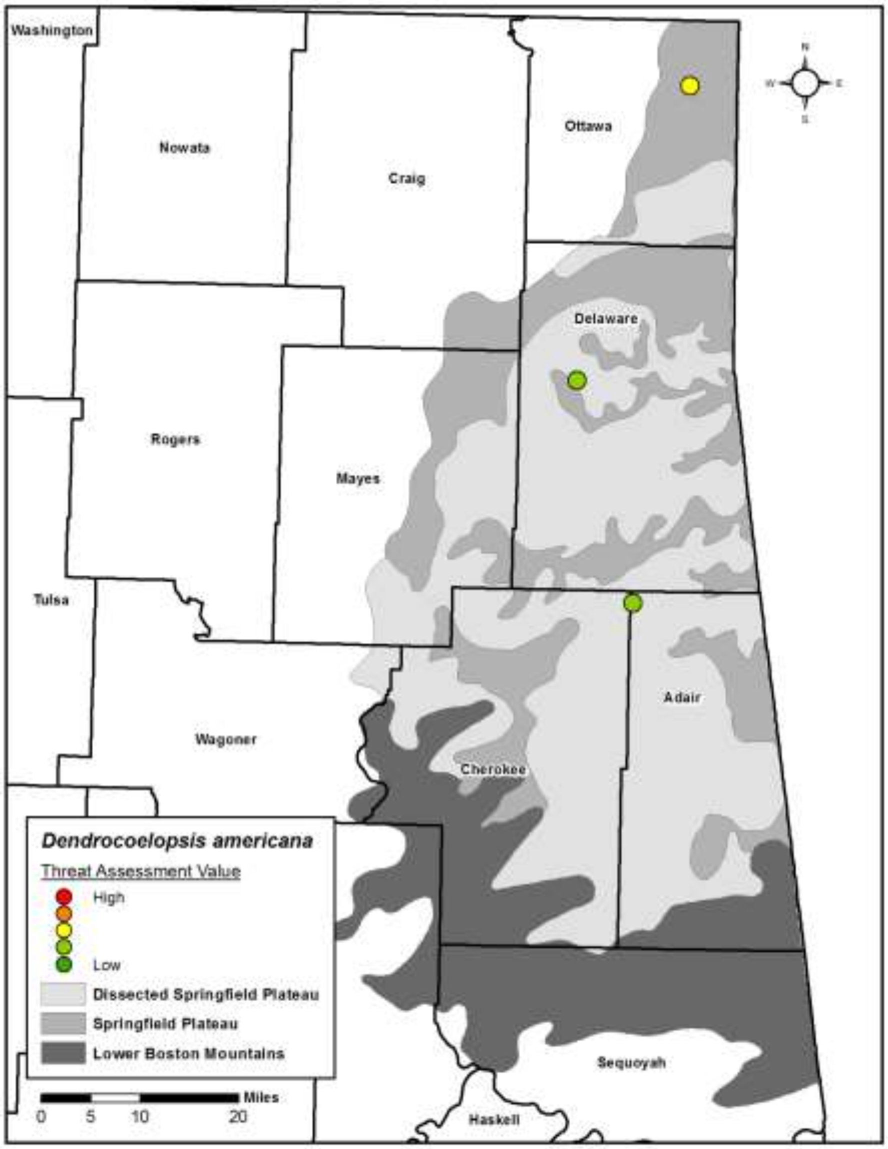

Figure 8. Distribution of *Dendrocoelopsis americana* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Phylum Arthropoda
Class Malacostraca
Order Amphipoda
Family Crangonyctidae

Stygobromus alabamensis
(Stout 1911) (Figure 9)

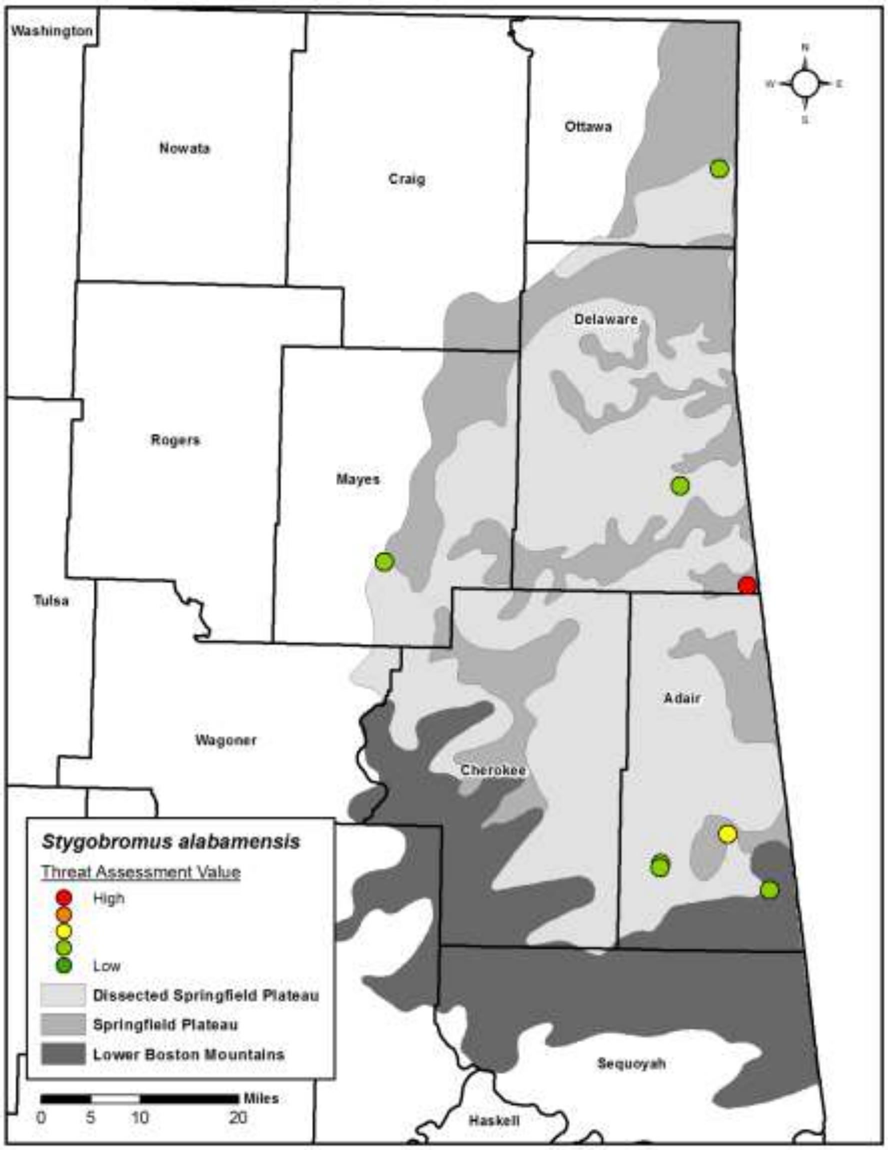

Figure 9. Distribution of *Stygobromus alabamensis* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Phylum Arthropoda
Class Malacostraca
Order Amphipoda
Family Crangonyctidae

Stygobromus bowmani
(Holsinger 1967) (Figure 10)

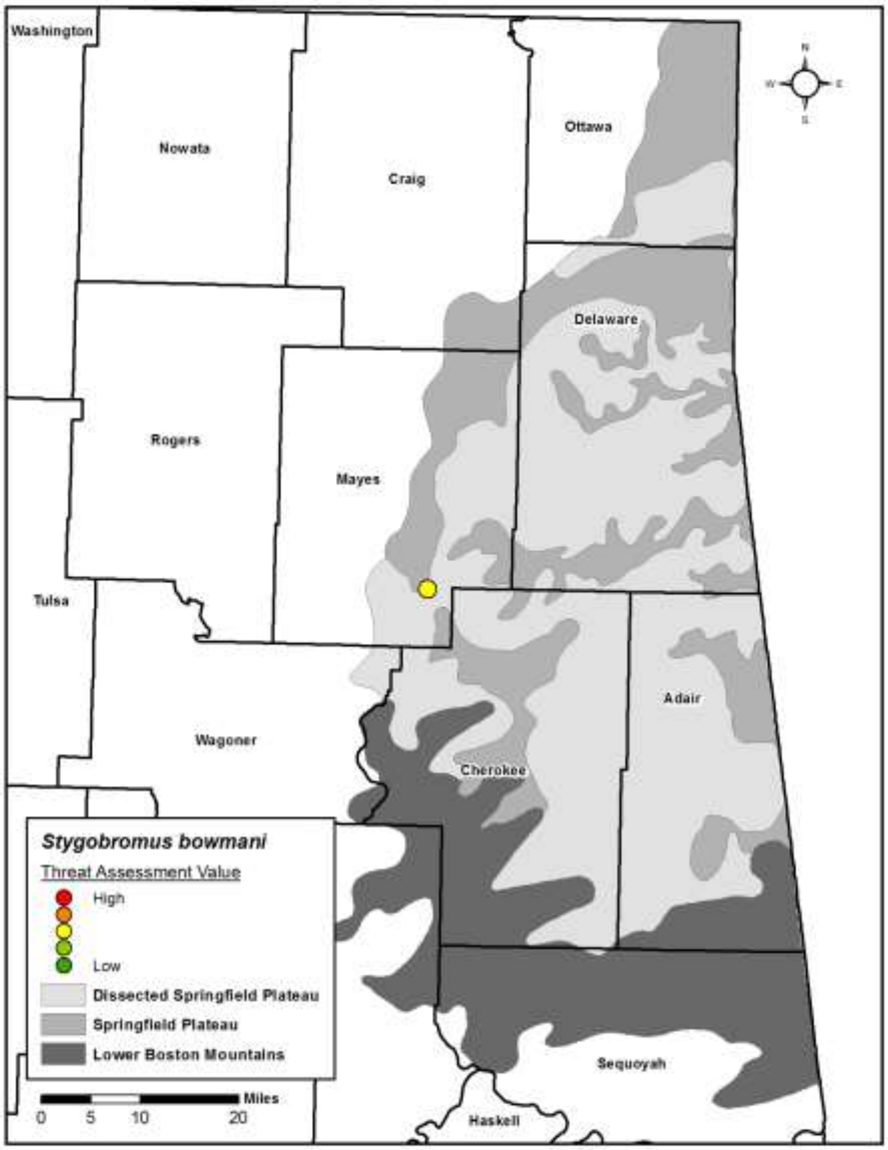

Figure 10. Distribution of *Stygobromus bowmani* in Oklahoma and associated threat assessment value for the occupied site. Ozark Ecoregion is shown as the shaded region.

Phylum Arthropoda
Class Malacostraca
Order Amphipoda
Family Crangonyctidae

Stygobromus onondagaensis
(Hubricht and Mackin 1940) (Figure 11)

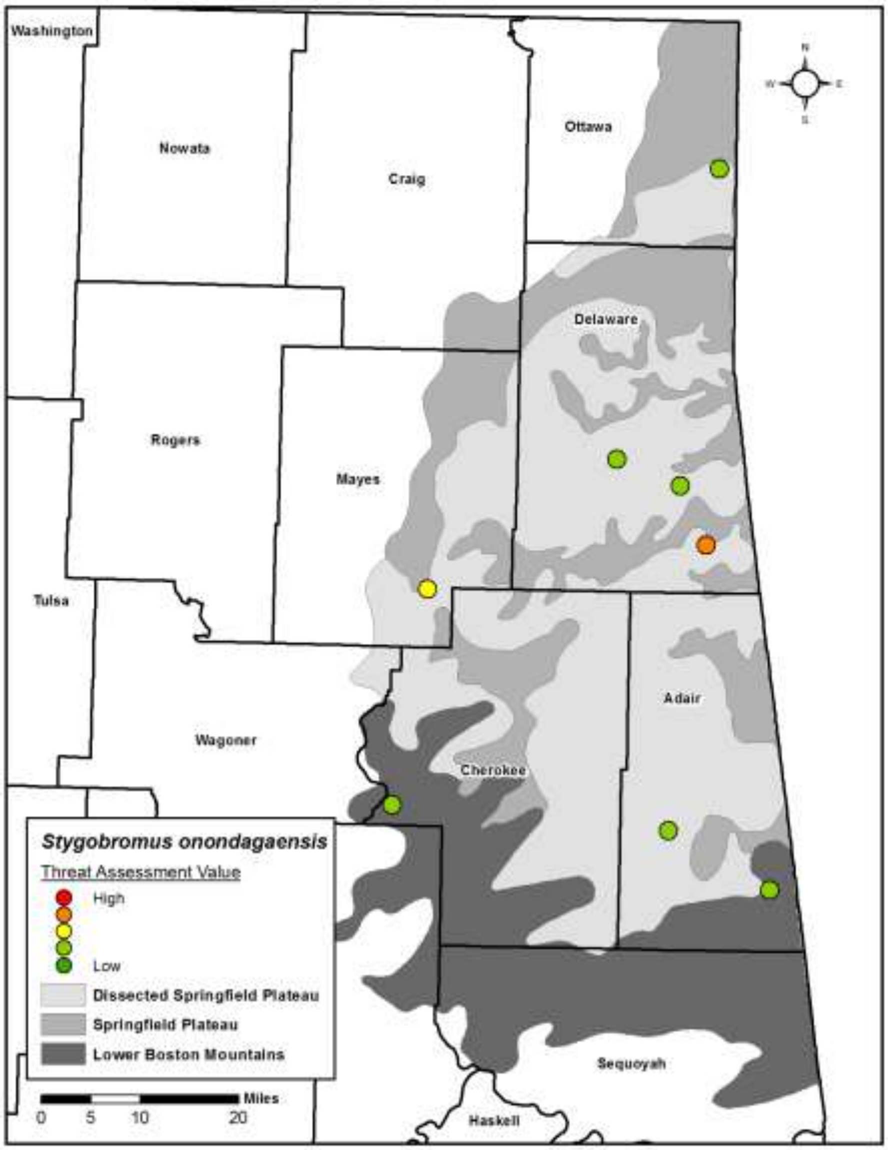

Figure 11. Distribution of *Stygobromus onondagaensis* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Phylum Arthropoda
Class Malacostraca
Order Amphipoda
Family Crangonyctidae

Stygobromus ozarkensis
(Holsinger 1967) (Figure 12)

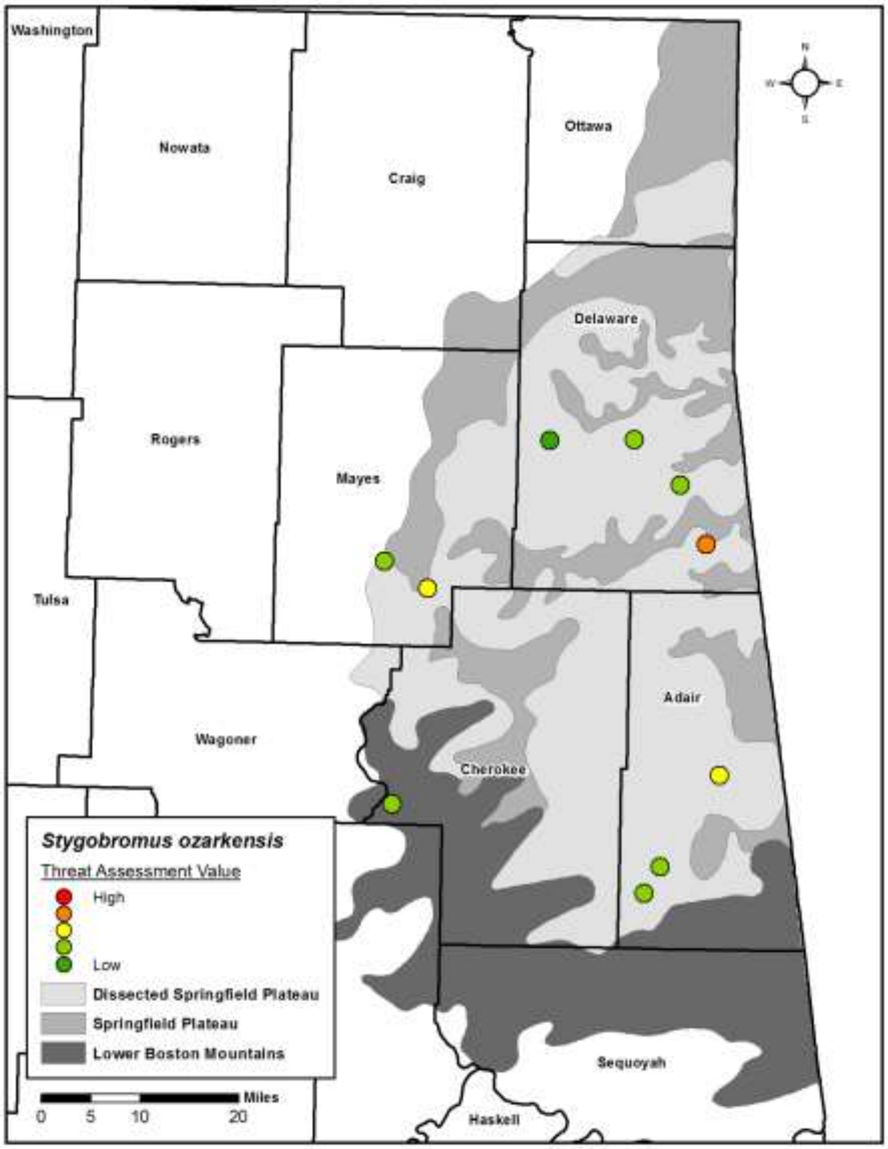

Figure 12. Distribution of *Stygobromus ozarkensis* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Order Isopoda
Family Asellidae

Caecidotea ancyla
(Fleming 1972) (Figure 13)

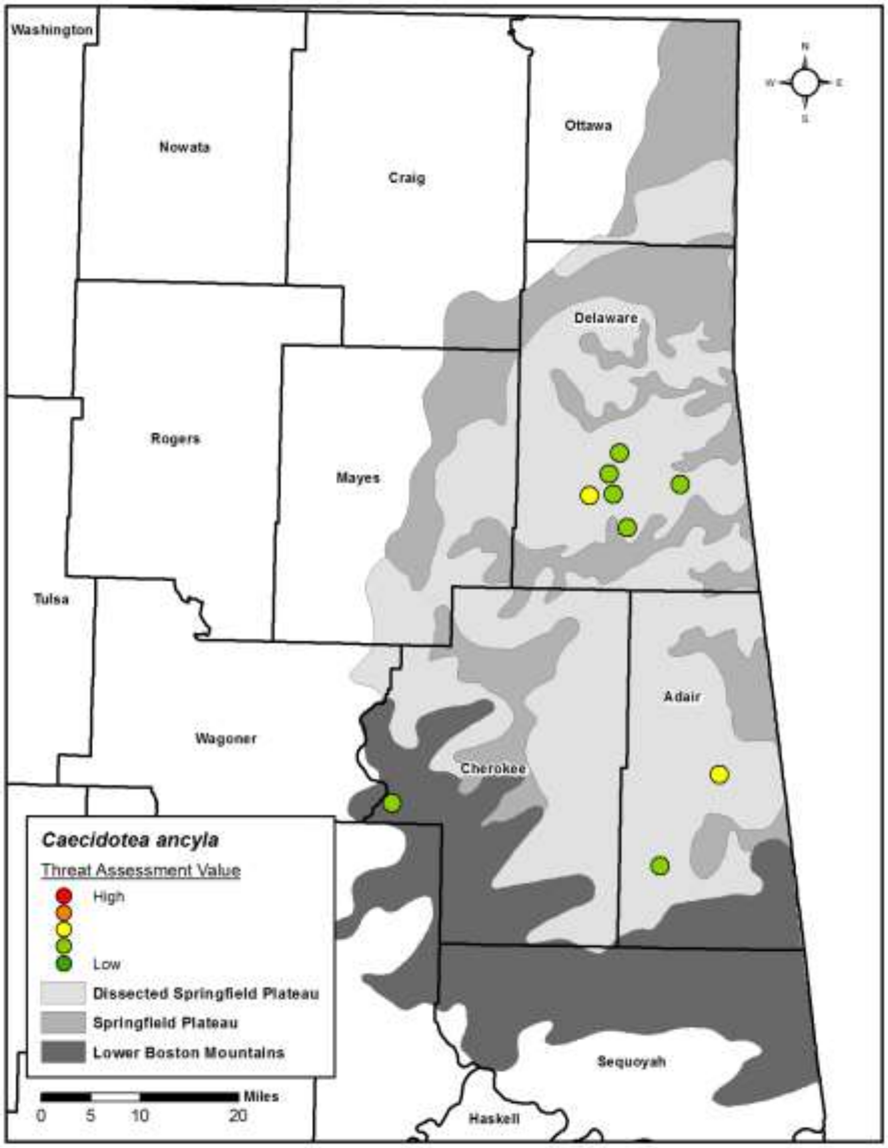

Figure 13. Distribution of *Caecidotea ancyla* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Order Isopoda
Family Asellidae

Caecidotea antricola
Creaser 1931 (Figure 14)

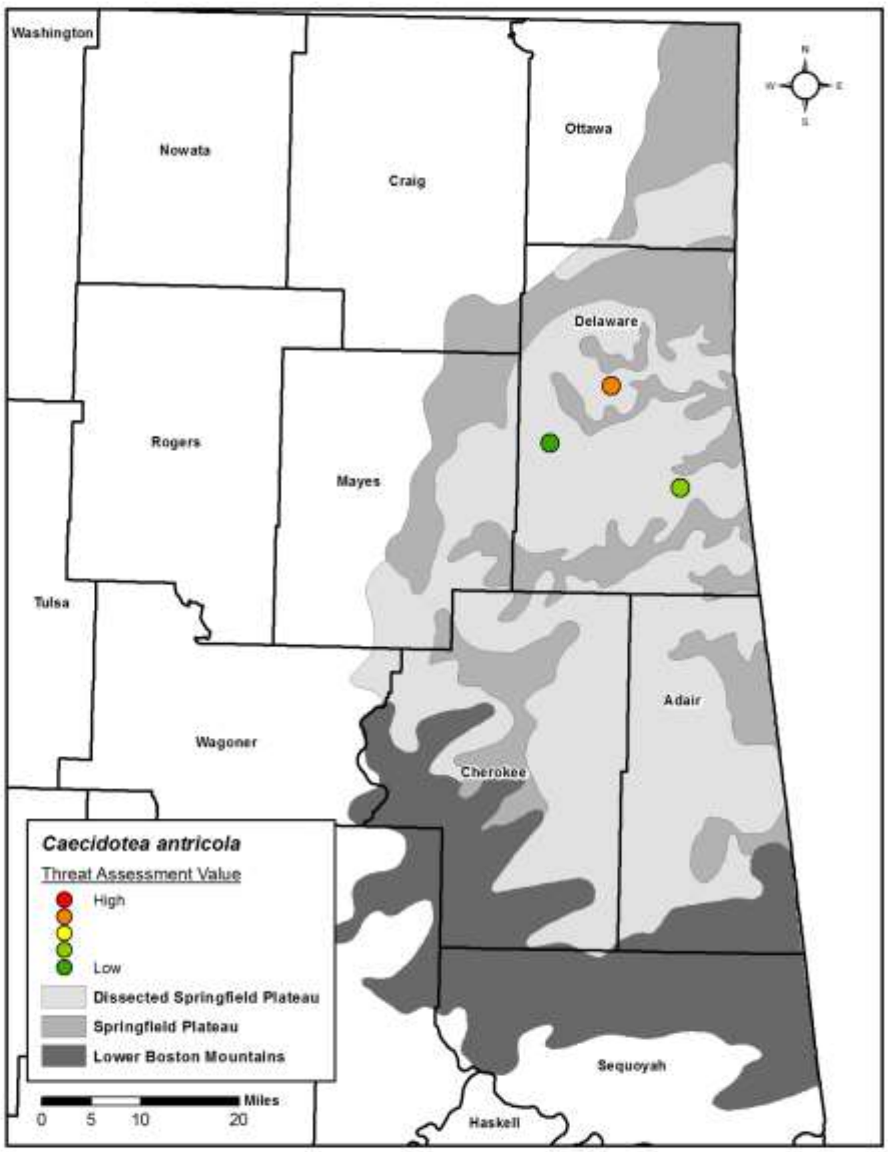

Figure 14. Distribution of *Caecidotea antricola* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Order Isopoda
Family Asellidae

Caecidotea mackini
Lewis 2006 (Figure 15)

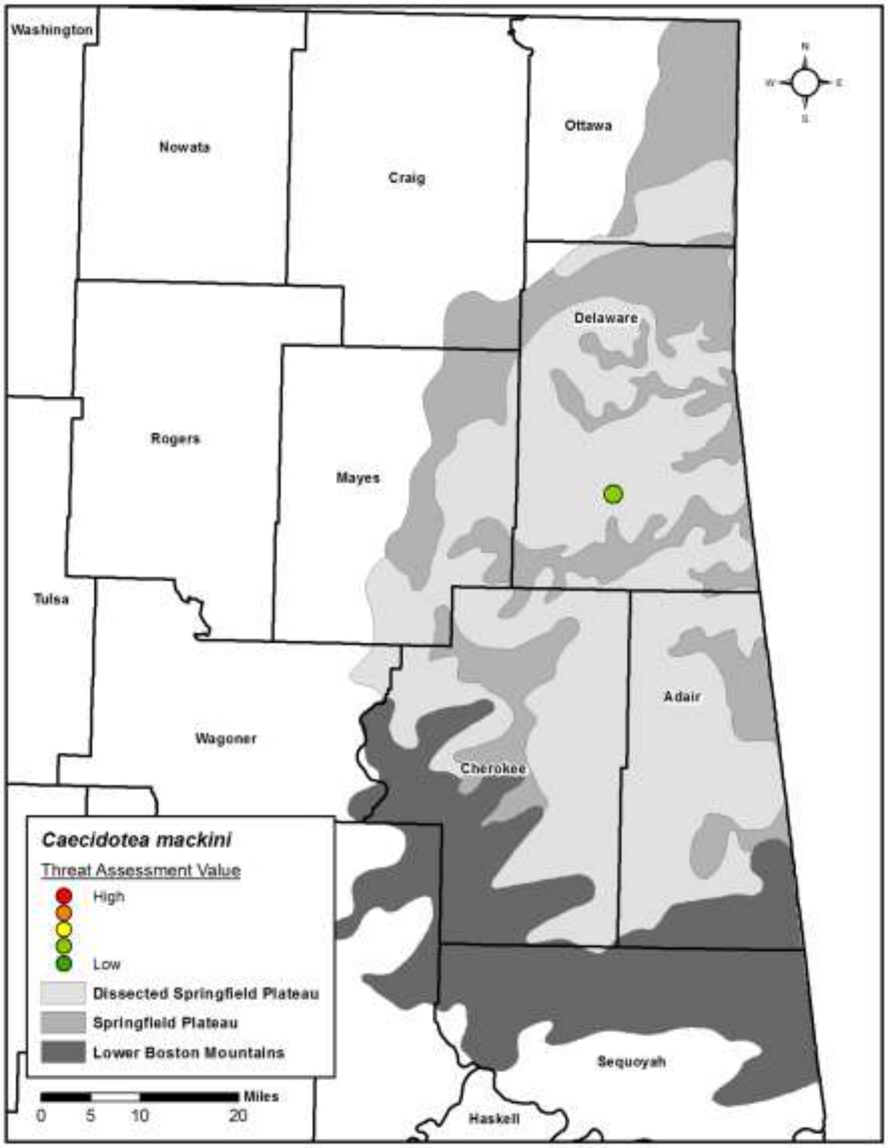

Figure 15. Distribution of *Caecidotea mackini* in Oklahoma and associated threat assessment value for the occupied site. Ozark Ecoregion is shown as the shaded region.

Order Isopoda
Family Asellidae

Caecidotea macropropoda
Chase and Blair 1937 (Figure 16)

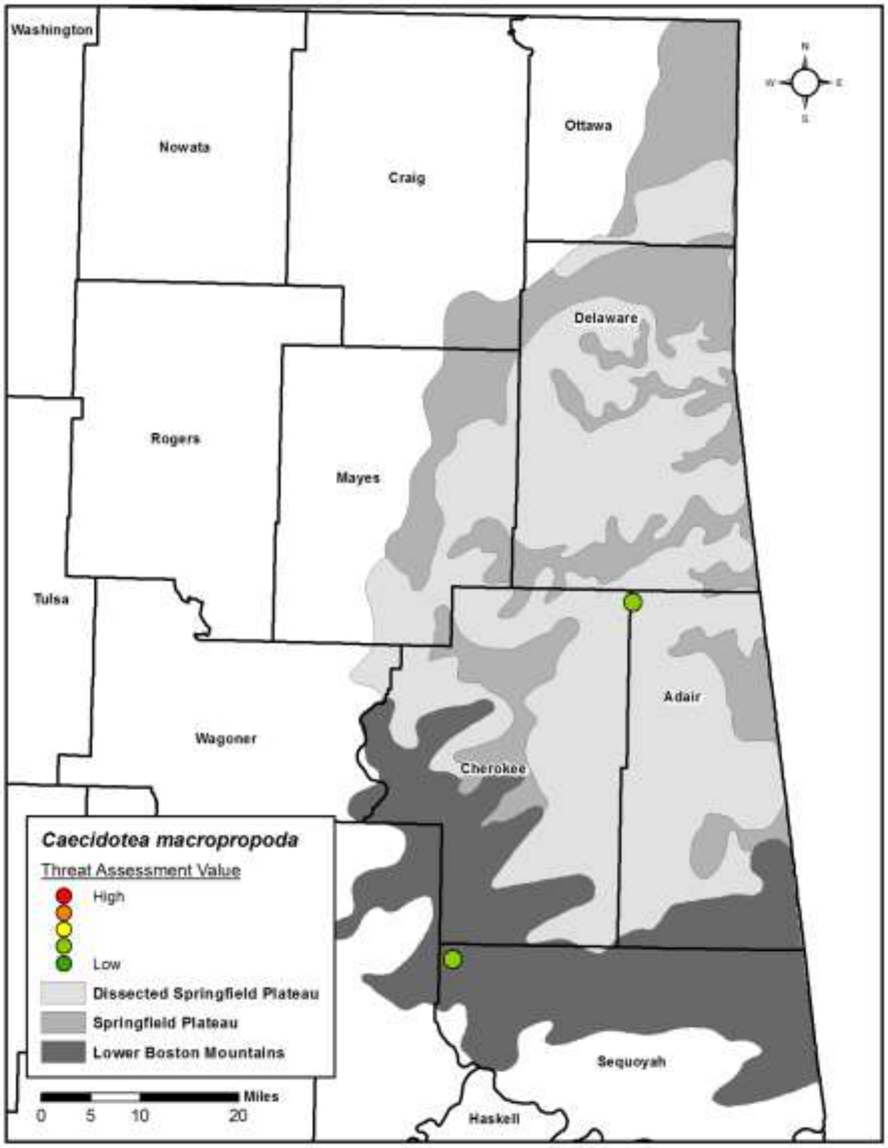

Figure 16. Distribution of *Caecidotea macropropoda* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Order Isopoda
Family Asellidae

Caecidotea simulator
Lewis 1999 (Figure 17)

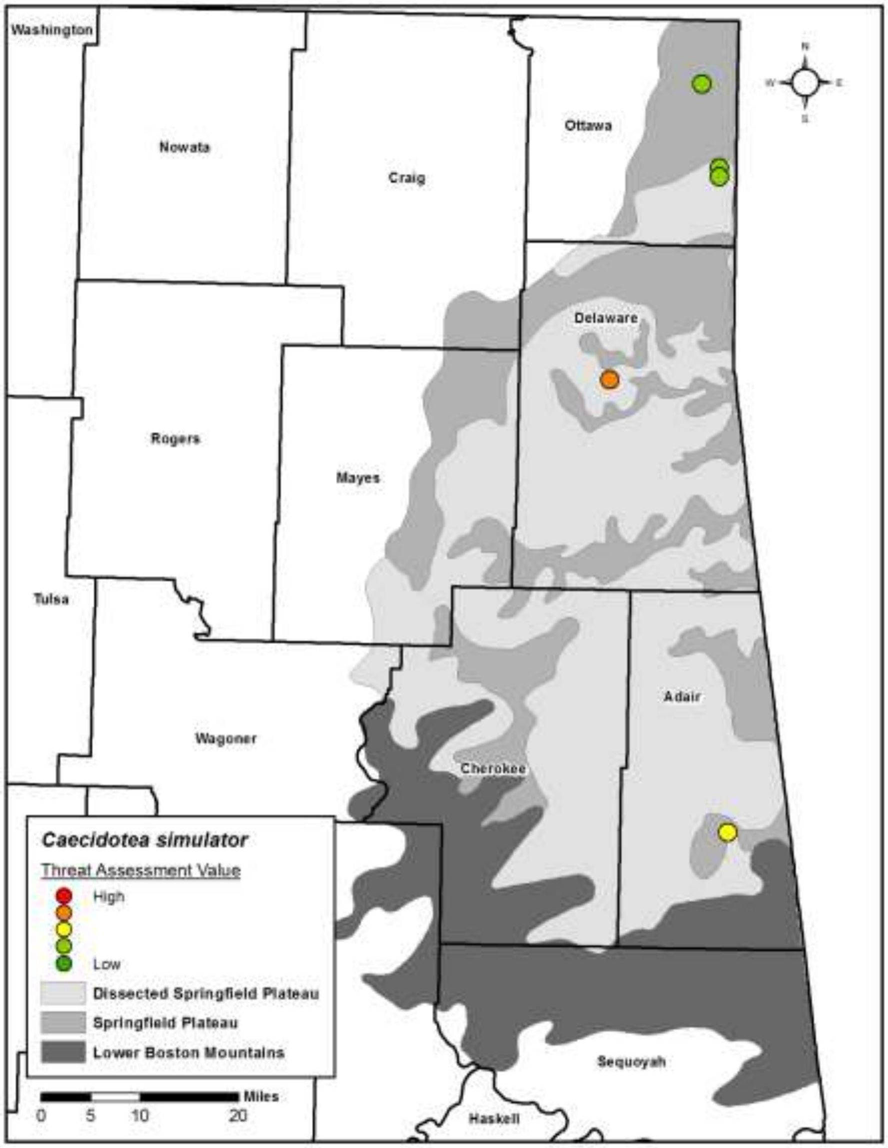

Figure 17. Distribution of *Caecidotea simulator* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Order Isopoda
Family Asellidae

Caecidotea steevesi
(Fleming 1972) (Figure 18)

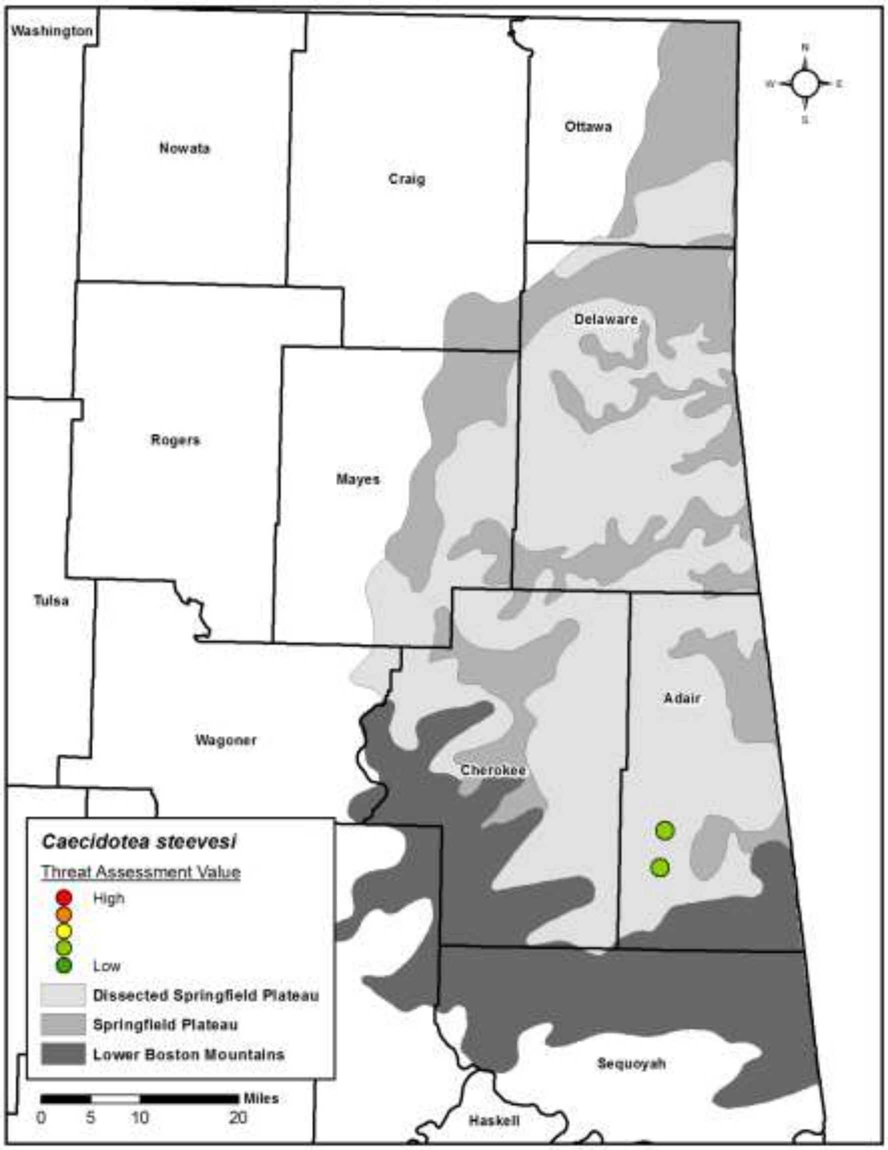

Figure 18. Distribution of *Caecidotea steevesi* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Order Isopoda
Family Asellidae

Caecidotea stiladactyla
Mackin and Hubricht 1940 (Figure 19)

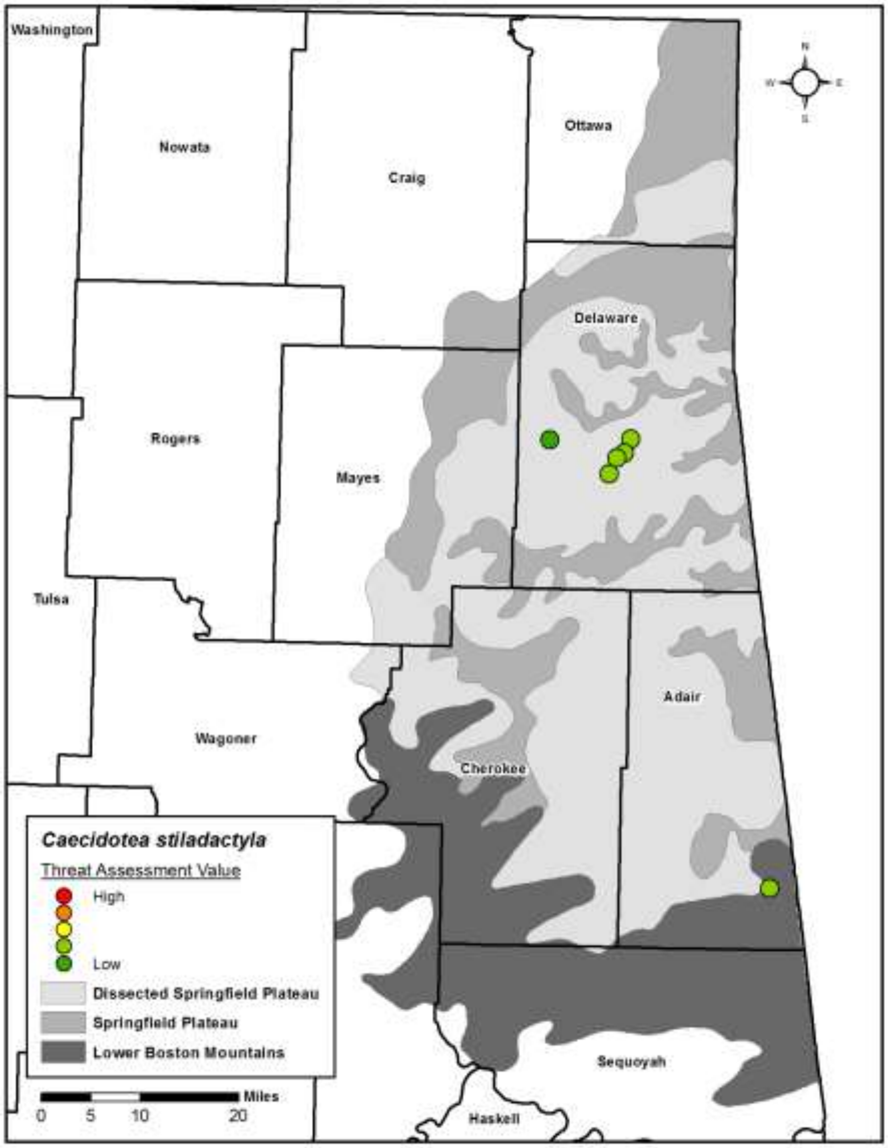

Figure 19. Distribution of *Caecidotea stiladactyla* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Order Decapoda
Family Cambaridae

Cambarus subterraneus
Hobbs III 1993 (Figure 20)

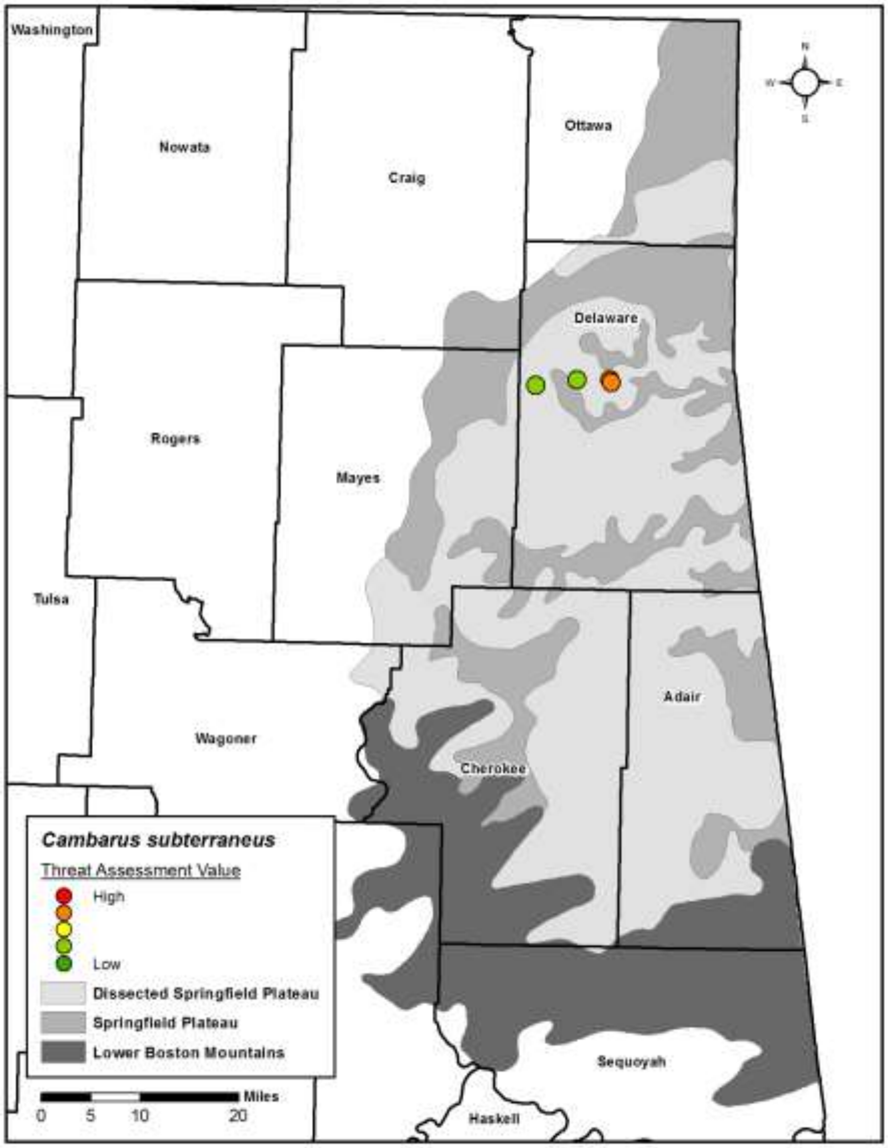

Figure 20. Distribution of *Cambarus subterraneus* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Order Decapoda
Family Cambaridae

Cambarus tartarus
Hobbs Jr and Cooper 1972 (Figure 21)

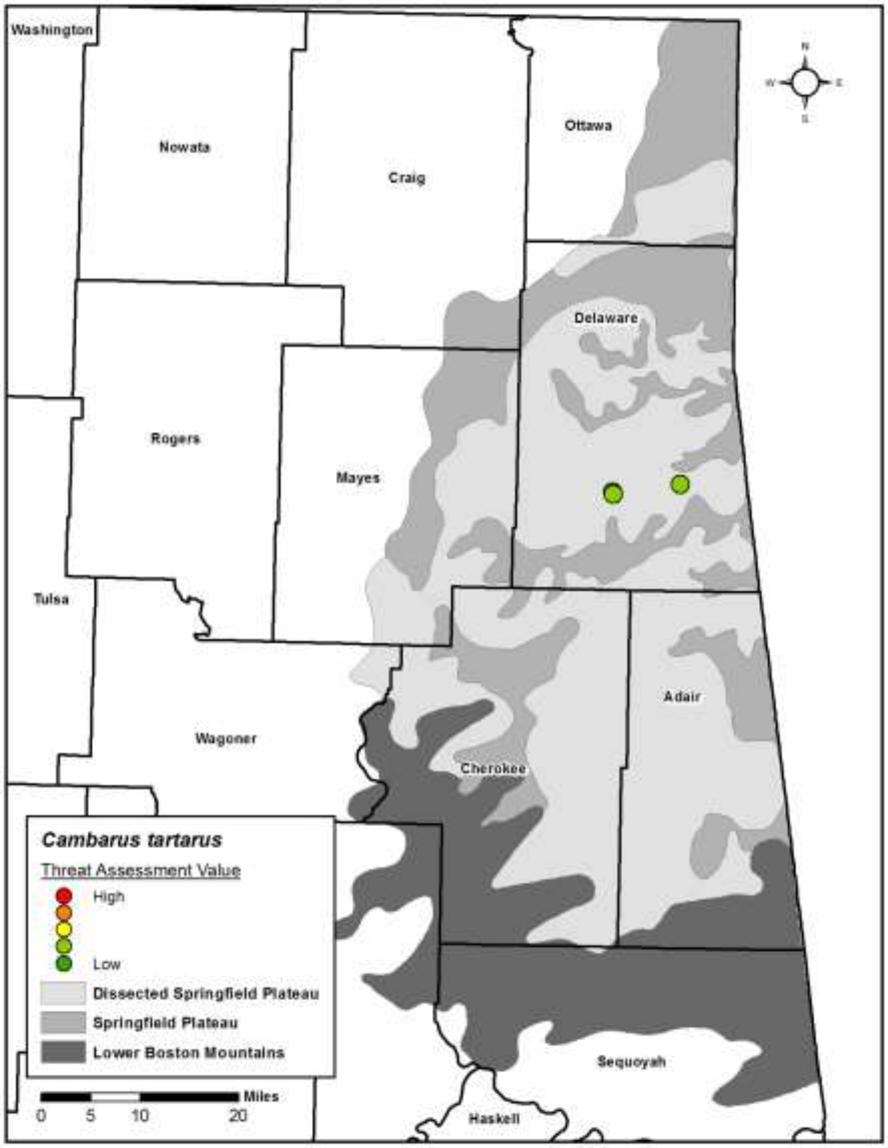

Figure 21. Distribution of *Cambarus tartarus* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Class Arachnida
Order Pseudoscorpionida
Family Chernitidae

Hesperochernes occidentalis
(Hoff and Bolsterli 1956) (Figure 22)

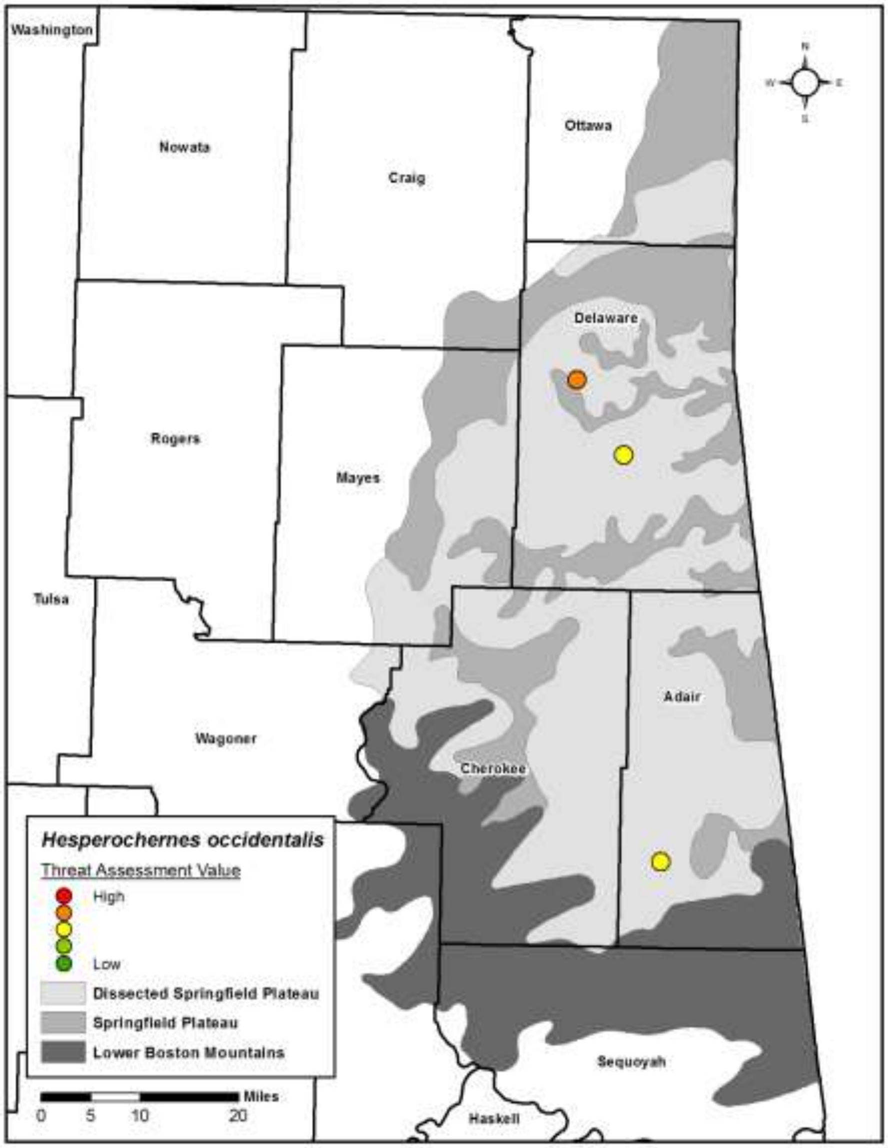

Figure 22. Distribution of *Hesperochernes occidentalis* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Class Arachnida
Order Araneae
Family Linyphiidae

Porrhomma cavernicola
(Keyserling 1886) (Figure 23)

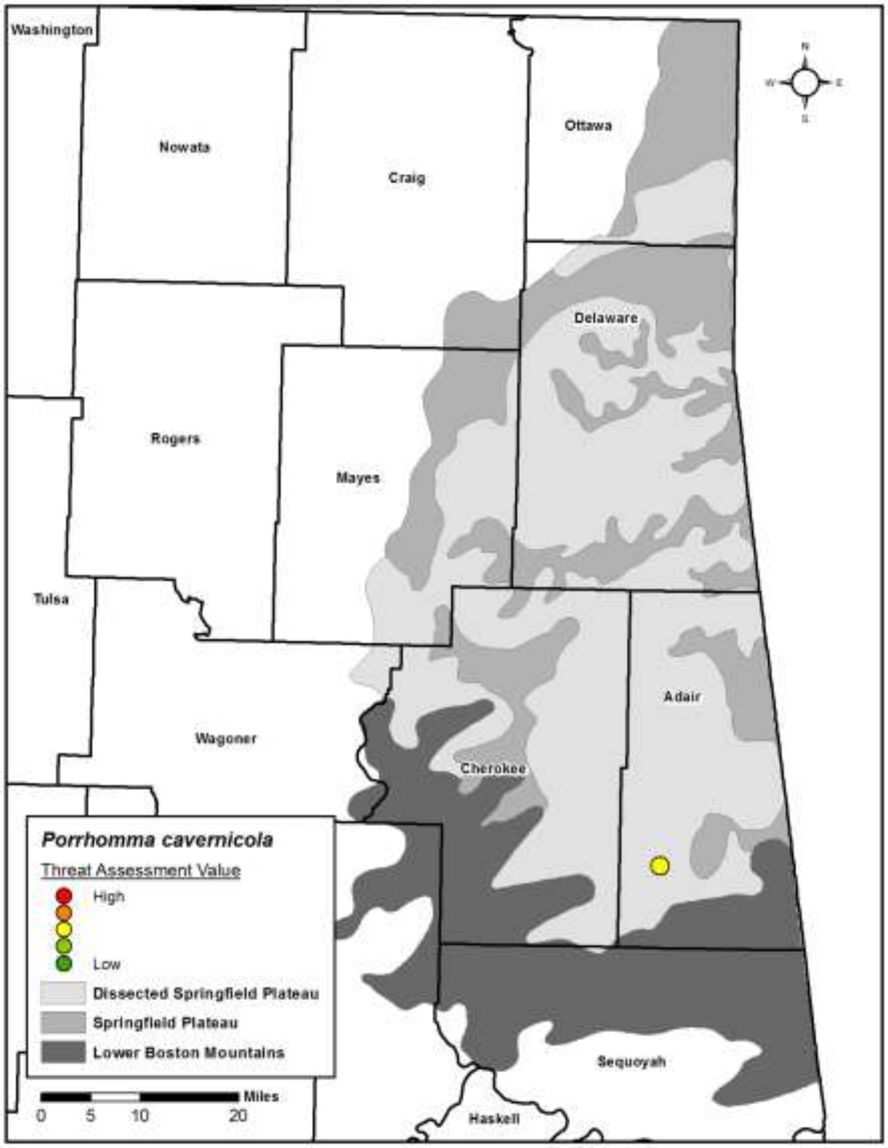

Figure 23. Distribution of *Porrhomma cavernicola* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Class Diplopoda
Order Chordeumatida
Family Trichopetalidae

Trigenotyla blacki
Shear 2003 (Figure 24)

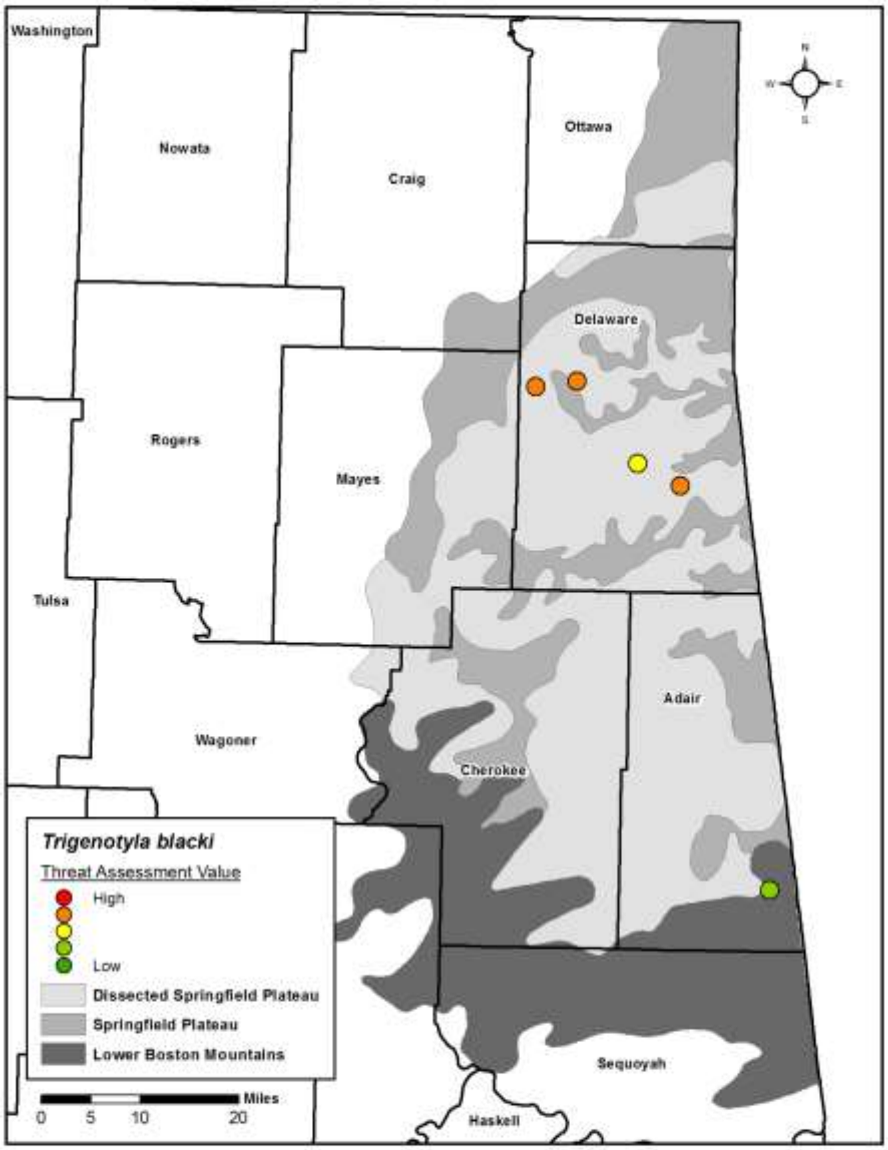

Figure 24. Distribution of *Trigenotyla blacki* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Class Hexapoda
Order Collembola
Family Arrhopalitidae

Pygmarrhopalites jay
(Christiansen and Bellinger 1996) (Figure 25)

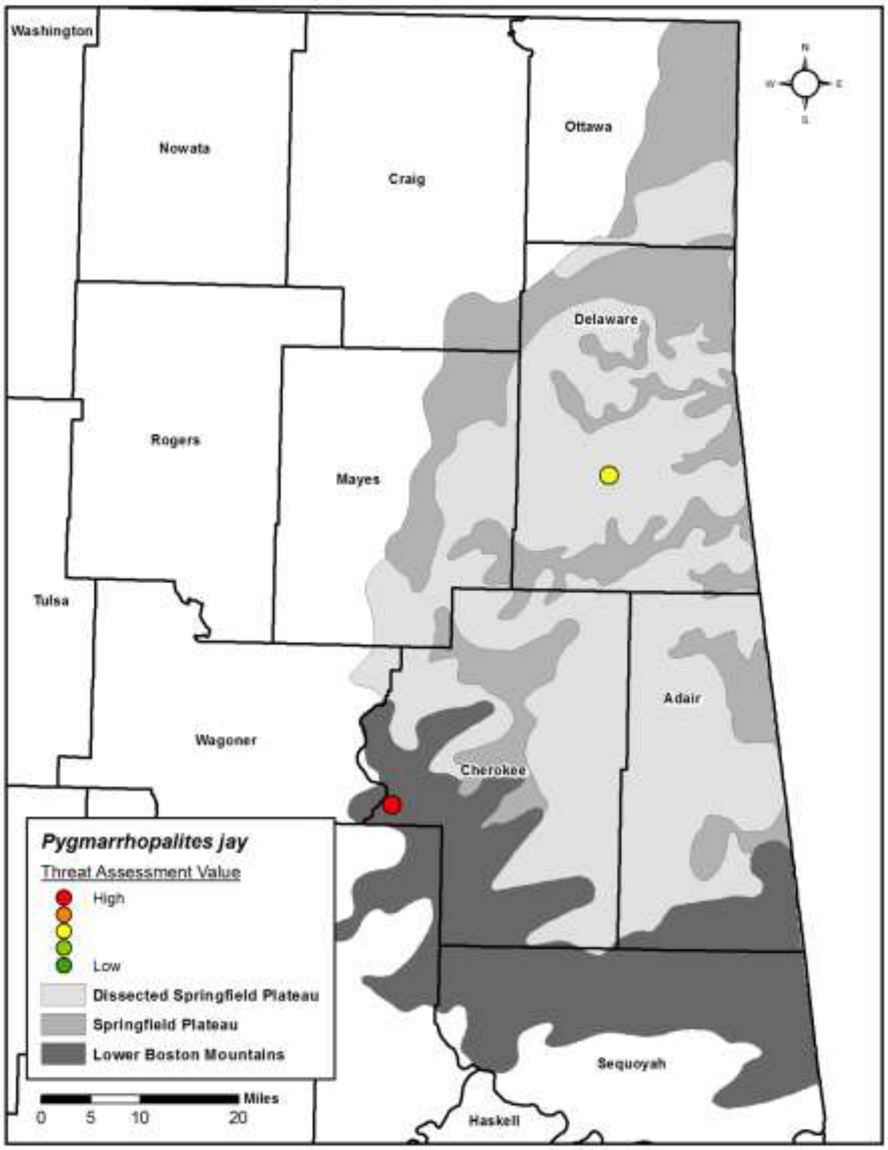

Figure 25. Distribution of *Pygmarrhopalites jay* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Class Hexapoda
Order Collembola
Family Entomobryiidae

Pseudosinella dubia
Christiansen 1960 (Figure 26)

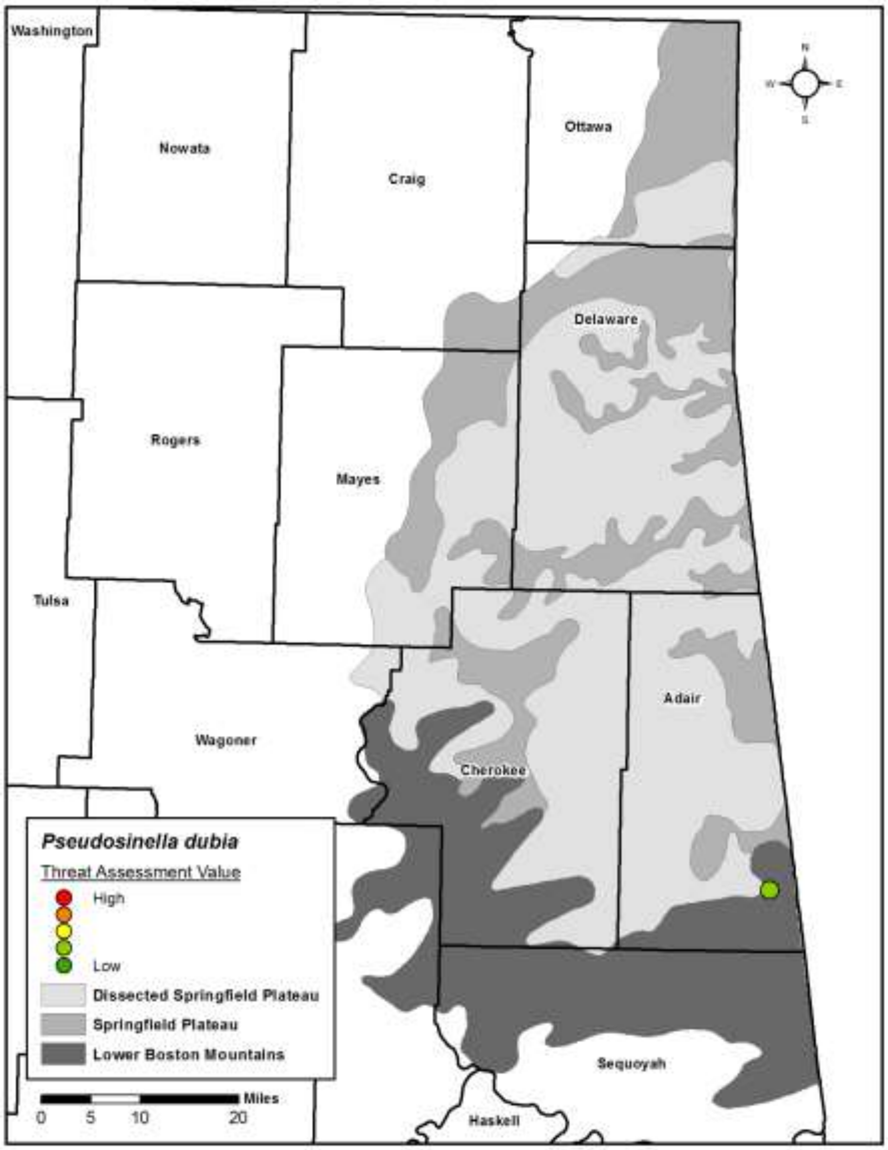

Figure 26. Distribution of *Pseudosinella dubia* in Oklahoma and associated threat assessment value for the occupied site. Ozark Ecoregion is shown as the shaded region.

Class Hexapoda
Order Thysanura
Family Nicoletiidae

Speleonycta ozarkensis
Espinasa et al 2010 (Figure 27)

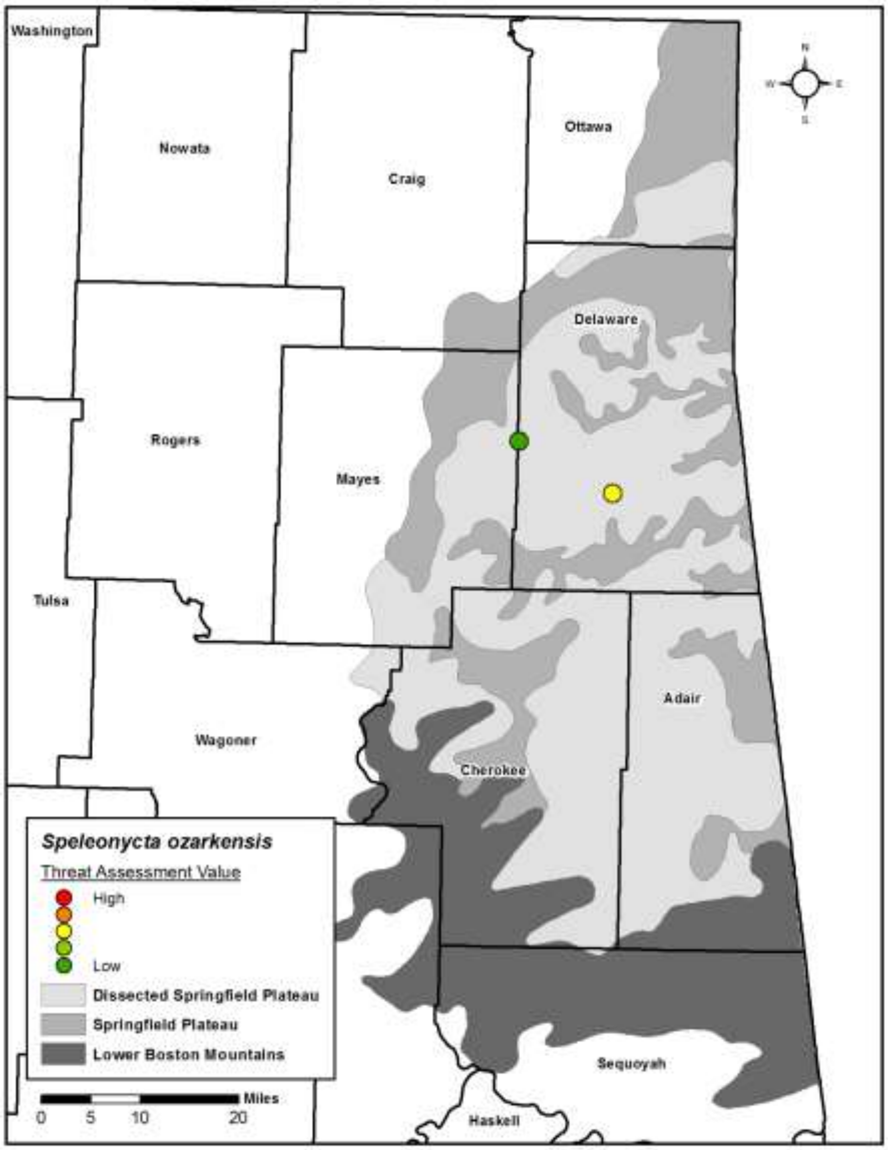

Figure 27. Distribution of *Speleonycta ozarkensis* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Class Insecta
Order Diptera
Family Sphaeroceridae

Spelobia tenebrarum
Aldrich 1897 (Figure 28)

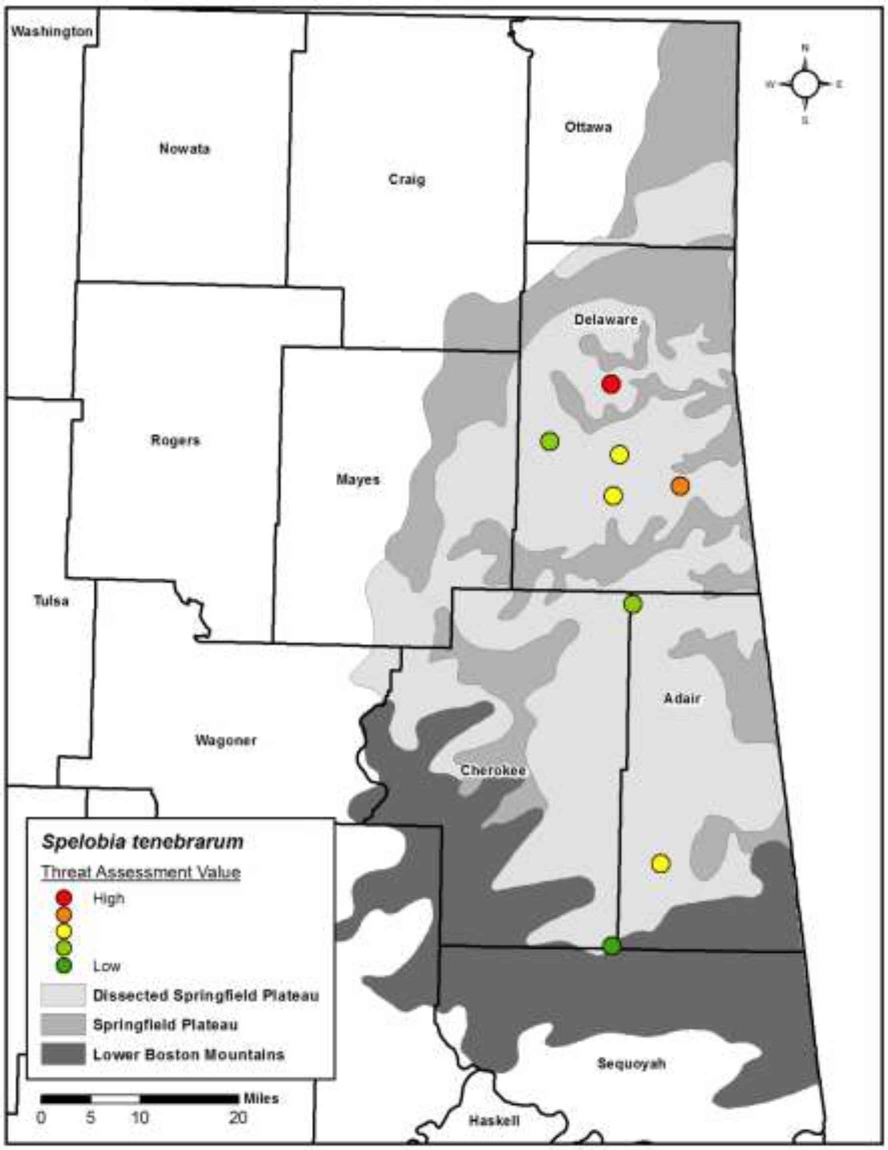

Figure 28. Distribution of *Spelobia tenebrarum* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Phylum Chordata
Class Actinopterygii
Order Perciformes
Family Amblyopsidae

Amblyopsis rosae
(Eigenmann 1898) (Figure 29)

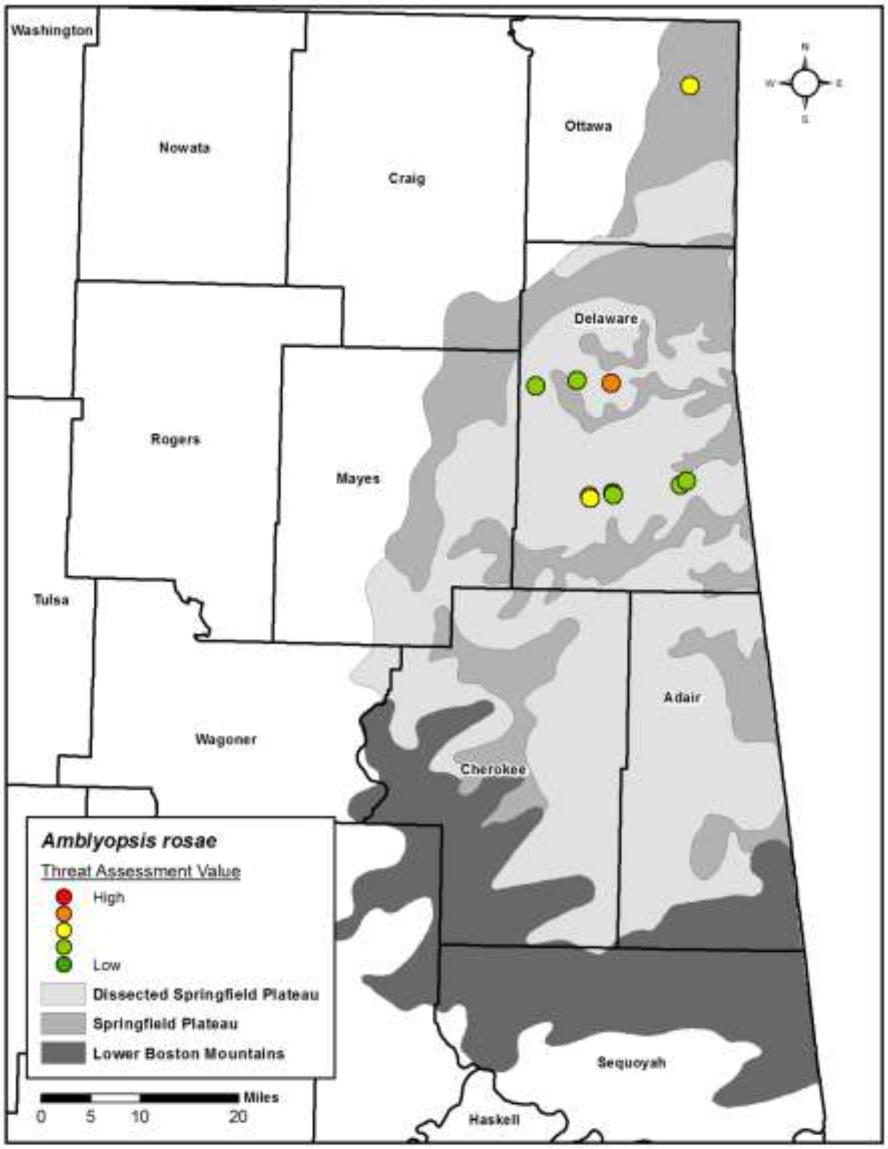

Figure 29. Distribution of *Amblyopsis rosae* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Class Amphibia
Order Urodela
Family Plethodontidae

Eurycea spelaea
(Stejneger 1892) (Figure 30)

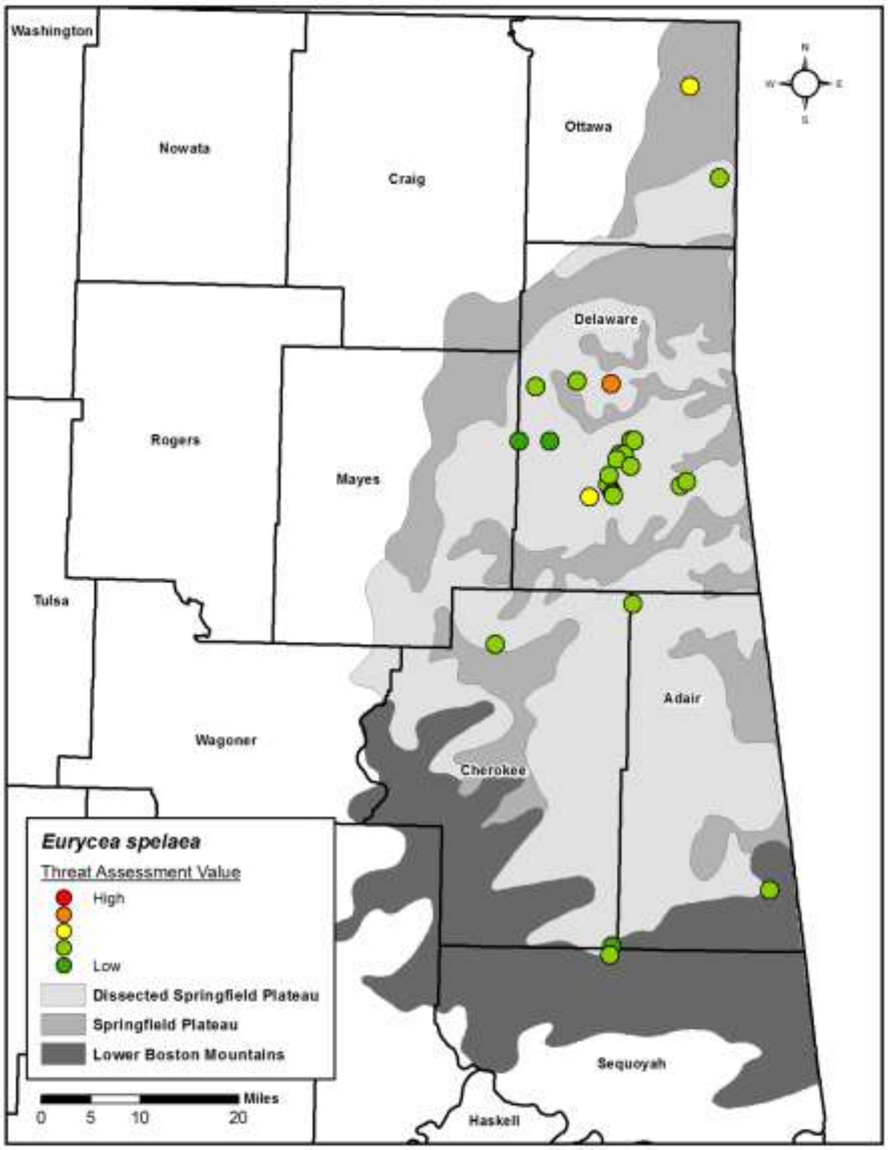

Figure 30. Distribution of *Eurycea spelaea* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Class Amphibia
Order Urodela
Family Plethodontidae

Plethodon angusticlavius
Highton 1997 (Figure 31)

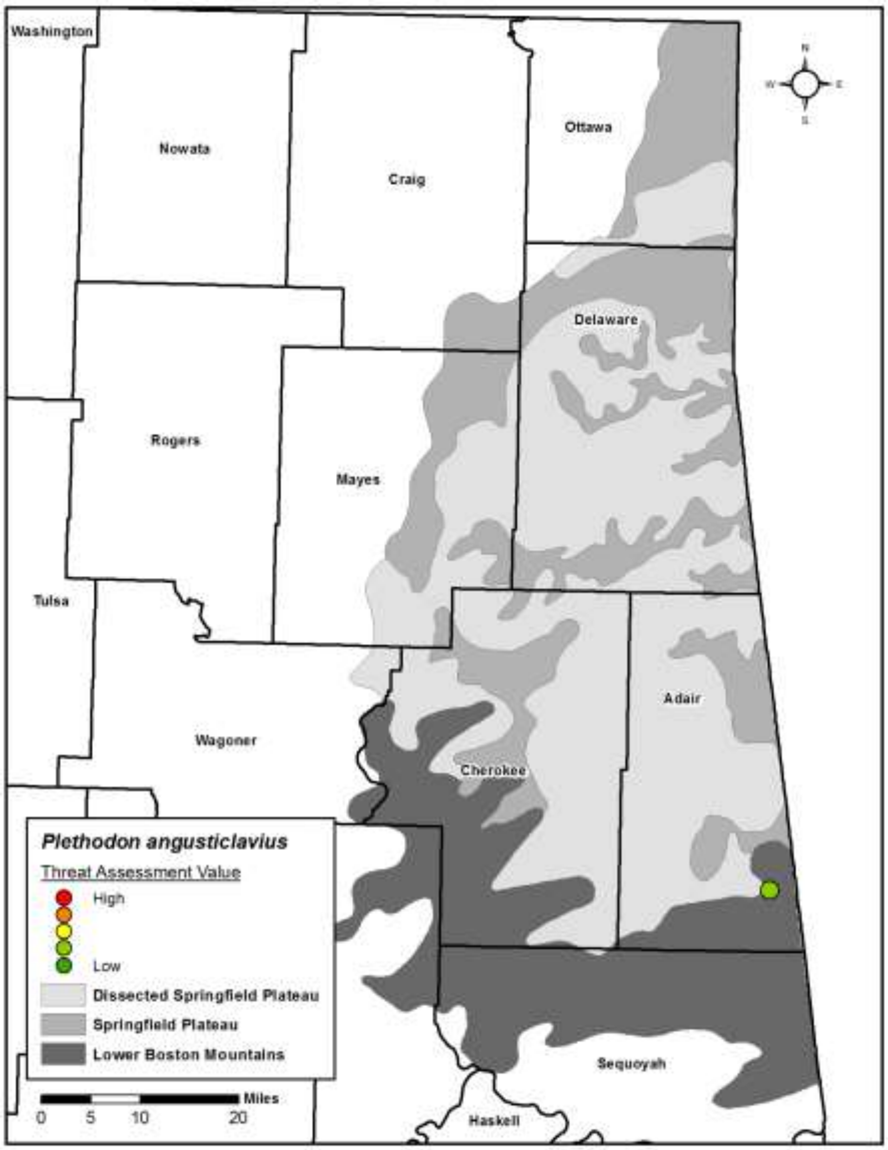

Figure 31. Distribution of *Plethodon angusticlavius* cave records in Oklahoma and associated threat assessment value for the occupied site. Ozark Ecoregion is shown as the shaded region.

Class Mammalia
Order Chiroptera
Family Vespertilionidae

Myotis grisescens
(Figure 32)

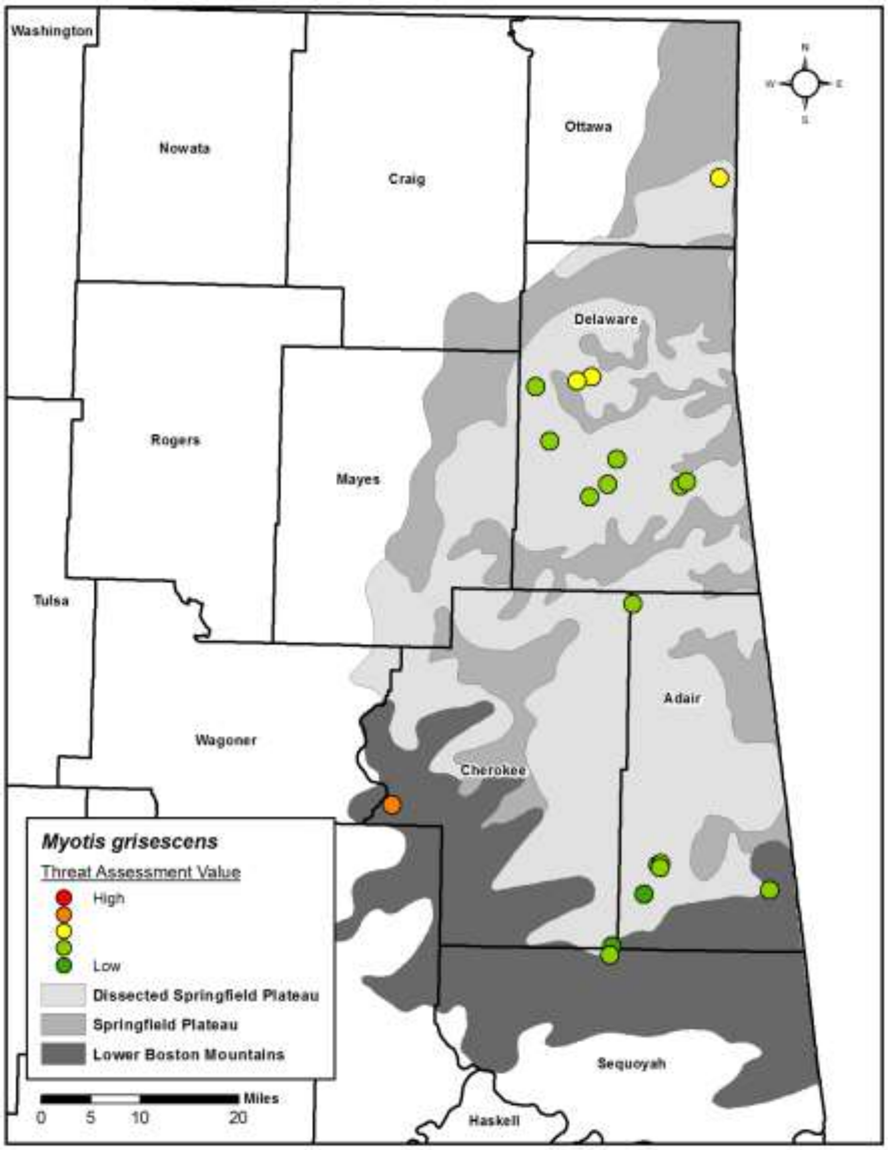

Figure 32. Distribution of *Myotis grisescens* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Class Mammalia
Order Chiroptera
Family Vespertilionidae

Myotis septentrionalis
(Figure 33)

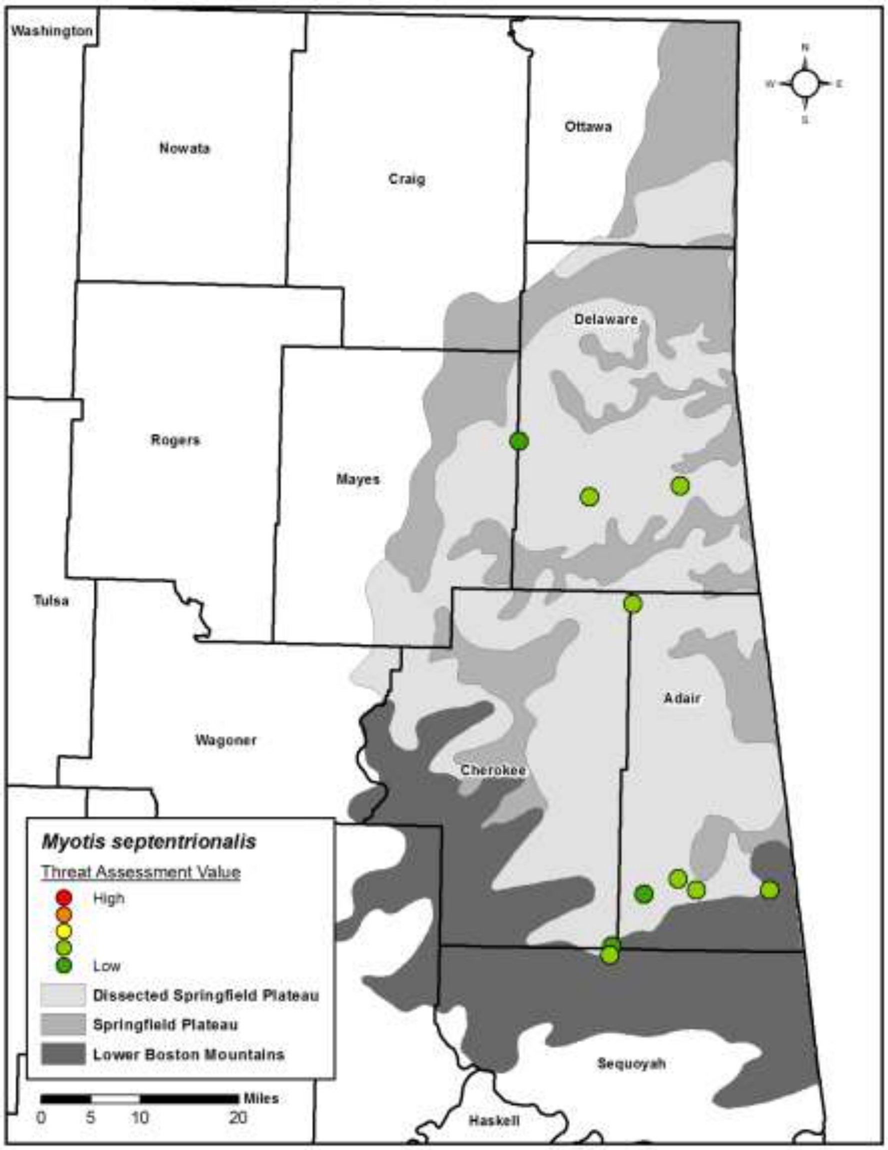

Figure 33. Distribution of *Myotis septentrionalis* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Class Mammalia
Order Chiroptera
Family Vespertilionidae

Myotis sodalis
(Figure 34)

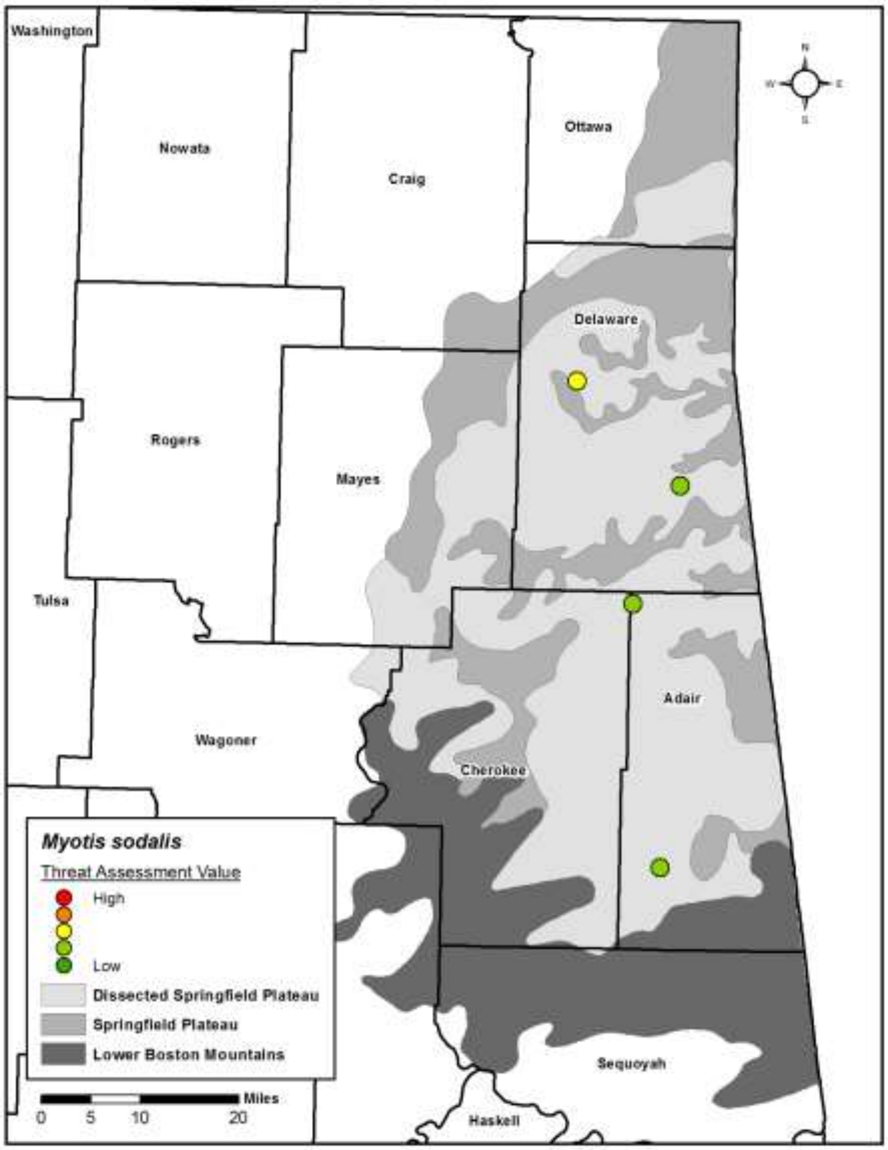

Figure 34. Distribution of *Myotis sodalis* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Class Mammalia
Order Chiroptera
Family Vespertilionidae

Corynorhinus townsendii ingens
(Figure 35)

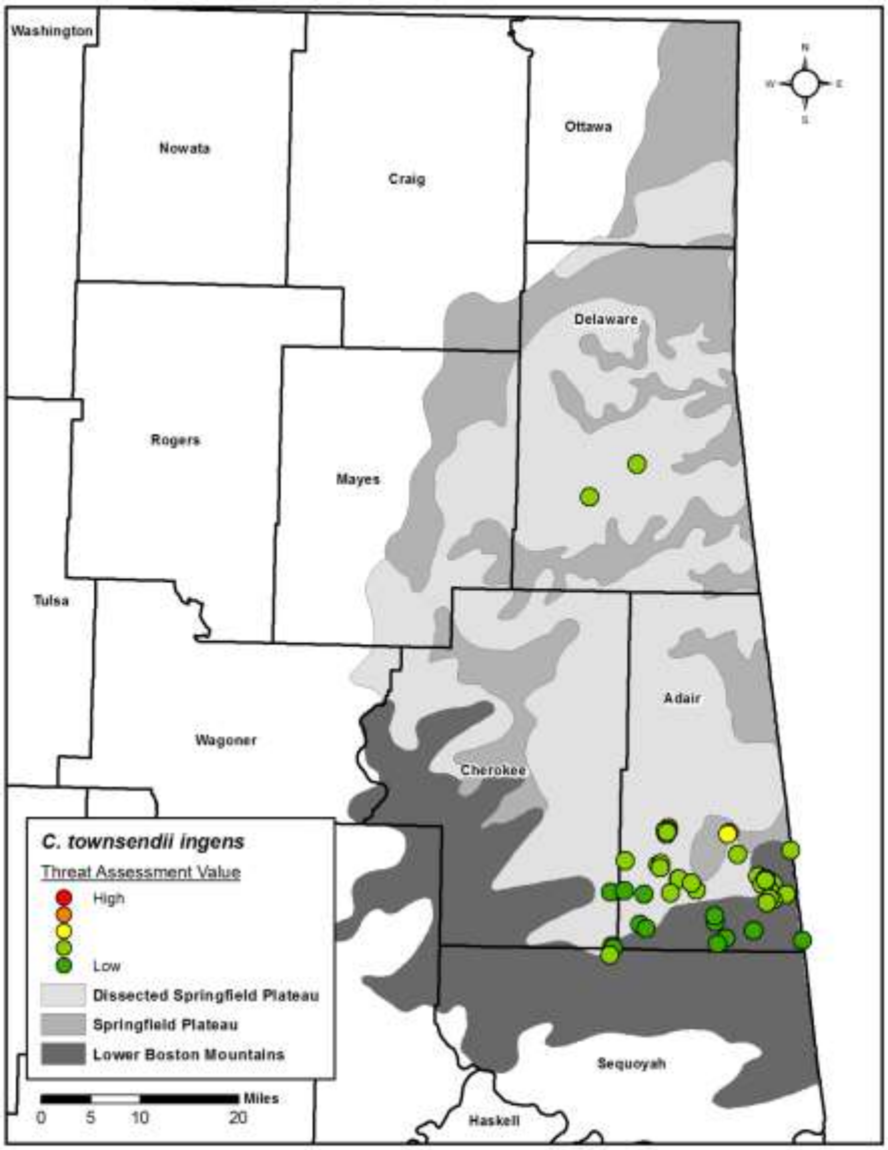

Figure 35. Distribution of *Corynorhinus townsendii ingens* in Oklahoma and associated threat assessment values for each occupied site. Ozark Ecoregion is shown as the shaded region.

Table 2. Twenty-eight karst dependent species occur in the Oklahoma Ozarks. *These species were not originally included in the Oklahoma Comprehensive Wildlife Conservation Strategy.

Class	Common Name	Scientific Name	No. of sites
Amphibians	Grotto Salamander	*Eurycea spelaea*	28
	Ozark Salamander	*Plethodon angusticlavius*	1
Crayfish	Cave Crayfish	*Cambarus subterraneaus*	4
	Oklahoma Cave Crayfish	*Cambarus tartarus*	3
Fish	Ozark Cavefish	*Amblyopsis rosae*	11
Insect	Ozark Cave Silverfish	*Speleonycta ozarkensis**	2
	Cave Dung Fly	*Spelobia tenebrarum**	8
	Cave Springtail	*Pseudosinella dubia*	1
	Cave Springtail	*Pygmarrhopalites jayi*	2
Invertebrates Other	Cave Flatworm	*Dendrocoelopsis americana**	4
	Cave Isopod	*Caecidotea ancyla*	9
	Cave Isopod	*Caecidotea antricola*	3
	Cave Isopod	*Caecidotea macropropoda*	5
	Cave Isopod	*Caecidotea mackini*	1
	Cave Isopod	*Caecidotea simulator*	5
	Cave Isopod	*Caecidotea steevesi**	2
	Cave Isopod	*Caecidotea stiladactyla*	6
	Alabama Cave Amphipod	*Stygobromus alabamensis**	8
	Bowman's Cave Amphipod	*Stygobromus bowmani*	1
	Onondaga Cave Amphipod	*Stygobromus onondagaensis**	8
	Ozark Cave Amphipod	*Stygobromus ozarkensis*	10
	Appalachian Cave Spider	*Porrhomma cavernicola**	1
	Cave False Scorpion	*Hesperochernes occidentalis**	3
	Black's Cave Millipede	*Trigenotyla blacki*	5
Mammals	Gray Myotis	*Myotis grisescens*	20
	Indiana Myotis	*Myotis sodalis*	4
	Northern Long-eared Myotis	*Myotis septentrionalis*	10
	Ozark Big-eared Bat	*Corynorhinus townsendii ingens*	51

Threat Assessment

Terrestrial Community Group

The terrestrial community analysis included 23 occurrences of eight species from 18 sites. The overall threat assessment for sites with terrestrial cave species was generated by the visitation (RVI) risk model (Figure 36). To characterize threats for each terrestrial cave species, Visitation Risk Model values (RVIP, RVIA, RVIX, and RVI) were extracted from each community threat model and averaged (Table 3). All terrestrial cave species experienced some level of threat from visitation. The species with the highest threat score was the cave springtail, *Pygmarrhopalites jay*. Three species had overall scores greater than 0.5. The most frequently occurring species (*Spelobia tenebrarum*) had an average threat value of 0.46. Separate threat values for each terrestrial cave species population at each site are included in Appendix C.

Table 3. Mean index values for threats associated with terrestrial cave species, ordered in decreasing values of threat. RVIP is the derived threat score generated from proximate human population. RVIA is the derived threat score generated from available access to the site. RVIX is the derived threat score generated from the proximity of the site to a road. RVI is the overall threat from visitation generated by combining RVIP, RVIA, and RVIX. The THREAT Scaled value is calculated by subtracting the RVI Scaled value from 1. A higher THREAT Scaled value indicates a higher level of threat.

Terrestrial Cave Species	No. sites	RVIP Scaled	RVIA Scaled	RVIX Scaled	RVI Scaled	THREAT Scaled
Pygmarrhopalites jay	2	0.33	0.10	0.15	0.33	0.67
Trigenotyla blacki	5	0.58	0.12	0.11	0.46	0.54
Hesperochernes occidentalis	3	0.55	0.15	0.15	0.48	0.52
Spelobia tenebrarum	8	0.61	0.18	0.14	0.54	0.46
Porrhomma cavernicola	1	0.56	0.22	0.17	0.54	0.46
Pseudosinella dubia	1	0.63	0.22	0.16	0.58	0.42
Plethodon angusticlavius	1	0.63	0.22	0.16	0.58	0.42
Speleonycta ozarkensis	2	0.61	0.17	0.53	0.75	0.25

Bat Community Group

The overall threat assessment for bat sites included assessing threats generated by two risk models: visitation (RVI) and available foraging habitat (RBH). Relative to all bat sites, only two caves are highly threatened by visitation (Figure 37). However, numerous sites were scored as having a medium or higher threat associated with visitation. Bat sites with the highest threat scores associated with foraging habitat were not the same sites as those identified by using the visitation indices (Figure 38). Combining these two risk models produced an overall threat index for bat sites that suggests some of these threats may interact to produce cumulative impacts (Figure 39). Overall, only three bat sites were categorized with the highest threat scores; however, many sites were classified with more than a medium level of threat.

For the purpose of generating threat scores for bat sites, a cave was considered "occupied" regardless of whether the species is currently known from the site. In some instances, bat species are no longer occupying sites (e.g. several historic gray bat and Indiana bat sites). However, all sites were included for analysis because even currently unoccupied sites have the potential to house bats should conditions change. Assessing and reducing threats associated with currently unoccupied sites may allow bats to re-colonize historic locations.

Average overall threat scores were low for all four species (Table 4). Some threats due to visitation and foraging habitat may be more important than others. The presence of roads is associated with a higher level of threat. Average values for proximity to roads (RVIX) ranged from 0.13 to 0.23 (Threat values [1-RVIX]: 0.87 to 0.77), and average values for total length of roads (RVIA) ranged from 0.14 to 0.25 (Threat values [1-RVIX]: 0.86 to 0.75). Threats associated with habitat alteration (Threat values [1-RBH]: 0.11 to 0.18) were low. Threat scores associated with proximate human population (RVIP) were in the medium range of values. Separate threat values for each bat species at each site are included in Appendix D.

Table 4. Mean index scores for threats associated with bat species, ordered in decreasing values of overall threat (THREAT). Table is broken into 2 sections with "Species" and "No. Sites" repeating in each section. See Appendix A for definitions of threat variables. The THREAT Scaled value is calculated by subtracting the RVI Scaled value from 1. A higher THREAT Scaled value indicates a higher level of threat.

Bat Species	No. Sites	RBHF_01 Scaled	RBHF_02 Scaled	RBHF Scaled	RBHR_01 Scaled	RBHR_02 Scaled	RBHR Scaled
Myotis sodalis	4	0.66	0.81	0.84	0.82	0.72	0.77
Myotis grisescens	20	0.72	0.75	0.84	0.82	0.77	0.80
C. townsendii ingens	51	0.80	0.72	0.87	0.79	0.80	0.80
Myotis septentrionalis	10	0.81	0.77	0.90	0.87	0.82	0.85

Bat Species	No. Sites	RBH Scaled	RVIP Scaled	RVIA Scaled	RVIX Scaled	RVI Scaled	THREAT Scaled
Myotis sodalis	4	0.82	0.58	0.14	0.13	0.49	0.31
Myotis grisescens	20	0.84	0.58	0.16	0.15	0.51	0.29
C. townsendii ingens	51	0.85	0.64	0.23	0.19	0.61	0.23
Myotis septentrionalis	10	0.89	0.66	0.25	0.23	0.65	0.19

Aquatic Community Group

The overall threat assessment for aquatic cave species sites included assessing threats generated from a visitation risk model (RVI) and a groundwater sensitivity model (SENS). The groundwater sensitivity model was generated from a water quality and quantity risk model (RWQ) and a groundwater vulnerability model (VULN). The groundwater vulnerability model was generated using a modification of the model DRASTIC. Each of these models are comprised of threat indices which, in addition to overall threat scores, are useful in describing threats for each of the aquatic cave species. Separate threat values for each aquatic cave species at each site are included in Appendix E.

All 16 aquatic cave species are experiencing some level of threat, and average overall threat values ranged from 0.25 to 0.48 (Table 5). Threat values were scaled from 0 to 1, and the averages for each species were in the moderate to low range of values. These average moderate to low threat values suggest that some of the populations of each species may be reasonably insulated from threats. The species with the highest threat score was *Stygobromus bowmani*, which is known from a single location. Two species, *Caecidotea stiladactyla* and *C. macropropoda*, had the lowest overall threat scores.

The highest visitation threats were at sites adjacent to Oklahoma State Highway 412; however, sites with medium to high threat values were more broadly distributed (Figure 40). Aquatic cave species within these medium to high RVI sites include populations of *A. rosae*, *C. ancyla*, *C. antricola*, *C. simulator*, *Cambarus subterraneus*, *C. tartarus*, *D. americana*, *E. spelaea*, *S. alabamensis*, *S. onondagaensis*, and *S. ozarkensis*. Many sites had lower threat scores relative to water quality and quantity threats (Table 5), with the exception of Carroll's Grotto, DL-21 DL-22, and DL-74 (Appendix E). These sites harbor populations of Ozark cavefish and cave crayfish. The average RWQ score for the

11 sites containing *A. rosae* was 0.76 (Table 5), suggesting these four sites are more threatened by water quality and quantity issues than the other Ozark cavefish sites assessed. All four water quality and quantity parameters appear to be important threats for Ozark cavefish (Table 5). Sediment (RWQS) may be an important threat to *Cambarus tartarus* populations, while nutrients (RWQN) and pollutants (RWQP) may be more important threats to *C. subterraneus* populations.

Across the Oklahoma Ozarks, karst areas with the highest vulnerabilities, as modeled by DRASTIK, occurred primarily along and south of Oklahoma State Highway 412 (Figure 42). As expected, vulnerabilities were also highest along the streams and rivers that drain the uplands. Sites with aquatic cave species that occurred in karst areas of high vulnerability, as modeled by DRASTIC, were typically characterized as highly vulnerable (Figure 43). Groundwater vulnerability is an estimate of how easily contaminants can enter groundwater systems. In some instances, locations (such as a sinking stream, cave, or spring) may be highly vulnerable but relatively well protected because the sites have few or no potential groundwater threats. Alternatively, sites may be highly vulnerable and have many threats. Intuitively, highly vulnerable sites with many threats should be more sensitive to groundwater degradation. This relationship was characterized using a Groundwater Sensitivity Index (SENS) which combined values generated from the groundwater vulnerability assessment with threat scores water quality and quantity threat indices (RWQ). Aquatic cave species sites with the highest groundwater sensitivities were distributed throughout the Oklahoma Ozarks with no clear pattern (Figure 44). A similar pattern is observed overall when groundwater sensitivity is combined with threats due to visitation (Figure 45). Aquatic cave species with higher overall threat scores relative to the rest of the sites were widely distributed across the area.

E.2. DISCUSSION

This project updated species range maps for 28 karst species listed in the Oklahoma Comprehensive Wildlife Conservation Strategy. In addition, the project generated threat assessments for each of these species and for the 94 habitats where these species occur. Below, the results are briefly summarized relative to the objectives of the project.

Objective 1. Generate updated species range maps for each of the 29 Oklahoma species by integrating data from multiple sources.

Range maps were produce for each of 28 species. The species, *Bactrurus hubrichti*, is not part of the Oklahoma Ozark karst fauna. Six species were identified as endemic to the Oklahoma Ozarks, while another 15 were identified as endemic to the broader Ozark ecoregion. Several of the Oklahoma Ozark endemic species are known from just a few sites, and surveys of additional suitable habitats adjacent to these populations would help determine whether the geographical rarity is real or a result of a lack of surveys. Additional surveys would also determine whether the broader Ozark endemics were geographically rare or more common in the state.

Objective 2. Assess the current status of threats associated with each of these 28 species.

Threat assessments were generated for each of the 28 species and each of the 94 sites were the species occurred. Tables and appendices provide details and summaries of the threat assessments.

A broad conservation implementation priority list was developed that included all 28 species (Table 8). Values for this list were derived from a Species Richness metric (total number of sites where species was present) and a THREAT metric (average THREAT score for the species), and these calculated values were weighted by factors of endemism, rarity, endangered species status, and site ownership. For Endemism, species endemic to the Oklahoma Ozarks were assigned a weight of 10, species endemic to the broader Ozark Ecoregion were assigned a weight of 5, and species that also occur outside of the Ozarks were assigned a weight of 1. For Rarity, species known from 1-5 sites were assigned a weight of 10, species known from 6-10 sites were assigned a weight of 5, and species known from more than 10 sites were assigned a weight of 1. For Endangered Species Status, species designated as Endangered were assigned a weight of 5, species designated as Threatened were assigned a weight of 2, and species with no status were assigned a weight of 1. Because caves and species populations that occur on public land should, in theory, receive a higher level of conservation/protection efforts, a final weight was assigned to sites occurring on private land (Private Ownership). The Private Ownership weight for each species was calculated by subtracting the number of public sites from the total number of sites, dividing this value by the total number of sites, and then multiplying by a factor of 10. A weight of 1 was assigned for species that only occur on public lands. The Priority Raw scores were calculated by multiplying together the metrics and weighted factors, and Priority Scaled scores were calculated by rescaling the raw scores on a 0 to 1 scale with a value of 1 being the highest priority.

The Ozark Big-eared bat (*C. townsendii ingens*) ranked at the highest priority in terms of need for additional conservation implementation measures. Including both essential use sites and limited use sites in the site total (N = 51) explains partly why this species ranked as a top priority. Only 16 sites occur on public land, so there is a need to evaluate non-public sites to determine what specific actions may benefit this species. Ozark Big-eared bat sites are clustered in the southern part of the Oklahoma Ozarks (Figure 35) with many of these sites considered limited use locations, and a more detailed study of these locations may identify new essential sites for this species.

Three Oklahoma endemic cave species are included the upper 25% of the priority ranking. The lack of publicly owned *Cambarus subterraneus* sites coupled with a moderate level of threat suggests additional conservation implementation strategies should be focused on this aquatic cave species. This species receives some protection because one site, DL-91, is owned by The Nature Conservancy and is co-managed with the U.S. Fish and Wildlife Service. Groundwater recharge areas have been delineated for all four sites, so implementation tasks should include encouraging best management practices that would help reduce threats associated with these sites. Acquisition of additional sites or highly vulnerable areas within the recharge delineations may also be considered. The species, *Pygmarrhopalites jay*, is known from two locations separated by a significant geographic distance (Figure 25), and the overall threat score for the non-public site in Cherokee County was 0.82 (Appendix C). The distance between the *Pygmarrhopalites jay* locations suggests additional surveys of suitable habitat are needed, and surveys that discover additional populations may lower the priority score for this species. While having a high threat value, the cave millipede, *Trigenotyla blacki*, occurs mostly on public land, and these threats may be addressed through projects with resource managers.

There are several species that are known, individually, from just a single location in Oklahoma. The amphipod, *Stygobromus bowmani*, is known from a single seep in Mayes County (Figure 10), and is included in the upper 50% of the priority ranking. The exact location of this seep and continued existence of this species is unknown. Re-locating this seep and surveying suitable adjacent habitat is recommended. Discovering additional populations of *S. bowmani* may lower the priority score for this species. The isopod, *Caecidotea mackini*, has been found in one Delaware County site (Figure 15). The Delaware County site is owned by The Nature Conservancy, and the cave also provides habitat for *Amblyopsis rosae* and *Cambarus tartarus*. Conservation efforts that benefit *Amblyopsis rosae* and *Cambarus tartarus* will also benefit *Caecidotea mackini*. In addition to the Oklahoma cave, the springtail, *Pseudosinella dubia*, is known from sites nearby in Arkansas that are also on public land (Slay et al. 2009). The spider, *Porrhomma cavernicola*, is known from caves across the Ozarks and is widespread in caves farther east (Miller 2005, Elliott 2007, Graening et al. 2012).

In addition to the overall priority ranking, the 28 species can be characterized as part of aquatic, terrestrial, or bat communities, and their associated threats. Therefore conservation implementation priorities can be set within each of the groups, for a group of sites or species, or for a single site or species. Tables and appendices provide details and summaries of the threat assessments and are ranked according to highest overall threat. In some instances, implementing conservation actions may develop opportunistically for lower level priority species or when species-specific funding is available. In these situations, overriding priority rankings for projects is justified.

Table 5. Mean index scores for threats associated with aquatic cave species, ordered in decreasing values of overall threat (THREAT Scaled). See Appendix A for definitions of threat variables.

Species	No. Sites	RWQS Scaled	RWQN Scaled	RWQP Scaled	RWQH Scaled	RWQ Scaled	VULN Scaled	SENS Scaled	RVIP Scaled	RVIA Scaled	RVIX Scaled	RVI Scaled	THREAT Scaled
Stygobromus bowmani	1	0.77	0.39	0.63	0.58	0.63	0.00	0.44	0.55	0.40	0.12	0.53	0.48
Cambarus subterraneus	4	0.65	0.53	0.52	0.70	0.64	0.25	0.62	0.47	0.28	0.11	0.43	0.44
Caecidotea simulator	5	0.81	0.68	0.67	0.71	0.76	0.24	0.70	0.50	0.24	0.12	0.43	0.40
Amblyopsis rosae	11	0.62	0.66	0.76	0.81	0.76	0.21	0.68	0.59	0.30	0.09	0.49	0.38
Stygobromus alabamensis	8	0.76	0.84	0.84	0.85	0.88	0.18	0.74	0.52	0.29	0.09	0.45	0.37
Stygobromus onondagaensis	8	0.72	0.81	0.94	0.91	0.90	0.23	0.79	0.49	0.31	0.12	0.46	0.34
Stygobromus ozarkensis	10	0.74	0.86	0.93	0.92	0.92	0.19	0.77	0.50	0.32	0.13	0.48	0.34
Caecidotea ancyla	9	0.60	0.87	0.90	0.92	0.87	0.19	0.74	0.60	0.35	0.08	0.51	0.34
Caecidotea antricola	3	0.64	0.71	0.71	0.79	0.76	0.32	0.76	0.57	0.31	0.14	0.51	0.33
Cambarus tartarus	3	0.45	0.82	0.94	0.92	0.83	0.22	0.73	0.67	0.34	0.07	0.54	0.32
Dendrocoelopsis americana	4	0.82	0.87	0.93	0.94	0.95	0.17	0.78	0.57	0.32	0.12	0.50	0.32
Caecidotea steevesi	2	0.67	0.76	0.99	0.97	0.90	0.19	0.76	0.59	0.39	0.15	0.56	0.30
Caecidotea mackini	1	0.37	0.95	1.00	0.99	0.88	0.21	0.76	0.67	0.37	0.11	0.58	0.29
Eurycea spelaea	28	0.70	0.87	0.90	0.92	0.90	0.20	0.77	0.65	0.37	0.13	0.57	0.29
Caecidotea stiladactyla	6	0.74	0.97	0.92	0.96	0.95	0.24	0.83	0.69	0.39	0.09	0.59	0.25
Caecidotea macropropoda	5	0.77	0.97	0.96	0.96	0.97	0.13	0.77	0.74	0.46	0.10	0.65	0.25

Table 6. Mean index scores for sediment (RWQS) and nutrient (RWQN) threats associated with aquatic cave species, ordered in decreasing values of overall threat (THREAT Scaled). See Appendix A for definitions of threat variables.

		RWQS				RWQN					RWQ	THREAT
Aquatic Cave Species	No. Sites	01	02	03	04	01	02	03	04	05	Scaled	Scaled
Stygobromus bowmani	1	0.00	0.65	1.00	0.53	0.74	0.00	0.87	0.00	0.34	0.63	0.48
Cambarus subterraneus	4	0.74	0.31	0.26	0.54	0.48	0.79	0.73	0.54	0.12	0.64	0.44
Caecidotea simulator	5	0.79	0.64	0.22	0.62	0.58	0.97	0.99	0.62	0.26	0.76	0.40
Amblyopsis rosae	11	0.67	0.30	0.41	0.37	0.82	0.63	0.78	0.63	0.42	0.76	0.38
Stygobromus alabamensis	8	0.92	0.67	0.13	0.44	0.85	0.98	0.97	0.89	0.53	0.88	0.37
Stygobromus onondagaensis	8	0.80	0.59	0.25	0.39	0.95	0.85	0.95	0.79	0.51	0.90	0.34
Stygobromus ozarkensis	10	0.86	0.66	0.21	0.35	0.96	0.88	0.96	0.87	0.61	0.92	0.34
Caecidotea ancyla	9	0.86	0.44	0.18	0.22	0.96	0.87	0.96	0.87	0.68	0.87	0.34
Caecidotea antricola	3	0.82	0.39	0.24	0.36	0.66	0.89	0.90	0.69	0.41	0.76	0.33
Cambarus tartarus	3	0.74	0.03	0.36	0.15	0.95	0.78	0.88	0.85	0.61	0.83	0.32
Dendrocoelopsis americana	4	0.94	0.80	0.25	0.35	0.95	0.94	0.98	0.85	0.60	0.95	0.32
Caecidotea steevesi	2	0.92	0.54	0.08	0.35	0.98	0.75	0.50	0.96	0.59	0.90	0.30
Caecidotea mackini	1	0.95	0.02	0.08	0.00	1.00	1.00	1.00	0.98	0.76	0.88	0.29
Eurycea spelaea	28	0.87	0.62	0.21	0.26	0.94	0.90	0.93	0.88	0.71	0.90	0.29
Caecidotea stiladactyla	6	0.93	0.78	0.17	0.19	0.99	1.00	1.00	0.98	0.89	0.95	0.25
Caecidotea macropropoda	5	0.95	0.84	0.16	0.23	0.98	1.00	1.00	0.98	0.88	0.97	0.25

Table 7. Mean index scores for pollutant (RWQP) and hydrologic alteration (RWQH) threats associated with aquatic cave species, ordered in decreasing values of overall threat (THREAT Scaled). See Appendix A for definitions of threat variables.

Aquatic Cave Species	No. Sites	RWQP 01	RWQP 02	RWQP 03	RWQP 04	RWQP 05	RWQH 01	RWQH 02	RWQ Scaled	THREAT Scaled
Stygobromus bowmani	1	0.00	0.41	0.72	1.00	1.00	0.23	0.93	0.63	0.48
Cambarus subterraneus	4	0.76	0.38	0.48	0.50	0.50	0.47	0.93	0.64	0.44
Caecidotea simulator	5	0.83	0.63	0.58	0.60	0.71	0.55	0.88	0.76	0.40
Amblyopsis rosae	11	0.76	0.65	0.82	0.76	0.81	0.66	0.96	0.76	0.38
Stygobromus alabamensis	8	0.93	0.69	0.84	0.83	0.92	0.81	0.88	0.88	0.37
Stygobromus onondagaensis	8	0.87	0.89	0.95	1.00	1.00	0.86	0.96	0.90	0.34
Stygobromus ozarkensis	10	0.89	0.88	0.95	0.97	0.98	0.88	0.95	0.92	0.34
Caecidotea ancyla	9	0.88	0.78	0.96	0.93	0.96	0.87	0.96	0.87	0.34
Caecidotea antricola	3	0.85	0.72	0.66	0.67	0.67	0.64	0.94	0.76	0.33
Cambarus tartarus	3	0.98	0.97	0.94	0.89	0.91	0.86	0.98	0.83	0.32
Dendrocoelopsis americana	4	0.97	0.76	0.94	1.00	1.00	0.93	0.96	0.95	0.32
Caecidotea steevesi	2	1.00	0.98	0.98	1.00	1.00	0.98	0.96	0.90	0.30
Caecidotea mackini	1	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.88	0.29
Eurycea spelaea	28	0.93	0.82	0.93	0.90	0.91	0.88	0.95	0.90	0.29
Caecidotea stiladactyla	6	0.99	0.90	0.99	0.89	0.83	0.96	0.96	0.95	0.25
Caecidotea macropropoda	5	0.97	0.87	0.97	1.00	1.00	0.95	0.96	0.97	0.25

Table 8. Conservation implementation priorities list for karst species that occur in the Oklahoma Ozarks.

Type	Species	No. sites	Public Sites	THREAT Scaled	Endemism Weight	Rarity Weight	T&E Weight	Non-public Weight	Priority Raw	Priority Scaled
B	*C. townsendii ingens*[2]	51	16	0.23	5	1	5	6.86	2015.84	1.00
A	*Cambarus subterraneus*[1]	4	1	0.44	10	10	1	7.50	1328.09	0.66
A	*Caecidotea simulator*[2]	5	0	0.40	5	10	1	10.00	1000.77	0.50
A	*Stygobromus ozarkensis*[2]	10	2	0.34	5	5	1	8.00	674.34	0.33
T	*Pygmarrhopalites jay*[1]	2	1	0.67	10	10	1	5.00	667.72	0.33
A	*Caecidotea macropropoda*[2]	5	0	0.25	5	10	1	10.00	612.78	0.30
T	*Trigenotyla blacki*[1]	5	4	0.54	10	10	1	2.00	541.67	0.27
A	*Stygobromus onondagaensis*[2]	8	2	0.34	5	5	1	7.50	509.29	0.25
A	*Stygobromus bowmani*[1]	1	0	0.48	10	10	1	10.00	484.21	0.24
A	*Caecidotea ancyla*[2]	9	5	0.34	5	5	1	4.44	335.04	0.17
B	*Myotis sodalis*	4	2	0.31	1	10	5	5.00	308.94	0.15
A	*Caecidotea steevesi*[2]	2	0	0.30	5	10	1	10.00	297.24	0.15
T	*Hesperochernes occidentalis*[2]	3	2	0.52	5	10	1	3.33	258.54	0.13
A	*Eurycea spelaea*[2]	28	12	0.29	5	1	1	5.71	229.45	0.11
A	*Amblyopsis rosae*[2]	11	5	0.38	5	1	2	5.45	228.23	0.11
A	*Caecidotea stiladactyla*[2]	6	3	0.25	5	5	1	5.00	185.55	0.09
B	*Myotis grisescens*	20	8	0.29	1	1	5	6.00	175.07	0.09
A	*Caecidotea antricola*[2]	3	2	0.33	5	10	1	3.33	165.27	0.08
A	*Cambarus tartarus*[1]	3	3	0.32	10	10	1	1.00	97.38	0.05
A	*Dendrocoelopsis americana*	4	1	0.32	1	10	1	7.50	96.27	0.05
T	*Spelobia tenebrarum*	8	4	0.46	1	5	1	5.00	92.91	0.05
A	*Stygobromus alabamensis*	8	3	0.37	1	5	1	6.25	91.89	0.05

Type	Species	No. sites	Public Sites	THREAT Scaled	Endemism Weight	Rarity Weight	T&E Weight	Non-public Weight	Priority Raw	Priority Scaled
B	*Myotis septentrionalis*	10	6	0.19	1	5	2	4.00	74.99	0.04
T	*Porrhomma cavernicola*	1	0	0.46	1	10	1	10.00	46.01	0.02
A	*Caecidotea mackini*[1]	1	1	0.29	10	10	1	1.00	28.88	0.01
T	*Speleonycta ozarkensis*[2]	2	2	0.25	5	10	1	1.00	25.47	0.01
T	*Plethodon angusticlavius*[2]	1	1	0.42	5	10	1	1.00	21.07	0.01
T	*Pseudosinella dubia*[2]	1	1	0.42	5	10	1	1.00	21.07	0.01

[1]Oklahoma Endemic Species; [2]Ozark Endemic Species

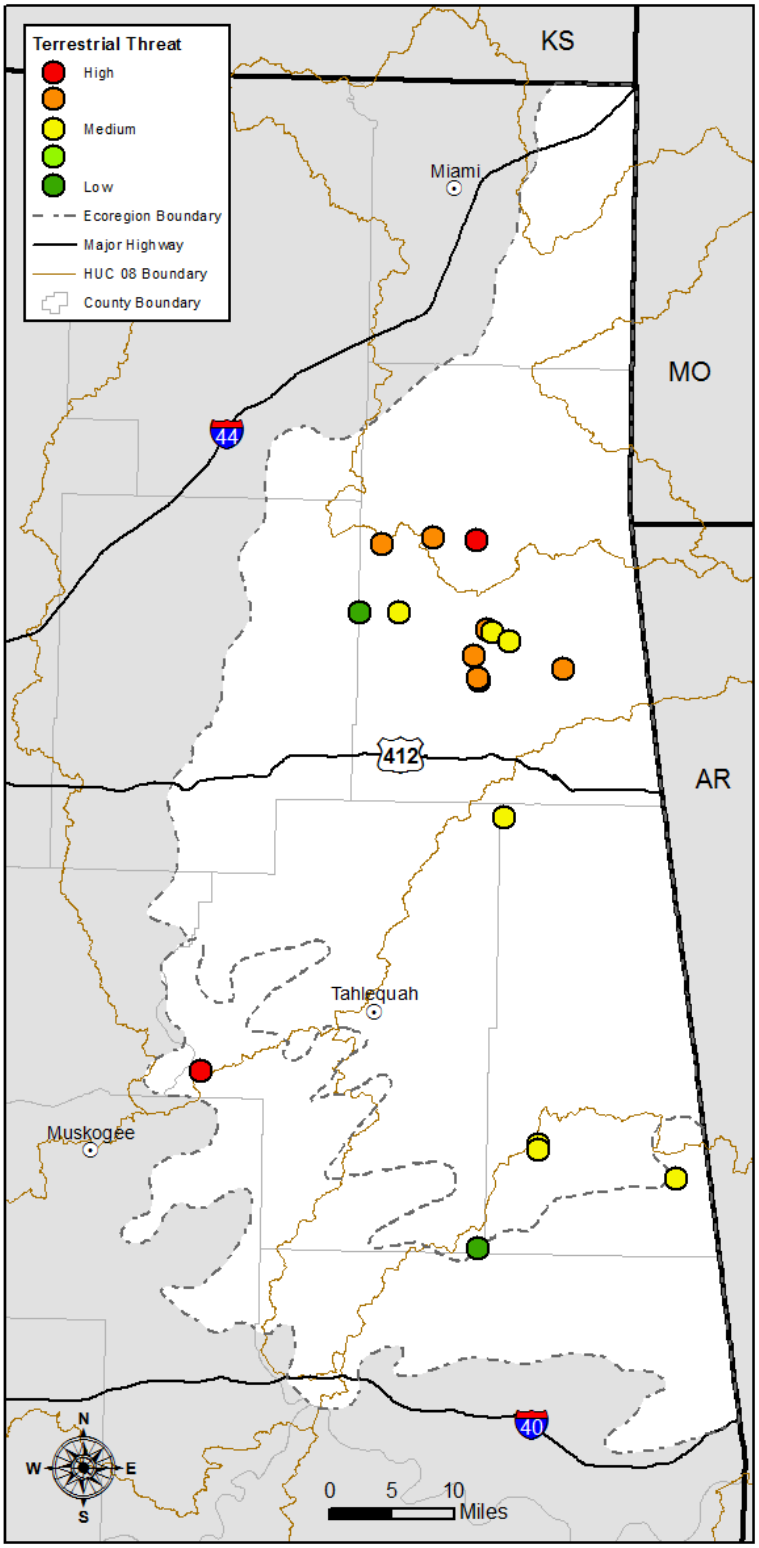

Figure 36. Threat score for sites occupied by terrestrial cave species.

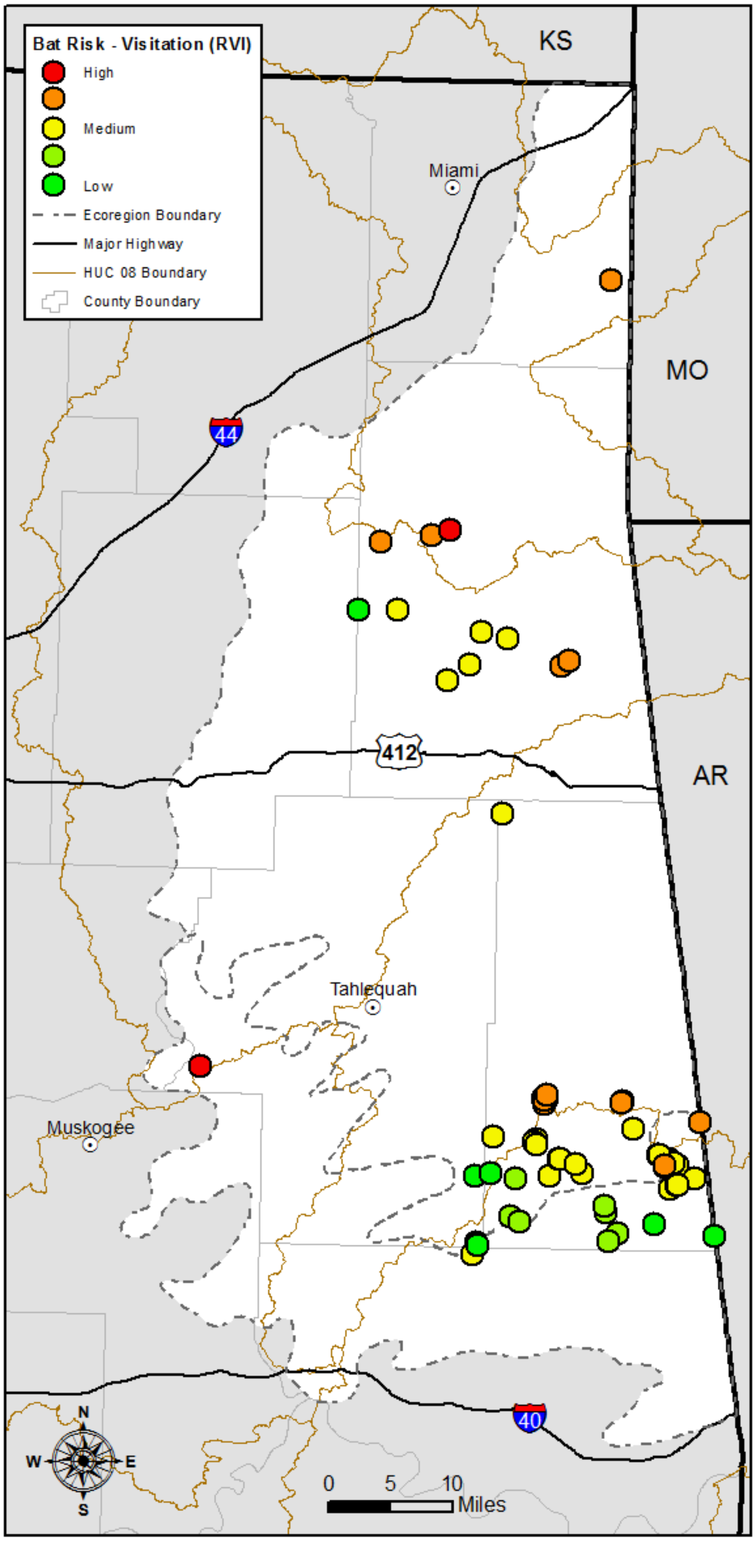

Figure 37. Threat scores generated from visitation indices (RVI) for sites occupied by bat species.

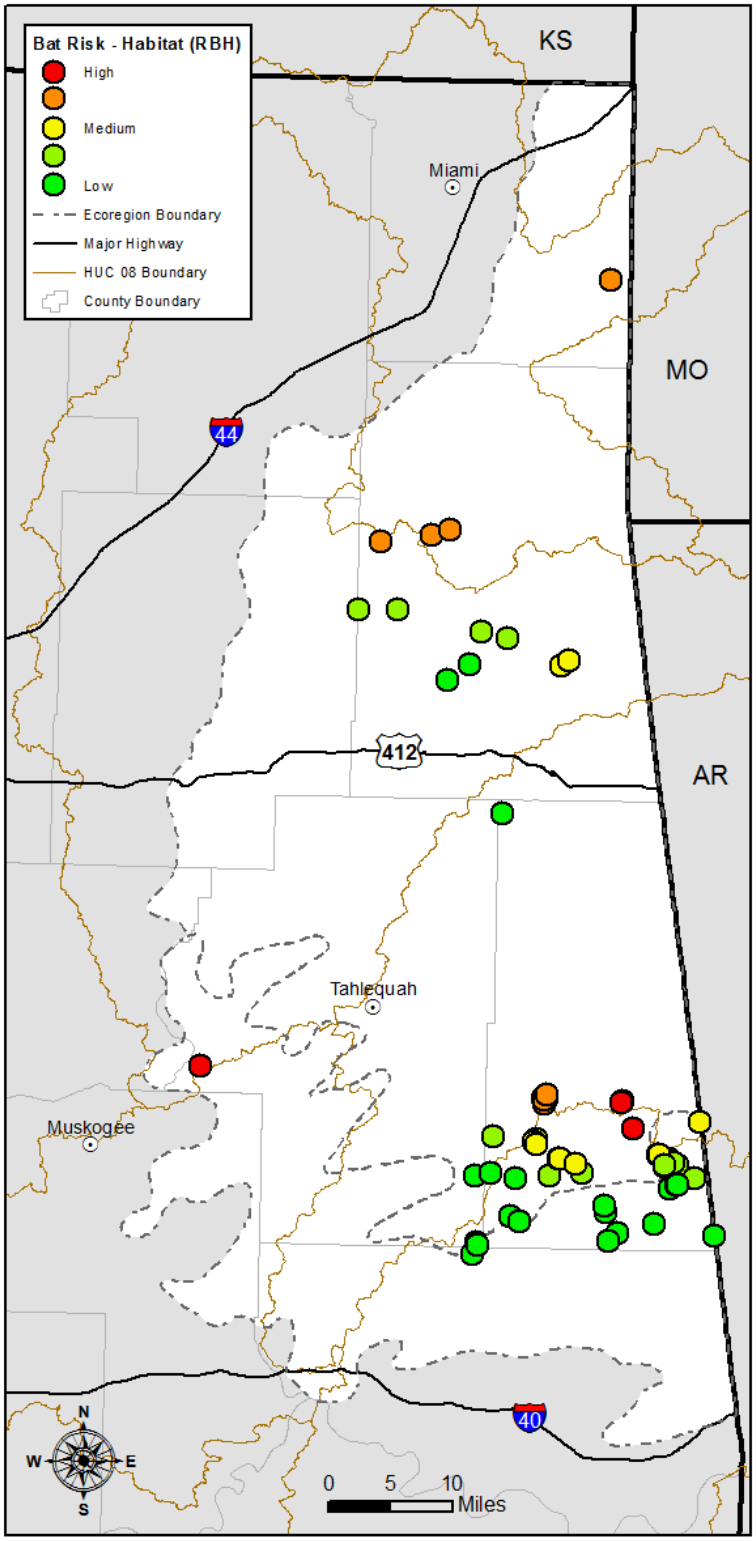

Figure 38. Threat scores generated from foraging habitat indices (RBH) for sites occupied by bat species.

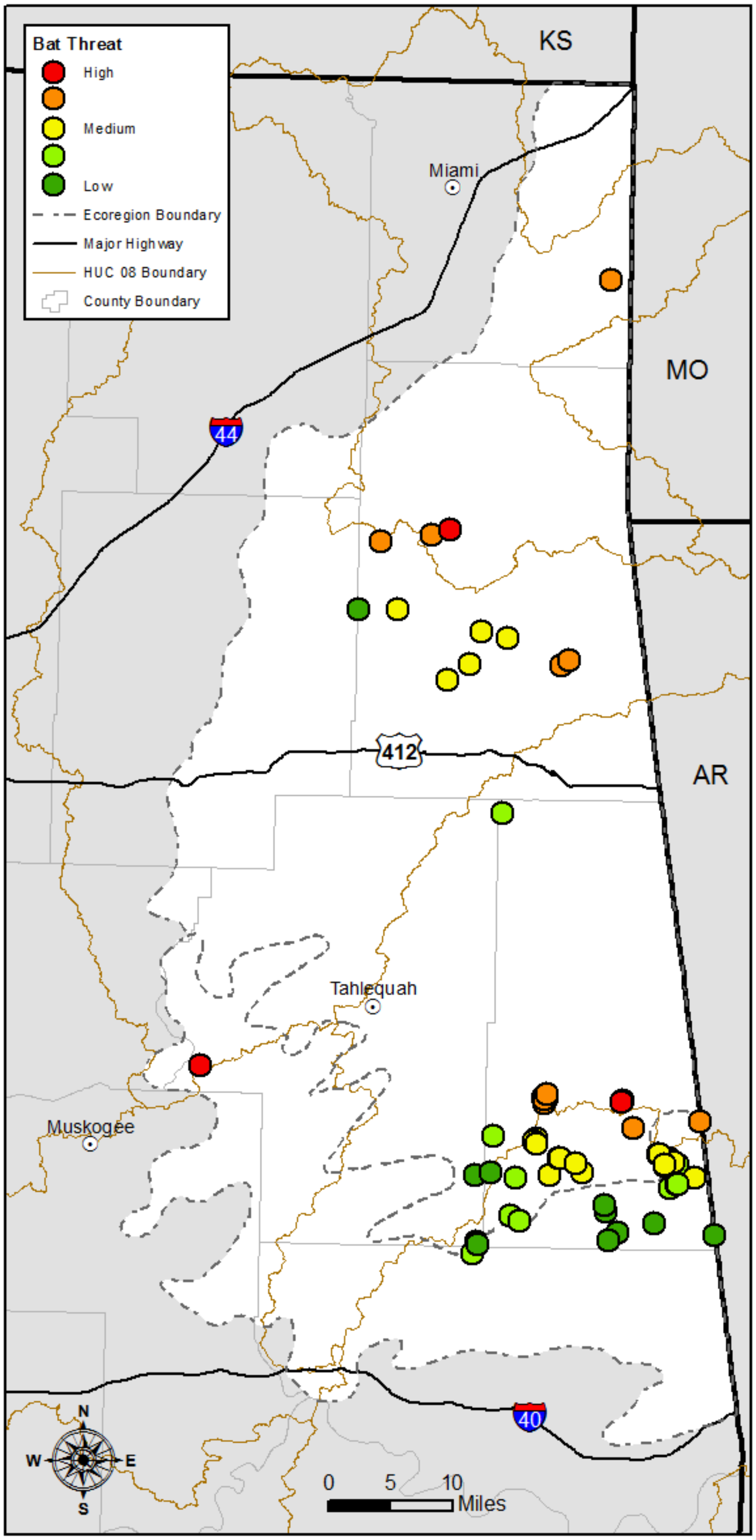

Figure 39. Overall threat scores for sites occupied by bat species. Scores were generated by combining values from visitation indices (RVI) and foraging habitat indices (RBH).

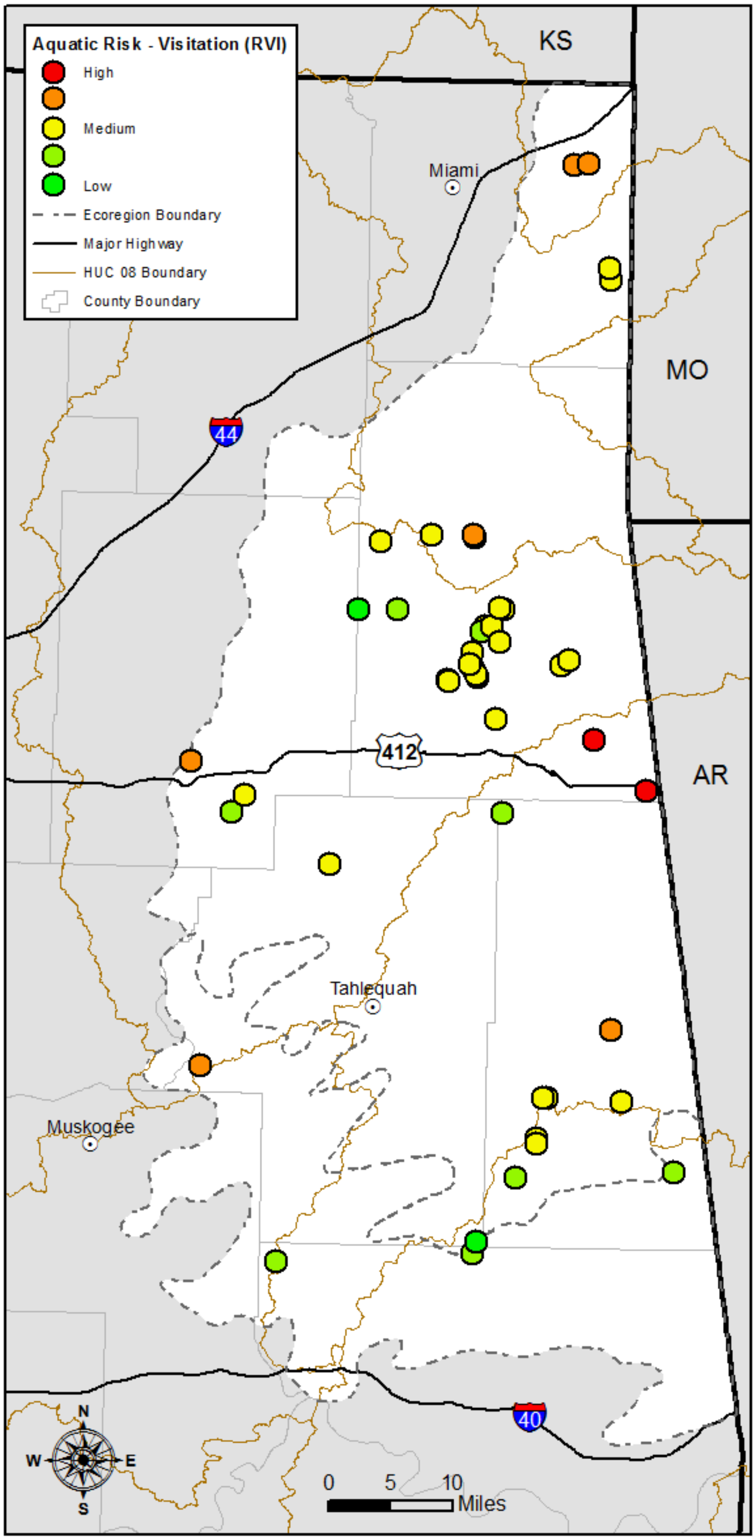

Figure 40. Threat scores generated from visitation indices (RVI) for sites occupied by aquatic cave species.

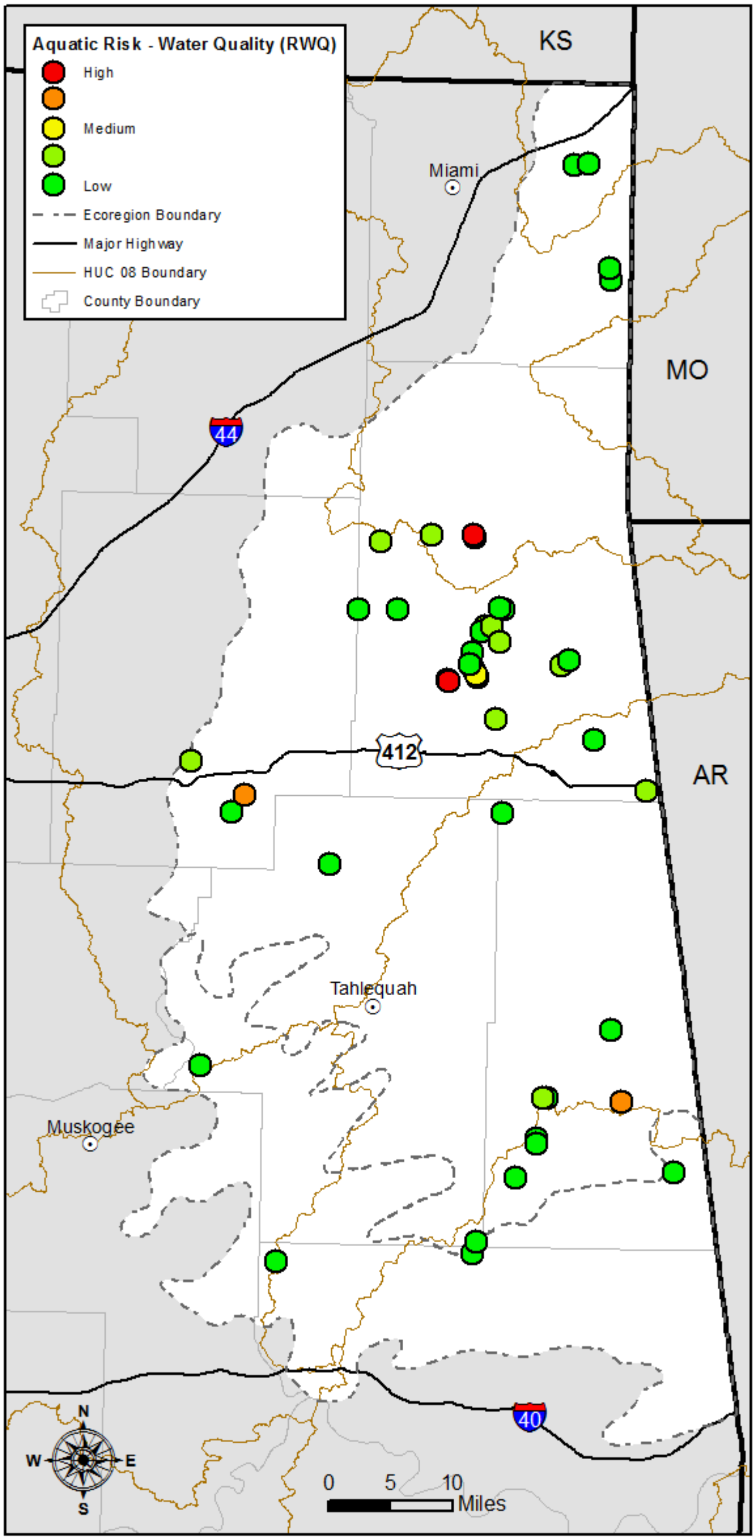

Figure 41. Threat scores generated from water quality and quantity indices (RWQ) for sites occupied by aquatic cave species.

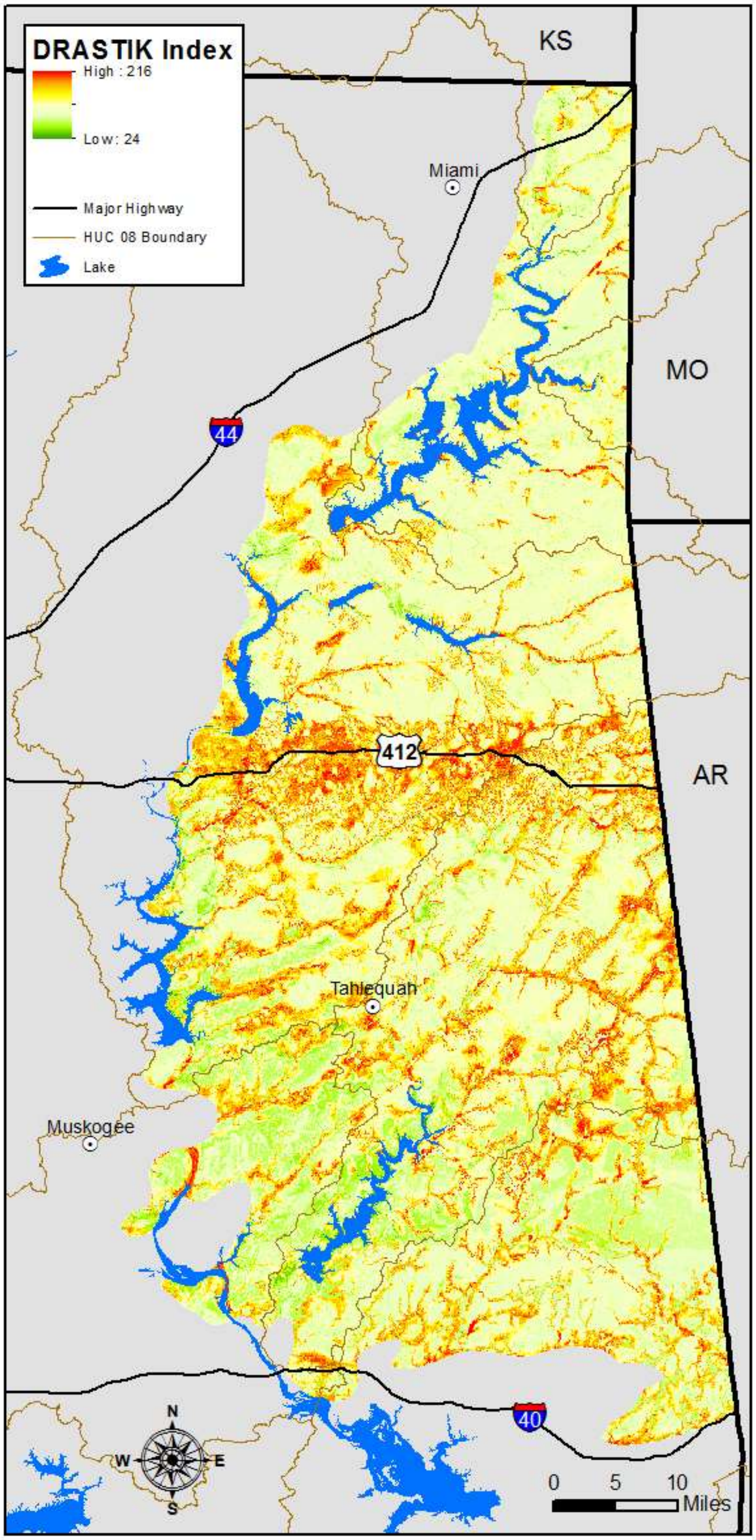

Figure 42. Groundwater vulnerability map, as modeled by DRASTIK, for the Oklahoma Ozarks.

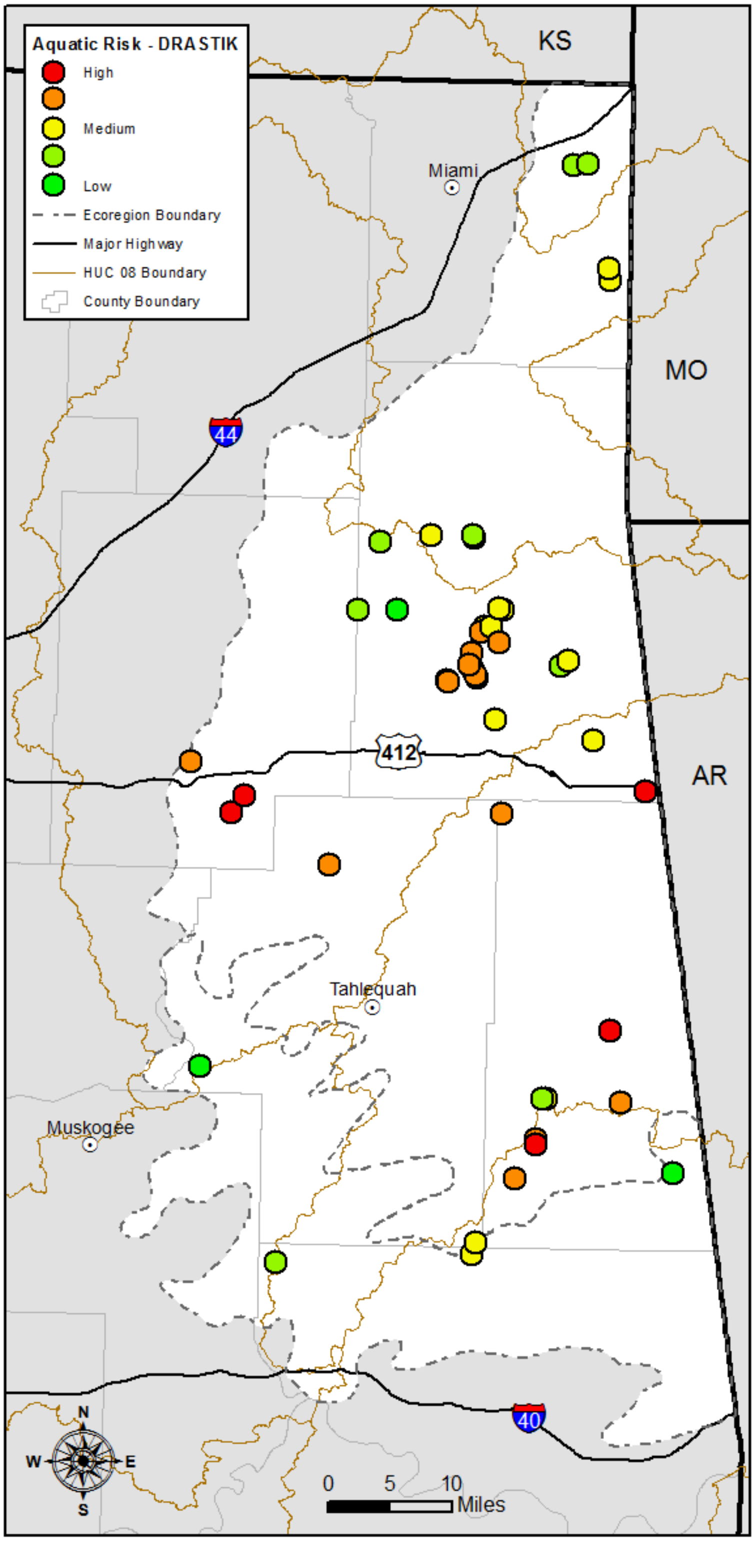

Figure 43. Groundwater vulnerability estimates were generated from the model DRASTIK for each site that contained aquatic cave species.

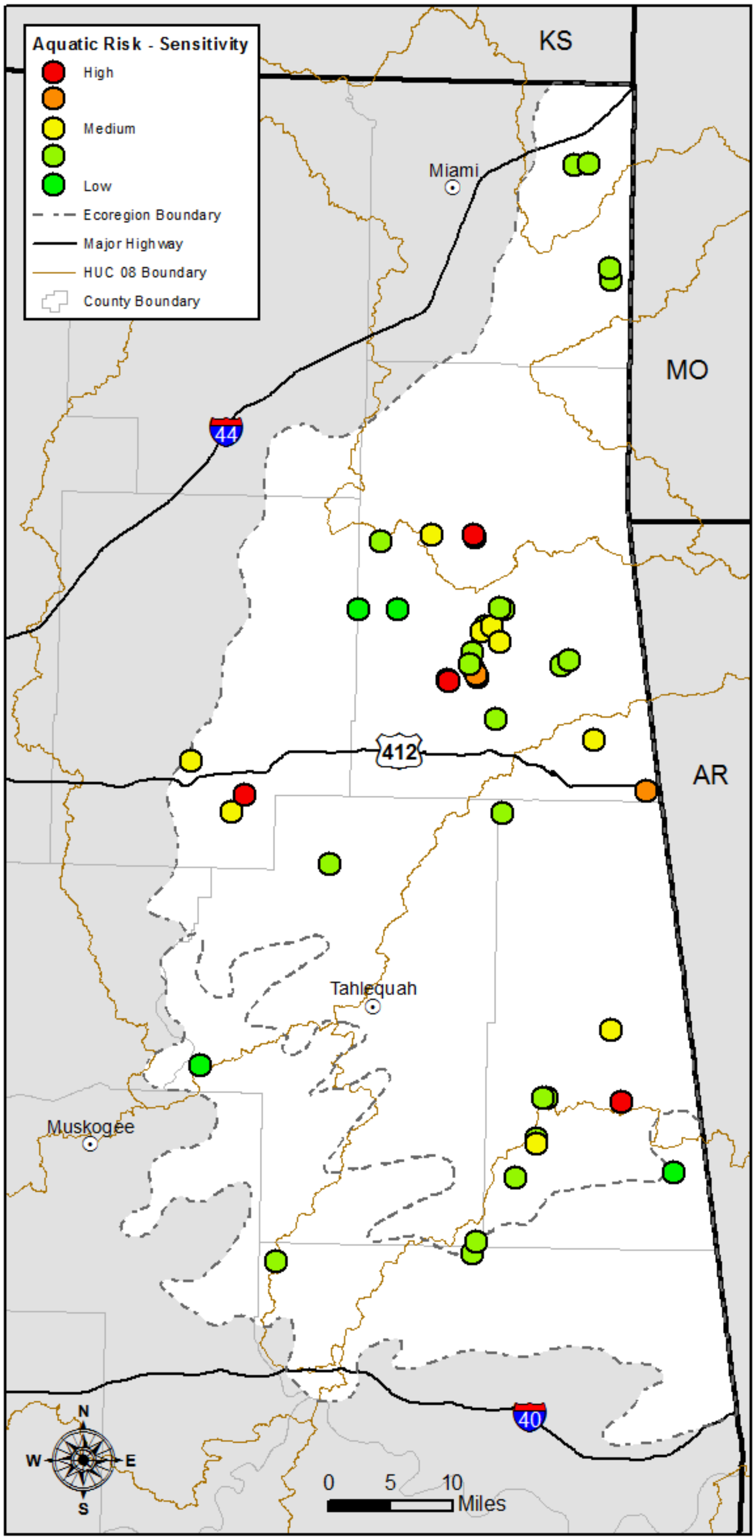

Figure 44. Groundwater sensitivity scores were generated by combining groundwater vulnerability (VULN) and RWQ values for each site that contained aquatic cave species.

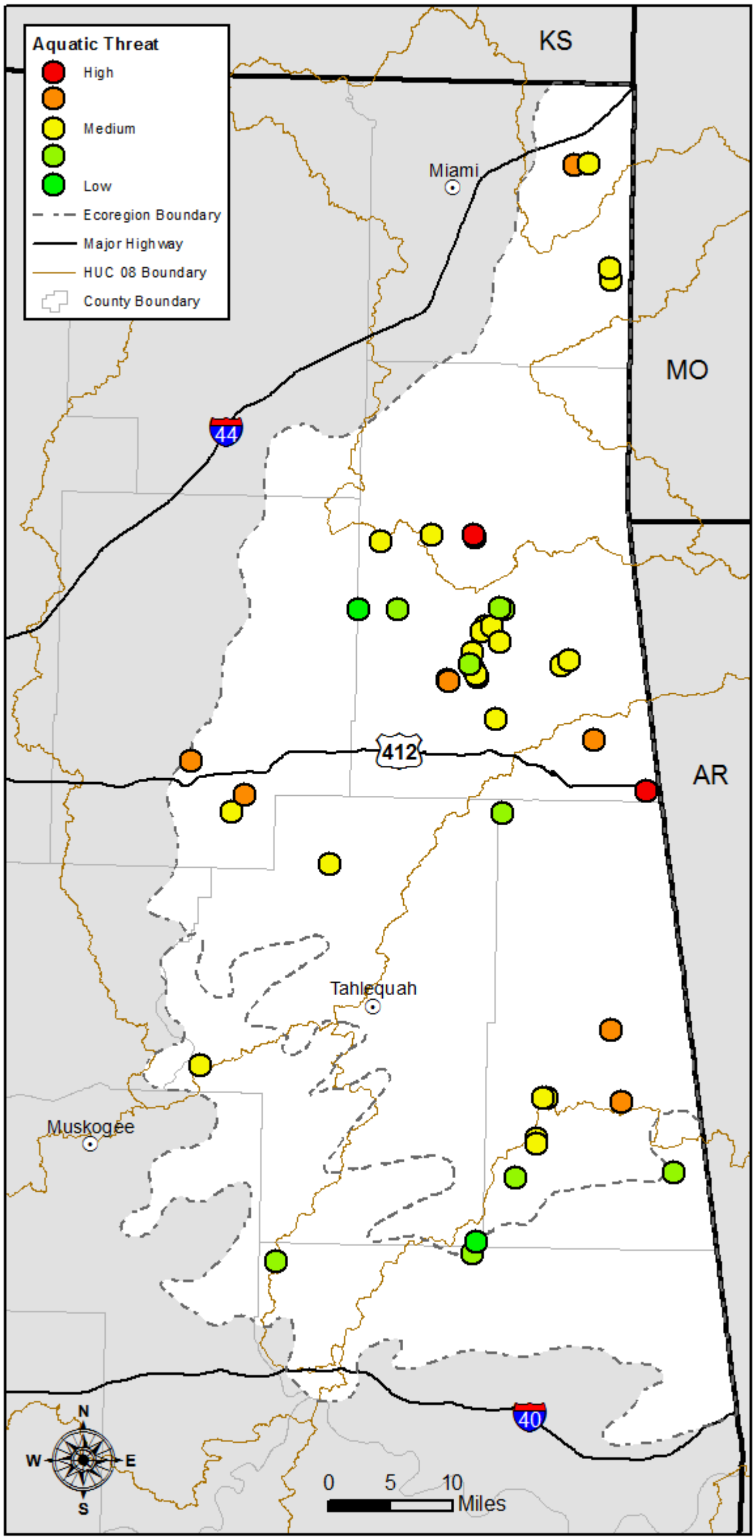

Figure 45. Overall threat scores for sites occupied by aquatic cave species. Scores were generated by combining groundwater sensitivity (SENS) and visitation (RVI) values.

E.2. APPENDICES

APPENDIX A. Descriptions of risk index variables and calculations.

MODEL: Risk: Visitation (RVI)

SUB-MODEL: Population (RVIP)

Index: RVIP_01
Name: Population (Count)
Assessment Area (AA): 10-mile radius from site.
Raw Score: The human population within the AA.
Highest Scaled Score: The site with the lowest human population within its AA (inverted).
Data Sources: US Census Bureau 2010 Census.
Notes: Used population count (chronic) for census block points occurring within the AA.

SUB-MODEL: Access (RVIA)

Index: RVIA_01
Name: Road Access
Assessment Area (AA): 10-mile radius from site.
Raw Score: The length of all roads in the AA
Highest Scaled Score: The site with the least amount of roads within its AA (inverted)
Data Sources: ODOT 2013 All Roads (OK), AHTD 2006 All Roads (AR), MoDOT 2015 Roads (MO), KDOT unknown year (KS).
Notes: Although all sites are within Oklahoma, some areas within a 10-mile radius occurred within Arkansas, Missouri, and Kansas. All road lines were rasterized to 30m cells for improved analysis efficiency. All road types were weighted equally.

SUB-MODEL: Proximity (RVIX)

Index: RVIX_01
Name: Road Proximity
Assessment Area (AA): Site.
Raw Score: The distance from the site to the nearest road
Highest Scaled Score: The site that is farthest from a road
Data Sources: ODOT 2013 All Roads
Notes: The units for this index are feet and the values represent the distance from each cave to the nearest road.

MODEL: Risk: Bat Habitat (RBH)

SUB-MODEL: Forest (RBHF)

Index: RBHF_01
Name: Forest Land Use (Percent)
Assessment Area (AA): 5-mile radius from site
Raw Score: The percent of the AA that has forest land use in the AA
Highest Scaled Score: The site with the highest percent of its AA in forest
Data Sources: USEPA NLCD 2011 (OK, AR, MO).
Notes:

Index: RBHF_02
Name: Forest Edge (Relative)
Assessment Area (AA): 5-mile radius from site
Raw Score: The number of forest edge cells in the AA
Highest Scaled Score: The site with the highest number of forest edge cells
Data Sources: USEPA NLCD 2011 (OK, AR, MO)
Notes: Forest edges were detected with a high-pass filter run on a binary forest land use raster. The raw value of the index is a count of edge cells.

SUB-MODEL: Riparian (RBHR)

Index: RBHR_01
Name: Riparian Forest (Area)
Assessment Area (AA): 5-mile radius from site
Raw Score: The total area of forest cells in the riparian zone in the AA
Highest Scaled Score: The site with the largest area of forest cells in the riparian zone
Data Sources USEPA NLCD 2011 (OK, AR, MO), NHD High Resolution Flowlines, NHD High Resolution Water Bodies
Notes: The riparian zone was defined by rasterizing the High Resolution NHD Flowline and NHD Waterbody vectors layer and the cells within a 1 cell distance of a watercourse or water body were selected to define it. The raw value of the index is the calculated area of forest cells

Index: RBHR_02
Name: Riparian Forest (Percent)
Assessment Area (AA): 5-mile radius from site
Raw Score: The percent of the riparian zone in forest cells in the AA
Highest Scaled Score: The site with the largest area of forest cells in the riparian zone
Data Sources: USEPA NLCD 2011 (OK, AR, MO), NHD High Resolution Flowlines
Notes: The riparian zone was defined by rasterizing the High Resolution NHD Flowline and NHD Waterbody vectors layer and the cells within a 1 cell distance of a watercourse or water body were selected to define it. The raw value of the index is the calculated area of forest cells

<u>MODEL: Risk: Water Quality (RWQ)</u>

SUB-MODEL: Sediment (RWQS)

Index: RWQS_01
Name: Unpaved Road Length
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The total length of unpaved roads
Highest Scaled Score: The site with the shortest length of unpaved roads (inverted)
Data Sources: ODOT 2013 All Roads
Notes: Unpaved roads were summarized and their total length was calculated within the AA.

Index: RWQS_02
Name: Unpaved Road Density
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The density of unpaved roads
Highest Scaled Score: The site with the lowest density of unpaved roads (inverted)
Data Sources: ODOT 2013 All Roads

Notes: Unpaved roads were summarized and their total length was divided by the total area of the AA.

Index: RWQS_03
Name: Forest Land Use (Area)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The total area of forest cells
Highest Scaled Score: The site with the largest amount of forested area
Data Sources: USEPA NLCD 2011
Notes: The calculated area of forest cells within the AA.

Index: RWQS_04
Name: Forest Land Use (Percent)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The percent of the AA in forest cells
Highest Scaled Score: The site with the highest percent of forested area
Data Sources: USEPA NLCD 2011
Notes: The calculated area of forest cells within the AA divided by the total area of the AA.

SUB-MODEL: Nutrients (RWQN)

Index: RWQN_01
Name: Households (Density)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The density of households
Highest Scaled Score: The site with the lowest density of households (inverted)
Data Sources: US Census Bureau 2010 Census.
Notes: Used household count for census block points occurring within the AA. Only blocks outside of city limits were included as this was a surrogate measure of the number of septic systems. It was assumed that incorporated municipalities had managed wastewater facilities. Number of households per pixel was calculated by running a Density tool in ArcGIS and then summarizing each AA.

Index: RWQN_02
Name: CAFO (Chicken Houses Count)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The number of chicken houses
Highest Scaled Score: The site with the smallest number of chicken houses (inverted)
Data Sources: OK 2006 Chicken Houses
Notes: The total number of chicken houses within the AA.

Index: RWQN_03
Name: CAFO (Chicken Houses Density)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The density of chicken houses
Highest Scaled Score: The site with the lowest density of chicken houses (inverted)
Data Sources: OK 2006 Chicken Houses
Notes: The total number of chicken houses within the AA divided by the total area of the AA.

Index: RWQN_04
Name: Pasture Land Use (Area)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The total area of pasture cells

Highest Scaled Score: The site with the smallest amount of pasture area (inverted)
Data Sources: USEPA NLCD 2011
Notes: The calculated area of cool and warm season pasture cells within the AA.

Index: RWQN_05
Name: Pasture Land Use (Percent)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The percent of the AA in pasture cells
Highest Scaled Score: The site with the lowest percent of pasture area (inverted)
Data Sources: USEPA NLCD 2011
Notes: The calculated area of pasture cells within the AA divided by the total area of the AA.

SUB-MODEL: Pollutants (RWQP)

Index: RWQP_01
Name: Paved Roads (Weighted Length)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The total length of paved roads
Highest Scaled Score: The site with the shortest length of weighted paved roads (inverted)
Data Sources: ODOT 2013 All Roads
Notes: Paved roads were summarized and their total length was calculated within the AA. Some roads in the "Miscellaneous" class were included in this index including airport runways and service roads.
Weight: This index is a measure of spill potential along transportation corridors. Road types were weighted based on their traffic volume and road type with "Interstate" receiving the highest weight of 50 and "City" or "County" roads receiving the lowest weight of 1.

Index: RWQP_02
Name: Paved Roads (Weighted Density)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The density of weighted paved roads
Highest Scaled Score: The site with the shortest length of weighted paved roads (inverted)
Data Sources: ODOT 2013 All Roads
Notes: Weighted paved roads were summarized and their total length was calculated within the AA divided by the total area of the AA. Some roads in the "Miscellaneous" class were included in this index including airport runways and service roads.

Index: RWQP_03
Name: Population (Density)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The density of the human population within the AA.
Highest Scaled Score: The site with the lowest human population density within its AA (inverted)
Data Sources: US Census Bureau 2010 Census.
Notes: Used population count (chronic) for census block points occurring within the AA.
Number of people per pixel was calculated by running a Density tool in ArcGIS and then summarizing each AA.

Index: RWQP_04
Name: Environmental Permitted Sites (Count)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The number of environmental permitted sites
Highest Scaled Score: The site with the smallest number of environmental permitted sites (inverted)

Data Sources: ODEQ Environmental Permitted Sites
Notes: The total number of environmental permitted sites within the AA.

Index: RWQP_05
Name: Environmental Permitted Sites (Density)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The density of environmental permitted sites
Highest Scaled Score: The site with the lowest density of environmental permitted sites (inverted)
Data Sources: ODEQ Environmental Permitted Sites
Notes: The total number of environmental permitted sites within the AA divided by the total area of the AA.

SUB-MODEL: Hydrologic Alteration (RWQH)

Index: RWQH_01
Name: Impervious Land Use (Area)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The area of impervious surfaces
Highest Scaled Score: The site with the smallest amount of impervious surfaces area (inverted)
Data Sources: USEPA NLCD 2011.
Notes: The calculated area of impervious cells within the AA divided by the total area of the AA. Impervious was defined as being either the "bare" or any of the "developed" classes from the NLCD 2011 raster, used in the RWQP indices above.

Index: RWQH_02
Name: Impervious Land Use (Percent)
Assessment Area (AA): Dye-traced recharge area/NHD Plus Catchment area
Raw Score: The percent of the AA in impervious surfaces
Highest Scaled Score: The site with the smallest percent of impervious surfaces area (inverted)
Data Sources: USEPA NLCD 2011.
Notes: The calculated area of impervious cells within the AA divided by the total area of the AA. Impervious was defined as being either the "bare" or any of the "developed" classes from the NLCD 2011 raster, used in the RWQP indices above.

APPENDIX B. DRASTIC Parameter ratings.

(D) Depth to Water Table	
Range (ft)	Rating
0	10
1 - 30	9
31 - 50	8
51 - 75	5
76 - 100	3
100+	1

(R) Recharge	
Range	Rating
0	0
1 -6	1
7 - 9	2
10 - 11	3
12 - 13	4
14 - 15	5
16 - 17	6
18 - 19	7
20 - 21	8
22 - 23	9
24 - 28	10

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PRISM (Rainfall in/yr)	
Range	Rating
42 - 45	1
46 - 47	2
48	3
49	4
50	5
51	6
52 - 53	7
54 - 56	8
57 - 59	9
60+	10

+

Ksat (Soil Permeability)	
Range	Rating
0.01 - 0.99	1
1 - 1.9	2
2 - 2.6	3
2.7 - 5.9	4
6 - 8.9	5
9 - 14	6
14.1 - 22.9	7
23 - 71.9	8
72 - 91.9	9
92+	10
0	10

+

(T) Topography (Percent Slope)	
Range	Rating
0 - 1	10
2 - 5	9
6 - 11	5
12 - 17	3
18 +	1

(A) Aquifer Media	
Range	Rating
Cretaceous rocks, Sand and clay	1
Chattanooga Shale (Lower Mississippian and Upper Devonian), Clifty Limestone (Middle Devonian), and Penters Chert (Lower Devonian), Moorefield Formation	4
Alluvium, Terrace deposits, Silt and sand, Wilcox Group	6
Atoka Formation, undivided, Bloyd Shale, and Prairie Grove Member of the Hale Formation, Pitkin Limestone, Fayetteville Shale (including the Wedington Sandstone member), and Batesville Sandstone (including the Hindsville Limestone Member)	7
Dune sand, Gravel	8
Boone Formation, Cason Shale and Fernvale Limestone (Upper Ordovician) and Kimmswick Limestone, Plattin Limestone, and Joachim Dolomite, Cotter and Jefferson City Dolomites, Lafferty, St. Clair and Brassfield Limestones, Powell Dolomite	10

(S) Soil Media	
Range	Rating
Silty Clay	1
Silty Clay Loam	2
Silt Loam	4
Loam	5
Sandy Loam	6
Loamy Sand	7
Sand	8
Riverwash	9
Rock, Water	10

(T) Topography (Percent Slope)	
Range	Rating
0 - 1	10
2 - 5	9
6 - 11	5
12 - 17	3
18 +	1

(I) Impact on Vadose Zone Media	
Range	Rating
0	0
1 - 2	1
3 -4	2
5 - 6	3
7 - 8	4
9 - 10	5
11 - 12	6
13 - 14	7
15 -16	8
17 - 18	9
19 - 20	10

====>

Ksat (Soil Permeability)	
Range	Rating
0.01 - 0.99	1
1 - 1.9	2
2 - 2.6	3
2.7 - 5.9	4
6 - 8.9	5
9 - 14	6
14.1 - 22.9	7
23 - 71.9	8
72 - 91.9	9
92+	10
0	10

+

(D) Depth to Water Table	
Range (ft)	Rating (Dr)
0	10
1 - 30	9
31 - 50	8
51 - 75	5
76 - 100	3
100+	1

(K) Lineament Density	
Range (lineament/sq mi)	Rating
.01 - .26	1
.27 - .73	2
.74 - 1.16	3
1.17 - 1.60	4
1.61 - 2.04	5
2.05 - 2.50	6
2.51 - 3.03	7
3.04 - 3.67	8
3.68 - 4.66	9
4.67 - 7.40	10

APPENDIX C. Raw index values and scaled scores for components of the Visitation Risk Model for each terrestrial cave species population at each site. Scaled values are scaled from 0-1, with 1 being the score with the most ecological benefit. Threat scores (THREAT Scaled column) discussed in the text are generated by subtracting scaled values from 1 (e.g. [1- (RVI Scaled)] equals overall threat from visitation). Descriptions of abbreviations used in this table can be found in Appendix A.

Species	Site	RVIP_01 Raw	RVIP_01 Scaled	RVIA_01 Raw	RVIA_01 Scaled	RVIX_01 Raw	RVIX_01 Scaled	RVI Raw	RVI Scaled	THREAT Scaled
Hesperochernes occidentalis										
	AD-7	13944.00	0.56	0.03	0.20	0.52	0.16	0.92	0.53	0.47
	DL-41	9925.00	0.69	0.03	0.18	0.20	0.06	0.93	0.53	0.47
	DL-91	18398.00	0.42	0.04	0.05	0.71	0.22	0.69	0.39	0.61
Plethodon angusticlavius										
	AD-14	11705.00	0.63	0.03	0.22	0.52	0.16	1.02	0.58	0.42
Porrhomma cavernicola										
	AD-9	13787.00	0.56	0.03	0.22	0.53	0.17	0.95	0.54	0.46
Pseudosinella dubia										
	AD-14	11705.00	0.63	0.03	0.22	0.52	0.16	1.02	0.58	0.42
Pygmarrhopalites jay										
	CZ-9	31588.00	0.00	0.04	0.02	0.95	0.30	0.32	0.18	0.82
	DL-51	10726.00	0.66	0.03	0.18	0.02	0.01	0.85	0.48	0.52
Speleonycta ozarkensis										
	DL-102	13441.00	0.57	0.03	0.18	3.20	1.00	1.76	1.00	0.00
	DL-119	11300.00	0.64	0.03	0.16	0.18	0.06	0.86	0.49	0.51
Spelobia tenebrarum										
	AD-7	13944.00	0.56	0.03	0.20	0.52	0.16	0.92	0.53	0.47
	AD-8	9096.00	0.71	0.03	0.29	0.29	0.09	1.10	0.62	0.38
	CZ-18	8272.00	0.74	0.02	0.39	1.15	0.36	1.49	0.85	0.15
	DL-148	11459.00	0.64	0.03	0.16	0.37	0.11	0.91	0.52	0.48

Species	Site	RVIP_01 Raw	RVIP_01 Scaled	RVIA_01 Raw	RVIA_01 Scaled	RVIX_01 Raw	RVIX_01 Scaled	RVI Raw	RVI Scaled	THREAT Scaled
	DL-19	9977.00	0.68	0.03	0.19	0.02	0.01	0.88	0.50	0.50
	DL-39	11982.00	0.62	0.04	0.04	0.16	0.05	0.72	0.41	0.59
	DL-74	20527.00	0.35	0.04	0.00	0.35	0.11	0.46	0.26	0.74
	DL-92	12318.00	0.61	0.03	0.18	0.82	0.25	1.05	0.60	0.40
Trigenotyla blacki										
	AD-14	11705.00	0.63	0.03	0.22	0.52	0.16	1.02	0.58	0.42
	DL-3	10526.00	0.67	0.03	0.17	0.28	0.09	0.92	0.52	0.48
	DL-38	14278.00	0.55	0.04	0.11	0.08	0.02	0.68	0.39	0.61
	DL-39	11982.00	0.62	0.04	0.04	0.16	0.05	0.72	0.41	0.59
	DL-91	18398.00	0.42	0.04	0.05	0.71	0.22	0.69	0.39	0.61

APPENDIX D. Raw index values and scaled scores for components of the Visitation Risk Model, Bat Habitat Risk Model, and overall Bat Community Threat Model for each bat species population at each site. Scaled values are scaled from 0-1, with 1 being the score with the most ecological benefit. Threat scores (THREAT Scaled column) discussed in the text are generated by subtracting scaled values from 1 (e.g. [1- (RVI Scaled)] equals overall threat from visitation). Descriptions of abbreviations used in these tables can be found in Appendix A.

Table Appendix D-1. Index values and scaled scores for RVIP_01 Raw through RVI Scaled.

Species	Site	RVIP_01 Raw	RVIP_01 Scaled	RVIA_01 Raw	RVIA_01 Scaled	RVIX_01 Raw	RVIX_01 Scaled	RVI Raw	RVI Scaled
Corynorhinus townsendii ingens									
	AD-10	12604.00	0.60	0.03	0.25	0.35	0.11	0.96	0.55
	AD-118	12080.00	0.62	0.04	0.07	0.35	0.11	0.80	0.46
	AD-12	14806.00	0.53	0.03	0.12	0.34	0.10	0.76	0.44
	AD-127	11576.00	0.64	0.03	0.19	0.78	0.24	1.07	0.61
	AD-13	14863.00	0.53	0.03	0.12	0.62	0.19	0.85	0.49
	AD-134	11711.00	0.63	0.03	0.19	0.93	0.29	1.11	0.64
	AD-14	11704.00	0.63	0.03	0.21	0.52	0.16	1.01	0.58
	AD-142	9980.00	0.69	0.03	0.20	0.34	0.11	0.99	0.57
	AD-15	10350.00	0.67	0.03	0.33	0.78	0.24	1.25	0.72
	AD-16	14649.00	0.54	0.03	0.14	0.23	0.07	0.75	0.43
	AD-17	13118.00	0.59	0.03	0.23	0.83	0.26	1.07	0.61
	AD-18	13144.00	0.59	0.03	0.23	0.94	0.29	1.11	0.63
	AD-19	14618.00	0.54	0.03	0.13	0.41	0.13	0.80	0.46
	AD-206	13357.00	0.58	0.03	0.24	0.78	0.24	1.07	0.61
	AD-215	13857.00	0.56	0.04	0.10	0.81	0.25	0.92	0.52
	AD-24	14786.00	0.53	0.03	0.12	0.25	0.08	0.74	0.42
	AD-25	14748.00	0.54	0.03	0.13	0.32	0.10	0.76	0.44
	AD-29	14584.00	0.54	0.04	0.04	0.69	0.22	0.79	0.45
	AD-3	13812.00	0.56	0.03	0.20	0.47	0.15	0.92	0.52
	AD-40	12100.00	0.62	0.03	0.18	0.53	0.16	0.96	0.55

Species	Site	RVIP_01 Raw	RVIP_01 Scaled	RVIA_01 Raw	RVIA_01 Scaled	RVIX_01 Raw	RVIX_01 Scaled	RVI Raw	RVI Scaled
	AD-42	12070.00	0.62	0.03	0.18	0.48	0.15	0.95	0.54
	AD-51	13004.00	0.59	0.03	0.24	0.31	0.10	0.92	0.53
	AD-53	7913.00	0.75	0.02	0.39	0.28	0.09	1.23	0.71
	AD-54	14585.00	0.54	0.04	0.04	0.56	0.17	0.75	0.43
	AD-57	7907.00	0.75	0.02	0.42	0.26	0.08	1.25	0.72
	AD-6	13861.00	0.56	0.03	0.21	1.00	0.31	1.08	0.62
	AD-65	9626.00	0.70	0.03	0.33	1.59	0.50	1.53	0.87
	AD-69	12045.00	0.62	0.03	0.30	0.33	0.10	1.02	0.58
	AD-7	13944.00	0.56	0.03	0.19	0.52	0.16	0.92	0.52
	AD-76	9672.00	0.70	0.03	0.34	1.88	0.59	1.63	0.93
	AD-87	11560.00	0.64	0.03	0.19	0.02	0.01	0.83	0.48
	AD-89	11619.00	0.63	0.03	0.19	0.07	0.02	0.85	0.49
	AD-9	13714.00	0.57	0.03	0.21	0.53	0.17	0.94	0.54
	AD-92	11708.00	0.63	0.03	0.18	0.81	0.25	1.07	0.61
	AD-93	11671.00	0.63	0.03	0.18	0.74	0.23	1.04	0.60
	AD-95	11580.00	0.63	0.03	0.18	0.75	0.23	1.05	0.60
	AD-T1	7195.00	0.77	0.02	0.42	0.70	0.22	1.41	0.81
	AD-T11	10091.00	0.68	0.02	0.38	0.92	0.29	1.35	0.77
	AD-T12	10489.00	0.67	0.03	0.36	1.04	0.33	1.35	0.77
	AD-T13	10911.00	0.66	0.03	0.22	0.35	0.11	0.99	0.57
	AD-T14	10799.00	0.66	0.03	0.22	0.40	0.12	1.00	0.57
	AD-T15	7351.00	0.77	0.03	0.35	1.43	0.45	1.57	0.90
	AD-T5	11092.00	0.65	0.03	0.22	0.39	0.12	1.00	0.57
	AD-T6	10917.00	0.66	0.03	0.23	0.26	0.08	0.96	0.55
	AD-T8	6615.00	0.79	0.02	0.45	0.37	0.11	1.35	0.77
	AD-T9	7471.00	0.76	0.03	0.28	1.73	0.54	1.59	0.91
	CZ-18	8265.00	0.74	0.02	0.38	1.15	0.36	1.48	0.85

Species	Site	RVIP_01 Raw	RVIP_01 Scaled	RVIA_01 Raw	RVIA_01 Scaled	RVIX_01 Raw	RVIX_01 Scaled	RVI Raw	RVI Scaled
	CZ-19	8229.00	0.74	0.02	0.39	1.06	0.33	1.46	0.84
	DL-21	10081.00	0.68	0.03	0.20	0.03	0.01	0.89	0.51
	DL-4	10559.00	0.67	0.03	0.15	0.31	0.10	0.92	0.53
	SQ-1	8366.00	0.74	0.02	0.38	0.08	0.03	1.14	0.65
Myotis grisescens									
	AD-14	11704.00	0.63	0.03	0.21	0.52	0.16	1.01	0.58
	AD-15	10350.00	0.67	0.03	0.33	0.78	0.24	1.25	0.72
	AD-6	13861.00	0.56	0.03	0.21	1.00	0.31	1.08	0.62
	AD-7	13944.00	0.56	0.03	0.19	0.52	0.16	0.92	0.52
	AD-8	9097.00	0.71	0.03	0.28	0.29	0.09	1.09	0.62
	AD-9	13714.00	0.57	0.03	0.21	0.53	0.17	0.94	0.54
	CZ-18	8265.00	0.74	0.02	0.38	1.15	0.36	1.48	0.85
	CZ-9	31725.00	0.00	0.04	0.01	0.95	0.30	0.30	0.17
	DL-105	11095.00	0.65	0.03	0.17	0.38	0.12	0.94	0.54
	DL-2	20524.00	0.35	0.04	0.00	0.44	0.14	0.49	0.28
	DL-21	10081.00	0.68	0.03	0.20	0.03	0.01	0.89	0.51
	DL-38	14244.00	0.55	0.04	0.09	0.08	0.02	0.67	0.38
	DL-39	11982.00	0.62	0.04	0.03	0.16	0.05	0.70	0.40
	DL-47	11776.00	0.63	0.04	0.03	0.40	0.12	0.78	0.45
	DL-48/49	11781.00	0.63	0.04	0.03	0.37	0.12	0.77	0.44
	DL-8	10020.00	0.68	0.03	0.18	0.42	0.13	0.99	0.57
	DL-91	18417.00	0.42	0.04	0.04	0.71	0.22	0.68	0.39
	DL-92	12343.00	0.61	0.03	0.17	0.82	0.25	1.04	0.59
	OT-4	13950.00	0.56	0.04	0.02	0.06	0.02	0.60	0.35
	SQ-1	8366.00	0.74	0.02	0.38	0.08	0.03	1.14	0.65
Myotis septentrionalis									
	AD-10	12604.00	0.60	0.03	0.25	0.35	0.11	0.96	0.55

Species	Site	RVIP_01 Raw	RVIP_01 Scaled	RVIA_01 Raw	RVIA_01 Scaled	RVIX_01 Raw	RVIX_01 Scaled	RVI Raw	RVI Scaled
	AD-14	11704.00	0.63	0.03	0.21	0.52	0.16	1.01	0.58
	AD-15	10350.00	0.67	0.03	0.33	0.78	0.24	1.25	0.72
	AD-17	13118.00	0.59	0.03	0.23	0.83	0.26	1.07	0.61
	AD-8	9097.00	0.71	0.03	0.28	0.29	0.09	1.09	0.62
	CZ-18	8265.00	0.74	0.02	0.38	1.15	0.36	1.48	0.85
	DL-102	13447.00	0.58	0.03	0.17	3.20	1.00	1.75	1.00
	DL-21	10081.00	0.68	0.03	0.20	0.03	0.01	0.89	0.51
	DL-39	11982.00	0.62	0.04	0.03	0.16	0.05	0.70	0.40
	SQ-1	8366.00	0.74	0.02	0.38	0.08	0.03	1.14	0.65
Myotis sodalis									
	AD-8	9097.00	0.71	0.03	0.28	0.29	0.09	1.09	0.62
	AD-9	13714.00	0.57	0.03	0.21	0.53	0.17	0.94	0.54
	DL-39	11982.00	0.62	0.04	0.03	0.16	0.05	0.70	0.40
	DL-91	18417.00	0.42	0.04	0.04	0.71	0.22	0.68	0.39

Table Appendix D-2. Index values and scaled scores for RBHF_01 Raw through RBHR_02 Scaled.

Species	Site	RBHF_01 Raw	RBHF_01 Scaled	RBHF_02 Raw	RBHF_02 Scaled	RBHF Raw	RBHF Scaled	RBHR_01 Raw	RBHR_01 Scaled	RBHR_02 Raw	RBHR_02 Scaled
C. t. ingens											
	AD-10	0.64	0.76	1423170.00	0.81	1.57	0.90	12402000.00	0.80	0.61	0.73
	AD-118	0.60	0.71	1087650.00	0.62	1.33	0.76	11677500.00	0.76	0.61	0.74
	AD-12	0.49	0.58	1311660.00	0.75	1.33	0.76	10728000.00	0.69	0.51	0.62
	AD-127	0.70	0.83	1184220.00	0.68	1.51	0.86	11700000.00	0.76	0.68	0.82
	AD-13	0.48	0.57	1305930.00	0.75	1.32	0.75	10581300.00	0.68	0.51	0.61
	AD-134	0.72	0.85	1169940.00	0.67	1.52	0.87	11943900.00	0.77	0.69	0.84
	AD-14	0.75	0.90	1158060.00	0.66	1.56	0.89	12796200.00	0.83	0.74	0.90
	AD-142	0.81	0.96	997530.00	0.57	1.53	0.87	12886200.00	0.83	0.80	0.96

Species	Site	RBHF_01 Raw	RBHF_01 Scaled	RBHF_02 Raw	RBHF_02 Scaled	RBHF Raw	RBHF Scaled	RBHR_01 Raw	RBHR_01 Scaled	RBHR_02 Raw	RBHR_02 Scaled
	AD-15	0.76	0.90	1354350.00	0.77	1.67	0.95	13629600.00	0.88	0.70	0.84
	AD-16	0.50	0.60	1310520.00	0.75	1.35	0.77	10810800.00	0.70	0.52	0.63
	AD-17	0.62	0.74	1340610.00	0.76	1.50	0.86	11336400.00	0.73	0.58	0.70
	AD-18	0.62	0.73	1349400.00	0.77	1.50	0.86	11319300.00	0.73	0.58	0.69
	AD-19	0.50	0.59	1319790.00	0.75	1.35	0.77	10848600.00	0.70	0.52	0.63
	AD-206	0.67	0.80	1385790.00	0.79	1.59	0.91	13575600.00	0.88	0.65	0.79
	AD-215	0.46	0.55	1230660.00	0.70	1.25	0.71	8600400.00	0.56	0.49	0.59
	AD-24	0.49	0.58	1309920.00	0.75	1.32	0.76	10735200.00	0.69	0.51	0.61
	AD-25	0.49	0.59	1315920.00	0.75	1.34	0.76	10862100.00	0.70	0.52	0.62
	AD-29	0.39	0.46	1244880.00	0.71	1.17	0.67	7880400.00	0.51	0.43	0.52
	AD-3	0.63	0.75	1305990.00	0.75	1.49	0.85	11806200.00	0.76	0.60	0.73
	AD-40	0.64	0.77	1265070.00	0.72	1.49	0.85	10773000.00	0.70	0.63	0.76
	AD-42	0.64	0.76	1266210.00	0.72	1.49	0.85	10728000.00	0.69	0.63	0.76
	AD-51	0.62	0.74	1356150.00	0.77	1.51	0.86	11327400.00	0.73	0.60	0.72
	AD-53	0.78	0.93	1339590.00	0.76	1.70	0.97	14199300.00	0.92	0.73	0.88
	AD-54	0.39	0.46	1237020.00	0.71	1.17	0.67	7875000.00	0.51	0.43	0.52
	AD-57	0.77	0.92	1383600.00	0.79	1.71	0.97	13683600.00	0.88	0.71	0.86
	AD-6	0.63	0.75	1310130.00	0.75	1.49	0.85	12056400.00	0.78	0.62	0.74
	AD-65	0.78	0.92	1333740.00	0.76	1.68	0.96	14073300.00	0.91	0.76	0.91
	AD-69	0.68	0.81	1440450.00	0.82	1.64	0.93	12599100.00	0.81	0.64	0.77
	AD-7	0.61	0.73	1284960.00	0.73	1.46	0.84	11565900.00	0.75	0.60	0.72
	AD-76	0.78	0.93	1300680.00	0.74	1.67	0.95	14095800.00	0.91	0.74	0.90
	AD-87	0.72	0.85	1173060.00	0.67	1.52	0.87	11709900.00	0.76	0.70	0.85
	AD-89	0.72	0.85	1175880.00	0.67	1.52	0.87	11764800.00	0.76	0.71	0.85
	AD-9	0.63	0.75	1309770.00	0.75	1.50	0.86	11847600.00	0.77	0.61	0.74
	AD-92	0.69	0.82	1183530.00	0.68	1.50	0.86	11422800.00	0.74	0.67	0.81
	AD-93	0.68	0.81	1200300.00	0.68	1.50	0.85	11247300.00	0.73	0.66	0.80

Species	Site	RBHF_01 Raw	RBHF_01 Scaled	RBHF_02 Raw	RBHF_02 Scaled	RBHF Raw	RBHF Scaled	RBHR_01 Raw	RBHR_01 Scaled	RBHR_02 Raw	RBHR_02 Scaled
	AD-95	0.69	0.82	1187910.00	0.68	1.50	0.85	11352600.00	0.73	0.67	0.81
	AD-T1	0.79	0.94	1364970.00	0.78	1.72	0.98	14705100.00	0.95	0.78	0.94
	AD-T11	0.75	0.90	1398990.00	0.80	1.69	0.97	13612500.00	0.88	0.72	0.86
	AD-T12	0.74	0.88	1365060.00	0.78	1.66	0.95	13434300.00	0.87	0.70	0.85
	AD-T13	0.80	0.96	1084200.00	0.62	1.58	0.90	13250700.00	0.86	0.79	0.95
	AD-T14	0.81	0.96	1065120.00	0.61	1.57	0.90	13175100.00	0.85	0.80	0.96
	AD-T15	0.84	1.00	1191000.00	0.68	1.68	0.96	15464700.00	1.00	0.83	1.00
	AD-T5	0.80	0.95	1095420.00	0.62	1.58	0.90	13416300.00	0.87	0.79	0.95
	AD-T6	0.81	0.97	1106490.00	0.63	1.60	0.91	13756500.00	0.89	0.80	0.97
	AD-T8	0.78	0.92	1450740.00	0.83	1.75	1.00	14095800.00	0.91	0.78	0.94
	AD-T9	0.83	0.99	993570.00	0.57	1.56	0.89	13566600.00	0.88	0.82	0.99
	CZ-18	0.79	0.94	1346040.00	0.77	1.71	0.97	13311000.00	0.86	0.76	0.91
	CZ-19	0.78	0.93	1353570.00	0.77	1.71	0.97	13014000.00	0.84	0.75	0.91
	DL-21	0.73	0.87	1319940.00	0.75	1.62	0.92	14751900.00	0.95	0.74	0.90
	DL-4	0.69	0.82	1257930.00	0.72	1.54	0.88	15064200.00	0.97	0.71	0.86
	SQ-1	0.77	0.91	1418820.00	0.81	1.72	0.98	12605400.00	0.82	0.75	0.90
Myotis grisescens											
	AD-14	0.75	0.90	1158060.00	0.66	1.56	0.89	12796200.00	0.83	0.74	0.90
	AD-15	0.76	0.90	1354350.00	0.77	1.67	0.95	13629600.00	0.88	0.70	0.84
	AD-6	0.63	0.75	1310130.00	0.75	1.49	0.85	12056400.00	0.78	0.62	0.74
	AD-7	0.61	0.73	1284960.00	0.73	1.46	0.84	11565900.00	0.75	0.60	0.72
	AD-8	0.61	0.73	1752720.00	1.00	1.73	0.99	15006600.00	0.97	0.59	0.72
	AD-9	0.63	0.75	1309770.00	0.75	1.50	0.86	11847600.00	0.77	0.61	0.74
	CZ-18	0.79	0.94	1346040.00	0.77	1.71	0.97	13311000.00	0.86	0.76	0.91
	CZ-9	0.45	0.53	1225440.00	0.70	1.23	0.70	10394100.00	0.67	0.47	0.56
	DL-105	0.73	0.87	1205100.00	0.69	1.56	0.89	14978700.00	0.97	0.75	0.91
	DL-2	0.46	0.55	1482630.00	0.85	1.39	0.79	9092700.00	0.59	0.52	0.63

Species	Site	RBHF_01 Raw	RBHF_01 Scaled	RBHF_02 Raw	RBHF_02 Scaled	RBHF Raw	RBHF Scaled	RBHR_01 Raw	RBHR_01 Scaled	RBHR_02 Raw	RBHR_02 Scaled
	DL-21	0.73	0.87	1319940.00	0.75	1.62	0.92	14751900.00	0.95	0.74	0.90
	DL-38	0.43	0.51	1347090.00	0.77	1.28	0.73	10399500.00	0.67	0.57	0.69
	DL-39	0.53	0.63	1217250.00	0.69	1.32	0.76	14554800.00	0.94	0.66	0.80
	DL-47	0.51	0.61	1211820.00	0.69	1.30	0.74	14023800.00	0.91	0.65	0.78
	DL-48/49	0.51	0.61	1210560.00	0.69	1.30	0.74	14004900.00	0.91	0.65	0.78
	DL-8	0.68	0.81	1250520.00	0.71	1.52	0.87	13245300.00	0.86	0.71	0.85
	DL-91	0.45	0.53	1428690.00	0.82	1.35	0.77	9304200.00	0.60	0.53	0.64
	DL-92	0.64	0.76	1159110.00	0.66	1.42	0.81	13414500.00	0.87	0.69	0.83
	OT-4	0.47	0.56	1327080.00	0.76	1.32	0.75	11835000.00	0.77	0.51	0.62
	SQ-1	0.77	0.91	1418820.00	0.81	1.72	0.98	12605400.00	0.82	0.75	0.90
Myotis septentrionalis											
	AD-10	0.64	0.76	1423170.00	0.81	1.57	0.90	12402000.00	0.80	0.61	0.73
	AD-14	0.75	0.90	1158060.00	0.66	1.56	0.89	12796200.00	0.83	0.74	0.90
	AD-15	0.76	0.90	1354350.00	0.77	1.67	0.95	13629600.00	0.88	0.70	0.84
	AD-17	0.62	0.74	1340610.00	0.76	1.50	0.86	11336400.00	0.73	0.58	0.70
	AD-8	0.61	0.73	1752720.00	1.00	1.73	0.99	15006600.00	0.97	0.59	0.72
	CZ-18	0.79	0.94	1346040.00	0.77	1.71	0.97	13311000.00	0.86	0.76	0.91
	DL-102	0.62	0.74	1149900.00	0.66	1.39	0.79	14340600.00	0.93	0.69	0.83
	DL-21	0.73	0.87	1319940.00	0.75	1.62	0.92	14751900.00	0.95	0.74	0.90
	DL-39	0.53	0.63	1217250.00	0.69	1.32	0.76	14554800.00	0.94	0.66	0.80
	SQ-1	0.77	0.91	1418820.00	0.81	1.72	0.98	12605400.00	0.82	0.75	0.90
Myotis sodalis											
	AD-8	0.61	0.73	1752720.00	1.00	1.73	0.99	15006600.00	0.97	0.59	0.72
	AD-9	0.63	0.75	1309770.00	0.75	1.50	0.86	11847600.00	0.77	0.61	0.74
	DL-39	0.53	0.63	1217250.00	0.69	1.32	0.76	14554800.00	0.94	0.66	0.80
	DL-91	0.45	0.53	1428690.00	0.82	1.35	0.77	9304200.00	0.60	0.53	0.64

Table Appendix D-3. Index values and scaled scores for RBHR Raw through THREAT Scaled.

Species	Site	RBHR Raw	RBHR Scaled	RBH Raw	RBH Scaled	TBC Raw	TBC Scaled	THREAT Scaled
C. townsendii ingens								
	AD-10	1.53	0.77	1.66	0.85	1.40	0.74	0.26
	AD-118	1.50	0.75	1.51	0.77	1.23	0.65	0.35
	AD-12	1.31	0.65	1.41	0.72	1.16	0.61	0.39
	AD-127	1.57	0.79	1.65	0.84	1.45	0.77	0.23
	AD-13	1.30	0.65	1.40	0.71	1.20	0.63	0.37
	AD-134	1.61	0.81	1.67	0.85	1.49	0.79	0.21
	AD-14	1.72	0.86	1.75	0.89	1.47	0.78	0.22
	AD-142	1.80	0.90	1.77	0.90	1.47	0.77	0.23
	AD-15	1.72	0.86	1.82	0.93	1.64	0.87	0.13
	AD-16	1.33	0.66	1.43	0.73	1.16	0.61	0.39
	AD-17	1.43	0.71	1.57	0.80	1.42	0.75	0.25
	AD-18	1.43	0.71	1.57	0.80	1.44	0.76	0.24
	AD-19	1.33	0.66	1.43	0.73	1.19	0.63	0.37
	AD-206	1.66	0.83	1.74	0.89	1.50	0.79	0.21
	AD-215	1.15	0.57	1.29	0.66	1.18	0.62	0.38
	AD-24	1.31	0.65	1.41	0.72	1.14	0.60	0.40
	AD-25	1.33	0.66	1.43	0.73	1.17	0.61	0.39
	AD-29	1.03	0.51	1.18	0.60	1.06	0.56	0.44
	AD-3	1.49	0.75	1.60	0.82	1.34	0.71	0.29
	AD-40	1.46	0.73	1.58	0.81	1.36	0.71	0.29
	AD-42	1.46	0.73	1.58	0.81	1.35	0.71	0.29
	AD-51	1.45	0.73	1.59	0.81	1.34	0.71	0.29
	AD-53	1.80	0.90	1.87	0.95	1.66	0.87	0.13
	AD-54	1.03	0.51	1.18	0.60	1.03	0.54	0.46
	AD-57	1.75	0.87	1.85	0.94	1.66	0.87	0.13

Species	Site	RBHR Raw	RBHR Scaled	RBH Raw	RBH Scaled	TBC Raw	TBC Scaled	THREAT Scaled
	AD-6	1.52	0.76	1.61	0.82	1.44	0.76	0.24
	AD-65	1.82	0.91	1.87	0.96	1.83	0.96	0.04
	AD-69	1.58	0.79	1.73	0.88	1.47	0.77	0.23
	AD-7	1.47	0.74	1.57	0.80	1.33	0.70	0.30
	AD-76	1.81	0.90	1.86	0.95	1.88	0.99	0.01
	AD-87	1.61	0.80	1.67	0.85	1.33	0.70	0.30
	AD-89	1.61	0.81	1.68	0.86	1.34	0.71	0.29
	AD-9	1.50	0.75	1.61	0.82	1.36	0.72	0.28
	AD-92	1.55	0.78	1.63	0.83	1.44	0.76	0.24
	AD-93	1.53	0.76	1.62	0.83	1.42	0.75	0.25
	AD-95	1.54	0.77	1.63	0.83	1.43	0.75	0.25
	AD-T1	1.89	0.95	1.93	0.99	1.79	0.94	0.06
	AD-T11	1.74	0.87	1.84	0.94	1.71	0.90	0.10
	AD-T12	1.72	0.86	1.81	0.92	1.70	0.89	0.11
	AD-T13	1.81	0.90	1.80	0.92	1.49	0.78	0.22
	AD-T14	1.81	0.91	1.80	0.92	1.50	0.79	0.21
	AD-T15	2.00	1.00	1.96	1.00	1.90	1.00	0.00
	AD-T5	1.82	0.91	1.81	0.92	1.50	0.79	0.21
	AD-T6	1.85	0.93	1.84	0.94	1.49	0.79	0.21
	AD-T8	1.85	0.93	1.93	0.98	1.76	0.93	0.07
	AD-T9	1.86	0.93	1.82	0.93	1.84	0.97	0.03
	CZ-18	1.77	0.89	1.86	0.95	1.80	0.95	0.05
	CZ-19	1.75	0.88	1.85	0.94	1.78	0.94	0.06
	DL-21	1.85	0.93	1.85	0.94	1.46	0.77	0.23
	DL-4	1.83	0.92	1.79	0.92	1.44	0.76	0.24
	SQ-1	1.72	0.86	1.84	0.94	1.59	0.84	0.16

Species	Site	RBHR Raw	RBHR Scaled	RBH Raw	RBH Scaled	TBC Raw	TBC Scaled	THREAT Scaled
Myotis grisescens								
	AD-14	1.72	0.86	1.75	0.89	1.47	0.78	0.22
	AD-15	1.72	0.86	1.82	0.93	1.64	0.87	0.13
	AD-6	1.52	0.76	1.61	0.82	1.44	0.76	0.24
	AD-7	1.47	0.74	1.57	0.80	1.33	0.70	0.30
	AD-8	1.69	0.84	1.83	0.93	1.56	0.82	0.18
	AD-9	1.50	0.75	1.61	0.82	1.36	0.72	0.28
	CZ-18	1.77	0.89	1.86	0.95	1.80	0.95	0.05
	CZ-9	1.24	0.62	1.32	0.67	0.85	0.45	0.55
	DL-105	1.88	0.94	1.83	0.93	1.47	0.77	0.23
	DL-2	1.21	0.61	1.40	0.72	1.00	0.53	0.47
	DL-21	1.85	0.93	1.85	0.94	1.46	0.77	0.23
	DL-38	1.37	0.68	1.42	0.72	1.11	0.58	0.42
	DL-39	1.74	0.87	1.62	0.83	1.23	0.65	0.35
	DL-47	1.69	0.84	1.59	0.81	1.26	0.66	0.34
	DL-48/49	1.69	0.84	1.59	0.81	1.25	0.66	0.34
	DL-8	1.71	0.86	1.72	0.88	1.45	0.76	0.24
	DL-91	1.24	0.62	1.39	0.71	1.10	0.58	0.42
	DL-92	1.70	0.85	1.66	0.85	1.44	0.76	0.24
	OT-4	1.38	0.69	1.44	0.74	1.08	0.57	0.43
	SQ-1	1.72	0.86	1.84	0.94	1.59	0.84	0.16
Myotis septentrionalis								
	AD-10	1.53	0.77	1.66	0.85	1.40	0.74	0.26
	AD-14	1.72	0.86	1.75	0.89	1.47	0.78	0.22
	AD-15	1.72	0.86	1.82	0.93	1.64	0.87	0.13
	AD-17	1.43	0.71	1.57	0.80	1.42	0.75	0.25
	AD-8	1.69	0.84	1.83	0.93	1.56	0.82	0.18

Species	Site	RBHR Raw	RBHR Scaled	RBH Raw	RBH Scaled	TBC Raw	TBC Scaled	THREAT Scaled
	CZ-18	1.77	0.89	1.86	0.95	1.80	0.95	0.05
	DL-102	1.76	0.88	1.67	0.85	1.85	0.98	0.02
	DL-21	1.85	0.93	1.85	0.94	1.46	0.77	0.23
	DL-39	1.74	0.87	1.62	0.83	1.23	0.65	0.35
	SQ-1	1.72	0.86	1.84	0.94	1.59	0.84	0.16
Myotis sodalis								
	AD-8	1.69	0.84	1.83	0.93	1.56	0.82	0.18
	AD-9	1.50	0.75	1.61	0.82	1.36	0.72	0.28
	DL-39	1.74	0.87	1.62	0.83	1.23	0.65	0.35
	DL-91	1.24	0.62	1.39	0.71	1.10	0.58	0.42

APPENDIX E. Raw index values and scaled scores for components of the Visitation Risk Model, Water Quality and Quantity Risk Model, Groundwater Vulnerability Model, Groundwater Sensitivity Model, and overall Aquatic Community Threat Model for each aquatic cave species population at each site. Scaled values are scaled from 0-1, with 1 being the score with the most ecological benefit. Threat scores (THREAT Scaled column) discussed in the text are generated by subtracting scaled values from 1 (e.g. [1- (RVI Scaled)] equals overall threat from visitation). Descriptions of abbreviations used in these tables can be found in Appendix A.

Table Appendix E-1. Index values and scaled scores for RWQP_01 Raw through RWQP_03 Scaled.

Species	Site	RWQP_01 Raw	RWQP_01 Scaled	RWQP_02 Raw	RWQP_02 Scaled	RWQP_03 Raw	RWQP_03 Scaled
Amblyopsis rosae							
	DL-119	23.27	0.94	0.56	0.91	811688.00	0.85
	DL-148	0.00	1.00	0.00	1.00	1327.00	1.00
	DL-21	385.56	0.00	6.21	0.00	1632268.00	0.69
	DL-22	385.56	0.00	6.21	0.00	1632268.00	0.69
	DL-38	1.99	0.99	0.49	0.92	145748.00	0.97
	DL-39	0.00	1.00	0.00	1.00	151421.00	0.97
	DL-47	1.21	1.00	0.29	0.98	96970.00	0.99
	DL-48/49	1.21	1.00	0.29	0.98	96970.00	0.99
	DL-74	171.63	0.55	4.90	0.21	5249808.00	0.00
	DL-91	30.35	0.92	5.05	0.19	345326.00	0.93
	OT-19	12.42	0.96	0.56	0.95	831331.00	0.90
Caecidotea ancyla							
	AD-137	0.81	1.00	1.03	0.92	94993.00	0.99
	AD-9	1.20	1.00	0.49	0.96	194353.00	0.98
	CZ-9	0.00	1.00	0.00	1.00	86707.00	0.99
	DL-148	0.00	1.00	0.00	1.00	1327.00	1.00
	DL-19	16.25	0.95	9.90	0.20	60180.00	0.99
	DL-21	385.56	0.00	6.21	0.00	1632268.00	0.69
	DL-39	0.00	1.00	0.00	1.00	151421.00	0.97
	DL-51	1.13	1.00	0.94	0.92	14734.00	1.00
	DL-97	0.00	1.00	0.00	1.00	1327.00	1.00

Species	Site	RWQP_01 Raw	RWQP_01 Scaled	RWQP_02 Raw	RWQP_02 Scaled	RWQP_03 Raw	RWQP_03 Scaled
Caecidotea antricola							
	DL-39	0.00	1.00	0.00	1.00	151421.00	0.97
	DL-74	171.63	0.55	4.90	0.21	5249808.00	0.00
	DL-92	3.24	0.99	0.65	0.95	24918.00	1.00
Caecidotea mackini							
	DL-148	0.00	1.00	0.00	1.00	1327.00	1.00
Caecidotea macropropoda							
	AD-8	2.22	0.99	0.54	0.96	215025.00	0.97
	Cave behind Hardwicks house	2.22	0.99	0.54	0.96	215025.00	0.97
	Cave behind old greenhouse	2.22	0.99	0.54	0.96	215025.00	0.97
	Gum Spring	30.86	0.90	5.92	0.52	334454.00	0.96
	Unnamed spring next to Christian School Cave	2.22	0.99	0.54	0.96	215025.00	0.97
Caecidotea simulator							
	AD-54	120.84	0.62	11.96	0.03	7960414.00	0.00
	Carroll's Grotto	171.63	0.55	4.90	0.21	5249808.00	0.00
	Matthews et al. (1983) Spring # 37	5.98	0.98	0.42	0.97	465238.00	0.94
	OT-4	4.50	0.99	0.48	0.96	135770.00	0.98
	Unnamed cave	1.81	0.99	0.24	0.98	207234.00	0.97
Caecidotea steevesi							
	AD-19	0.24	1.00	0.09	0.99	160829.00	0.98
	AD-9	1.20	1.00	0.49	0.96	194353.00	0.98
Caecidotea stiladactyla							
	AD-14	0.00	1.00	0.00	1.00	144507.00	0.98
	Cave near Brush Creek Bridge	0.00	1.00	0.00	1.00	61759.00	0.99
	DL-51	1.13	1.00	0.94	0.92	14734.00	1.00
	DL-59	9.68	0.97	3.35	0.73	39454.00	1.00

Species	Site	RWQP_01 Raw	RWQP_01 Scaled	RWQP_02 Raw	RWQP_02 Scaled	RWQP_03 Raw	RWQP_03 Scaled
	DL-8	13.98	0.96	2.17	0.83	173124.00	0.98
	DL-92	3.24	0.99	0.65	0.95	24918.00	1.00
Cambarus subterraneus							
	Carroll's Grotto	171.63	0.55	4.90	0.21	5249808.00	0.00
	DL-38	1.99	0.99	0.49	0.92	145748.00	0.97
	DL-74	171.63	0.55	4.90	0.21	5249808.00	0.00
	DL-91	30.35	0.92	5.05	0.19	345326.00	0.93
Cambarus tartarus							
	DL-119	23.27	0.94	0.56	0.91	811688.00	0.85
	DL-148	0.00	1.00	0.00	1.00	1327.00	1.00
	DL-39	0.00	1.00	0.00	1.00	151421.00	0.97
Dendrocoelopsis americana							
	AD-8	2.22	0.99	0.54	0.96	215025.00	0.97
	Christian School Annex Cave	2.22	0.99	0.54	0.96	215025.00	0.97
	DL-91	30.35	0.92	5.05	0.19	345326.00	0.93
	OT-19	12.42	0.96	0.56	0.95	831331.00	0.90
Eurycea spelaea							
	AD-14	0.00	1.00	0.00	1.00	144507.00	0.98
	AD-8	2.22	0.99	0.54	0.96	215025.00	0.97
	Cave near Brush Creek Bridge	0.00	1.00	0.00	1.00	61759.00	0.99
	CZ-18	0.00	1.00	0.00	1.00	22793.00	1.00
	DL-102	0.00	1.00	0.00	1.00	0.00	1.00
	DL-104	0.00	1.00	0.00	1.00	6190.00	1.00
	DL-105	2.21	0.99	0.67	0.95	15678.00	1.00
	DL-119	23.27	0.94	0.56	0.91	811688.00	0.85
	DL-148	0.00	1.00	0.00	1.00	1327.00	1.00
	DL-19	16.25	0.95	9.90	0.20	60180.00	0.99

Species	Site	RWQP_01 Raw	RWQP_01 Scaled	RWQP_02 Raw	RWQP_02 Scaled	RWQP_03 Raw	RWQP_03 Scaled
	DL-21	385.56	0.00	6.21	0.00	1632268.00	0.69
	DL-38	1.99	0.99	0.49	0.92	145748.00	0.97
	DL-39	0.00	1.00	0.00	1.00	151421.00	0.97
	DL-47	1.21	1.00	0.29	0.98	96970.00	0.99
	DL-51	1.13	1.00	0.94	0.92	14734.00	1.00
	DL-59	9.68	0.97	3.35	0.73	39454.00	1.00
	DL-64	0.00	1.00	0.00	1.00	61759.00	0.99
	DL-74	171.63	0.55	4.90	0.21	5249808.00	0.00
	DL-8	13.98	0.96	2.17	0.83	173124.00	0.98
	DL-91	30.35	0.92	5.05	0.19	345326.00	0.93
	DL-92	3.24	0.99	0.65	0.95	24918.00	1.00
	Krause Spring	19.44	0.94	7.76	0.37	52492.00	0.99
	Luck Spring	0.00	1.00	0.00	1.00	85441.00	0.99
	OT-19	12.42	0.96	0.56	0.95	831331.00	0.90
	OT-4	4.50	0.99	0.48	0.96	135770.00	0.98
	SQ-1	3.16	0.99	0.94	0.92	37293.00	1.00
	Unnamed spring 5 mi. S of Locust Grove	1.64	0.99	1.00	0.92	91511.00	0.99
	Unnamed spring next to Christian School Cave	2.22	0.99	0.54	0.96	215025.00	0.97
Stygobromus alabamensis							
	AD-14	0.00	1.00	0.00	1.00	144507.00	0.98
	AD-54	120.84	0.62	11.96	0.03	7960414.00	0.00
	AD-7	0.39	1.00	0.36	0.97	30363.00	1.00
	AD-9	1.20	1.00	0.49	0.96	194353.00	0.98
	DL-39	0.00	1.00	0.00	1.00	151421.00	0.97
	Matthews et al. (1983) Spring # 13	14.21	0.95	12.39	0.00	346690.00	0.96

Species	Site	RWQP_01 Raw	RWQP_01 Scaled	RWQP_02 Raw	RWQP_02 Scaled	RWQP_03 Raw	RWQP_03 Scaled
	Matthews et al. (1983) Spring # 37	5.98	0.98	0.42	0.97	465238.00	0.94
	Seeps 4.6 mi. W of Locust Grove	27.78	0.91	4.72	0.62	541844.00	0.93
Stygobromus bowmani							
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	315.19	0.00	7.29	0.41	2244463.00	0.72
Stygobromus onondagaensis							
	AD-14	0.00	1.00	0.00	1.00	144507.00	0.98
	AD-24	0.96	1.00	0.99	0.92	25511.00	1.00
	CZ-9	0.00	1.00	0.00	1.00	86707.00	0.99
	DL-39	0.00	1.00	0.00	1.00	151421.00	0.97
	DL-46	0.00	1.00	0.00	1.00	78504.00	0.99
	DL-8	13.98	0.96	2.17	0.83	173124.00	0.98
	Matthews et al. (1983) Spring # 37	5.98	0.98	0.42	0.97	465238.00	0.94
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	315.19	0.00	7.29	0.41	2244463.00	0.72
Stygobromus ozarkensis							
	AD-137	0.81	1.00	1.03	0.92	94993.00	0.99
	AD-15	2.45	0.99	0.38	0.97	140848.00	0.98
	AD-9	1.20	1.00	0.49	0.96	194353.00	0.98
	CZ-9	0.00	1.00	0.00	1.00	86707.00	0.99
	DL-39	0.00	1.00	0.00	1.00	151421.00	0.97
	DL-46	0.00	1.00	0.00	1.00	78504.00	0.99
	DL-64	0.00	1.00	0.00	1.00	61759.00	0.99
	DL-92	3.24	0.99	0.65	0.95	24918.00	1.00
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	315.19	0.00	7.29	0.41	2244463.00	0.72
	Seeps 4.6 mi. W of Locust Grove	27.78	0.91	4.72	0.62	541844.00	0.93

Table Appendix E-2. Index values and scaled scores for RWQP_04 Raw through RWQP Scaled.

Species	Site	RWQP_04 Raw	RWQP_04 Scaled	RWQP_05 Raw	RWQP_05 Scaled	RWQP Raw	RWQP Scaled
Amblyopsis rosae							
	DL-119	1.00	0.67	0.02	0.72	4.08	0.82
	DL-148	0.00	1.00	0.00	1.00	5.00	1.00
	DL-21	2.00	0.33	0.03	0.62	1.65	0.33
	DL-22	2.00	0.33	0.03	0.62	1.65	0.33
	DL-38	0.00	1.00	0.00	1.00	4.89	0.98
	DL-39	0.00	1.00	0.00	1.00	4.97	0.99
	DL-47	0.00	1.00	0.00	1.00	4.96	0.99
	DL-48/49	0.00	1.00	0.00	1.00	4.96	0.99
	DL-74	3.00	0.00	0.09	0.00	0.77	0.15
	DL-91	0.00	1.00	0.00	1.00	4.04	0.81
	OT-19	0.00	1.00	0.00	1.00	4.81	0.96
Caecidotea ancyla							
	AD-137	0.00	1.00	0.00	1.00	4.90	0.98
	AD-9	0.00	1.00	0.00	1.00	4.93	0.99
	CZ-9	0.00	1.00	0.00	1.00	4.99	1.00
	DL-148	0.00	1.00	0.00	1.00	5.00	1.00
	DL-19	0.00	1.00	0.00	1.00	4.14	0.83
	DL-21	2.00	0.33	0.03	0.62	1.65	0.33
	DL-39	0.00	1.00	0.00	1.00	4.97	0.99
	DL-51	0.00	1.00	0.00	1.00	4.92	0.98
	DL-97	0.00	1.00	0.00	1.00	5.00	1.00
Caecidotea antricola							
	DL-39	0.00	1.00	0.00	1.00	4.97	0.99
	DL-74	3.00	0.00	0.09	0.00	0.77	0.15

Species	Site	RWQP_04 Raw	RWQP_04 Scaled	RWQP_05 Raw	RWQP_05 Scaled	RWQP Raw	RWQP Scaled
	DL-92	0.00	1.00	0.00	1.00	4.93	0.99
Caecidotea mackini							
	DL-148	0.00	1.00	0.00	1.00	5.00	1.00
Caecidotea macropropoda							
	AD-8	0.00	1.00	0.00	1.00	4.92	0.98
	Cave behind Hardwicks house	0.00	1.00	0.00	1.00	4.92	0.98
	Cave behind old greenhouse	0.00	1.00	0.00	1.00	4.92	0.98
	Gum Spring	0.00	1.00	0.00	1.00	4.38	0.88
	Unnamed spring next to Christian School Cave	0.00	1.00	0.00	1.00	4.92	0.98
Caecidotea simulator							
	AD-54	3.00	0.00	0.30	0.57	1.22	0.24
	Carroll's Grotto	3.00	0.00	0.09	0.00	0.77	0.15
	Matthews et al. (1983) Spring # 37	0.00	1.00	0.00	1.00	4.89	0.98
	OT-4	0.00	1.00	0.00	1.00	4.93	0.99
	Unnamed cave	0.00	1.00	0.00	1.00	4.95	0.99
Caecidotea steevesi							
	AD-19	0.00	1.00	0.00	1.00	4.97	0.99
	AD-9	0.00	1.00	0.00	1.00	4.93	0.99
Caecidotea stiladactyla							
	AD-14	0.00	1.00	0.00	1.00	4.98	1.00
	Cave near Brush Creek Bridge	0.00	1.00	0.00	1.00	4.99	1.00
	DL-51	0.00	1.00	0.00	1.00	4.92	0.98
	DL-59	2.00	0.33	0.69	0.00	3.03	0.61
	DL-8	0.00	1.00	0.00	1.00	4.76	0.95
	DL-92	0.00	1.00	0.00	1.00	4.93	0.99

Species	Site	RWQP_04 Raw	RWQP_04 Scaled	RWQP_05 Raw	RWQP_05 Scaled	RWQP Raw	RWQP Scaled
Cambarus subterraneus							
	Carroll's Grotto	3.00	0.00	0.09	0.00	0.77	0.15
	DL-38	0.00	1.00	0.00	1.00	4.89	0.98
	DL-74	3.00	0.00	0.09	0.00	0.77	0.15
	DL-91	0.00	1.00	0.00	1.00	4.04	0.81
Cambarus tartarus							
	DL-119	1.00	0.67	0.02	0.72	4.08	0.82
	DL-148	0.00	1.00	0.00	1.00	5.00	1.00
	DL-39	0.00	1.00	0.00	1.00	4.97	0.99
Dendrocoelopsis americana							
	AD-8	0.00	1.00	0.00	1.00	4.92	0.98
	Christian School Annex Cave	0.00	1.00	0.00	1.00	4.92	0.98
	DL-91	0.00	1.00	0.00	1.00	4.04	0.81
	OT-19	0.00	1.00	0.00	1.00	4.81	0.96
Eurycea spelaea							
	AD-14	0.00	1.00	0.00	1.00	4.98	1.00
	AD-8	0.00	1.00	0.00	1.00	4.92	0.98
	Cave near Brush Creek Bridge	0.00	1.00	0.00	1.00	4.99	1.00
	CZ-18	0.00	1.00	0.00	1.00	5.00	1.00
	DL-102	0.00	1.00	0.00	1.00	5.00	1.00
	DL-104	0.00	1.00	0.00	1.00	5.00	1.00
	DL-105	0.00	1.00	0.00	1.00	4.94	0.99
	DL-119	1.00	0.67	0.02	0.72	4.08	0.82
	DL-148	0.00	1.00	0.00	1.00	5.00	1.00
	DL-19	0.00	1.00	0.00	1.00	4.14	0.83
	DL-21	2.00	0.33	0.03	0.62	1.65	0.33
	DL-38	0.00	1.00	0.00	1.00	4.89	0.98

Species	Site	RWQP_04 Raw	RWQP_04 Scaled	RWQP_05 Raw	RWQP_05 Scaled	RWQP Raw	RWQP Scaled
	DL-39	0.00	1.00	0.00	1.00	4.97	0.99
	DL-47	0.00	1.00	0.00	1.00	4.96	0.99
	DL-51	0.00	1.00	0.00	1.00	4.92	0.98
	DL-59	2.00	0.33	0.69	0.00	3.03	0.61
	DL-64	0.00	1.00	0.00	1.00	4.99	1.00
	DL-74	3.00	0.00	0.09	0.00	0.77	0.15
	DL-8	0.00	1.00	0.00	1.00	4.76	0.95
	DL-91	0.00	1.00	0.00	1.00	4.04	0.81
	DL-92	0.00	1.00	0.00	1.00	4.93	0.99
	Krause Spring	0.00	1.00	0.00	1.00	4.31	0.86
	Luck Spring	0.00	1.00	0.00	1.00	4.99	1.00
	OT-19	0.00	1.00	0.00	1.00	4.81	0.96
	OT-4	0.00	1.00	0.00	1.00	4.93	0.99
	SQ-1	0.00	1.00	0.00	1.00	4.91	0.98
	Unnamed spring 5 mi. S of Locust Grove	0.00	1.00	0.00	1.00	4.90	0.98
	Unnamed spring next to Christian School Cave	0.00	1.00	0.00	1.00	4.92	0.98
Stygobromus alabamensis							
	AD-14	0.00	1.00	0.00	1.00	4.98	1.00
	AD-54	3.00	0.00	0.30	0.57	1.22	0.24
	AD-7	0.00	1.00	0.00	1.00	4.97	0.99
	AD-9	0.00	1.00	0.00	1.00	4.93	0.99
	DL-39	0.00	1.00	0.00	1.00	4.97	0.99
	Matthews et al. (1983) Spring # 13	0.00	1.00	0.00	1.00	3.91	0.78
	Matthews et al. (1983) Spring # 37	0.00	1.00	0.00	1.00	4.89	0.98
	Seeps 4.6 mi. W of Locust Grove	1.00	0.67	0.17	0.75	3.88	0.78

Species	Site	RWQP_04 Raw	RWQP_04 Scaled	RWQP_05 Raw	RWQP_05 Scaled	RWQP Raw	RWQP Scaled
Stygobromus bowmani							
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	0.00	1.00	0.00	1.00	3.13	0.63
Stygobromus onondagaensis							
	AD-14	0.00	1.00	0.00	1.00	4.98	1.00
	AD-24	0.00	1.00	0.00	1.00	4.91	0.98
	CZ-9	0.00	1.00	0.00	1.00	4.99	1.00
	DL-39	0.00	1.00	0.00	1.00	4.97	0.99
	DL-46	0.00	1.00	0.00	1.00	4.99	1.00
	DL-8	0.00	1.00	0.00	1.00	4.76	0.95
	Matthews et al. (1983) Spring # 37	0.00	1.00	0.00	1.00	4.89	0.98
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	0.00	1.00	0.00	1.00	3.13	0.63
Stygobromus ozarkensis							
	AD-137	0.00	1.00	0.00	1.00	4.90	0.98
	AD-15	0.00	1.00	0.00	1.00	4.94	0.99
	AD-9	0.00	1.00	0.00	1.00	4.93	0.99
	CZ-9	0.00	1.00	0.00	1.00	4.99	1.00
	DL-39	0.00	1.00	0.00	1.00	4.97	0.99
	DL-46	0.00	1.00	0.00	1.00	4.99	1.00
	DL-64	0.00	1.00	0.00	1.00	4.99	1.00
	DL-92	0.00	1.00	0.00	1.00	4.93	0.99
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	0.00	1.00	0.00	1.00	3.13	0.63
	Seeps 4.6 mi. W of Locust Grove	1.00	0.67	0.17	0.75	3.88	0.78

Table Appendix E-3. Index values and scaled scores for RWQH_01 through RWQH Scaled.

Species	Site	RWQH_01 Raw	RWQH_01 Scaled	RWQH_02 Raw	RWQH_02 Scaled	RWQH Raw	RWQH Scaled
Amblyopsis rosae							
	DL-119	1331100.00	0.63	0.03	0.97	1.60	0.80
	DL-148	30600.00	0.99	0.01	0.99	1.98	0.99
	DL-21	3573000.00	0.01	0.06	0.94	0.95	0.47
	DL-22	3573000.00	0.01	0.06	0.94	0.95	0.47
	DL-38	159300.00	0.96	0.04	0.96	1.92	0.96
	DL-39	105300.00	0.97	0.02	0.98	1.95	0.98
	DL-47	124200.00	0.97	0.03	0.97	1.94	0.97
	DL-48/49	124200.00	0.97	0.03	0.97	1.94	0.97
	DL-74	3591000.00	0.00	0.10	0.90	0.90	0.45
	DL-91	310500.00	0.91	0.05	0.95	1.86	0.93
	OT-19	581400.00	0.86	0.03	0.97	1.83	0.92
Caecidotea ancyla							
	AD-137	38700.00	0.99	0.05	0.95	1.94	0.97
	AD-9	83700.00	0.98	0.03	0.97	1.94	0.97
	CZ-9	27900.00	0.99	0.01	0.99	1.98	0.99
	DL-148	30600.00	0.99	0.01	0.99	1.98	0.99
	DL-19	237600.00	0.94	0.14	0.86	1.80	0.90
	DL-21	3573000.00	0.01	0.06	0.94	0.95	0.47
	DL-39	105300.00	0.97	0.02	0.98	1.95	0.98
	DL-51	45900.00	0.99	0.04	0.96	1.95	0.98
	DL-97	30600.00	0.99	0.01	0.99	1.98	0.99
Caecidotea antricola							
	DL-39	105300.00	0.97	0.02	0.98	1.95	0.98
	DL-74	3591000.00	0.00	0.10	0.90	0.90	0.45
	DL-92	245700.00	0.94	0.05	0.95	1.89	0.95

Species	Site	RWQH_01 Raw	RWQH_01 Scaled	RWQH_02 Raw	RWQH_02 Scaled	RWQH Raw	RWQH Scaled
Caecidotea mackini							
	DL-148	30600.00	0.99	0.01	0.99	1.98	0.99
Caecidotea macropropoda							
	AD-8	137700.00	0.97	0.03	0.97	1.93	0.97
	Cave behind Hardwicks house	137700.00	0.97	0.03	0.97	1.93	0.97
	Cave behind old greenhouse	137700.00	0.97	0.03	0.97	1.93	0.97
	Gum Spring	373500.00	0.91	0.07	0.93	1.84	0.92
	Unnamed spring next to Christian School Cave	137700.00	0.97	0.03	0.97	1.93	0.97
Caecidotea simulator							
	AD-54	4027500.00	0.00	0.40	0.60	0.60	0.30
	Carroll's Grotto	3591000.00	0.00	0.10	0.90	0.90	0.45
	Matthews et al. (1983) Spring # 37	644400.00	0.84	0.05	0.95	1.79	0.90
	OT-4	264600.00	0.93	0.03	0.97	1.91	0.95
	Unnamed cave	189900.00	0.95	0.02	0.98	1.93	0.96
Caecidotea steevesi							
	AD-19	105300.00	0.97	0.04	0.96	1.94	0.97
	AD-9	83700.00	0.98	0.03	0.97	1.94	0.97
Caecidotea stiladactyla							
	AD-14	106200.00	0.97	0.02	0.98	1.96	0.98
	Cave near Brush Creek Bridge	22500.00	0.99	0.01	0.99	1.99	0.99
	DL-51	45900.00	0.99	0.04	0.96	1.95	0.98
	DL-59	243000.00	0.94	0.08	0.92	1.86	0.93
	DL-8	377100.00	0.91	0.06	0.94	1.85	0.92
	DL-92	245700.00	0.94	0.05	0.95	1.89	0.95
Cambarus subterraneus							

Species	Site	RWQH_01 Raw	RWQH_01 Scaled	RWQH_02 Raw	RWQH_02 Scaled	RWQH Raw	RWQH Scaled
	Carroll's Grotto	3591000.00	0.00	0.10	0.90	0.90	0.45
	DL-38	159300.00	0.96	0.04	0.96	1.92	0.96
	DL-74	3591000.00	0.00	0.10	0.90	0.90	0.45
	DL-91	310500.00	0.91	0.05	0.95	1.86	0.93
Cambarus tartarus							
	DL-119	1331100.00	0.63	0.03	0.97	1.60	0.80
	DL-148	30600.00	0.99	0.01	0.99	1.98	0.99
	DL-39	105300.00	0.97	0.02	0.98	1.95	0.98
Dendrocoelopsis americana							
	AD-8	137700.00	0.97	0.03	0.97	1.93	0.97
	Christian School Annex Cave	137700.00	0.97	0.03	0.97	1.93	0.97
	DL-91	310500.00	0.91	0.05	0.95	1.86	0.93
	OT-19	581400.00	0.86	0.03	0.97	1.83	0.92
Eurycea spelaea							
	AD-14	106200.00	0.97	0.02	0.98	1.96	0.98
	AD-8	137700.00	0.97	0.03	0.97	1.93	0.97
	Cave near Brush Creek Bridge	22500.00	0.99	0.01	0.99	1.99	0.99
	CZ-18	1800.00	1.00	0.00	1.00	2.00	1.00
	DL-102	10800.00	1.00	0.02	0.98	1.97	0.99
	DL-104	54900.00	0.99	0.03	0.97	1.96	0.98
	DL-105	101700.00	0.97	0.03	0.97	1.94	0.97
	DL-119	1331100.00	0.63	0.03	0.97	1.60	0.80
	DL-148	30600.00	0.99	0.01	0.99	1.98	0.99
	DL-19	237600.00	0.94	0.14	0.86	1.80	0.90
	DL-21	3573000.00	0.01	0.06	0.94	0.95	0.47
	DL-38	159300.00	0.96	0.04	0.96	1.92	0.96
	DL-39	105300.00	0.97	0.02	0.98	1.95	0.98

Species	Site	RWQH_01 Raw	RWQH_01 Scaled	RWQH_02 Raw	RWQH_02 Scaled	RWQH Raw	RWQH Scaled
	DL-47	124200.00	0.97	0.03	0.97	1.94	0.97
	DL-51	45900.00	0.99	0.04	0.96	1.95	0.98
	DL-59	243000.00	0.94	0.08	0.92	1.86	0.93
	DL-64	22500.00	0.99	0.01	0.99	1.99	0.99
	DL-74	3591000.00	0.00	0.10	0.90	0.90	0.45
	DL-8	377100.00	0.91	0.06	0.94	1.85	0.92
	DL-91	310500.00	0.91	0.05	0.95	1.86	0.93
	DL-92	245700.00	0.94	0.05	0.95	1.89	0.95
	Krause Spring	470700.00	0.88	0.19	0.81	1.70	0.85
	Luck Spring	65700.00	0.98	0.01	0.99	1.97	0.99
	OT-19	581400.00	0.86	0.03	0.97	1.83	0.92
	OT-4	264600.00	0.93	0.03	0.97	1.91	0.95
	SQ-1	156600.00	0.96	0.05	0.95	1.91	0.96
	Unnamed spring 5 mi. S of Locust Grove	99900.00	0.98	0.06	0.94	1.91	0.96
	Unnamed spring next to Christian School Cave	137700.00	0.97	0.03	0.97	1.93	0.97
Stygobromus alabamensis							
	AD-14	106200.00	0.97	0.02	0.98	1.96	0.98
	AD-54	4027500.00	0.00	0.40	0.60	0.60	0.30
	AD-7	27900.00	0.99	0.03	0.97	1.97	0.98
	AD-9	83700.00	0.98	0.03	0.97	1.94	0.97
	DL-39	105300.00	0.97	0.02	0.98	1.95	0.98
	Matthews et al. (1983) Spring # 13	289800.00	0.93	0.25	0.75	1.68	0.84
	Matthews et al. (1983) Spring # 37	644400.00	0.84	0.05	0.95	1.79	0.90
	Seeps 4.6 mi. W of Locust Grove	823500.00	0.80	0.14	0.86	1.66	0.83

Species	Site	RWQH_01 Raw	RWQH_01 Scaled	RWQH_02 Raw	RWQH_02 Scaled	RWQH Raw	RWQH Scaled
Stygobromus bowmani							
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	3095100.00	0.23	0.07	0.93	1.16	0.58
Stygobromus onondagaensis							
	AD-14	106200.00	0.97	0.02	0.98	1.96	0.98
	AD-24	41400.00	0.99	0.04	0.96	1.95	0.97
	CZ-9	27900.00	0.99	0.01	0.99	1.98	0.99
	DL-39	105300.00	0.97	0.02	0.98	1.95	0.98
	DL-46	127800.00	0.97	0.06	0.94	1.91	0.96
	DL-8	377100.00	0.91	0.06	0.94	1.85	0.92
	Matthews et al. (1983) Spring # 37	644400.00	0.84	0.05	0.95	1.79	0.90
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	3095100.00	0.23	0.07	0.93	1.16	0.58
Stygobromus ozarkensis							
	AD-137	38700.00	0.99	0.05	0.95	1.94	0.97
	AD-15	203400.00	0.95	0.03	0.97	1.92	0.96
	AD-9	83700.00	0.98	0.03	0.97	1.94	0.97
	CZ-9	27900.00	0.99	0.01	0.99	1.98	0.99
	DL-39	105300.00	0.97	0.02	0.98	1.95	0.98
	DL-46	127800.00	0.97	0.06	0.94	1.91	0.96
	DL-64	22500.00	0.99	0.01	0.99	1.99	0.99
	DL-92	245700.00	0.94	0.05	0.95	1.89	0.95
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	3095100.00	0.23	0.07	0.93	1.16	0.58
	Seeps 4.6 mi. W of Locust Grove	823500.00	0.80	0.14	0.86	1.66	0.83

Table Appendix E-4. Index values and scaled scores for RWQN_01 Raw through RWQN_03 Scaled.

Species	Site	RWQN_01 Raw	RWQN_01 Scaled	RWQN_02 Raw	RWQN_02 Scaled	RWQN_03 Raw	RWQN_03 Scaled
Amblyopsis rosae							
	DL-119	254930.00	0.87	3.00	0.50	0.07	0.90
	DL-148	403.00	1.00	0.00	1.00	0.00	1.00
	DL-21	580233.00	0.71	6.00	0.00	0.10	0.87
	DL-22	580233.00	0.71	6.00	0.00	0.10	0.87
	DL-38	60806.00	0.97	3.00	0.50	0.74	0.00
	DL-39	47823.00	0.98	1.00	0.83	0.19	0.74
	DL-47	34563.00	0.99	1.00	0.75	0.24	0.66
	DL-48/49	34563.00	0.99	1.00	0.75	0.24	0.66
	DL-74	1982309.00	0.00	1.00	0.83	0.03	0.96
	DL-91	128758.00	0.94	0.00	1.00	0.00	1.00
	OT-19	304293.00	0.90	1.00	0.75	0.04	0.94
Caecidotea ancyla							
	AD-137	29422.00	0.99	0.00	1.00	0.00	1.00
	AD-9	52471.00	0.98	0.00	1.00	0.00	1.00
	CZ-9	31802.00	0.99	0.00	1.00	0.00	1.00
	DL-148	403.00	1.00	0.00	1.00	0.00	1.00
	DL-19	25057.00	0.99	0.00	1.00	0.00	1.00
	DL-21	580233.00	0.71	6.00	0.00	0.10	0.87
	DL-39	47823.00	0.98	1.00	0.83	0.19	0.74
	DL-51	3250.00	1.00	0.00	1.00	0.00	1.00
	DL-97	403.00	1.00	0.00	1.00	0.00	1.00
Caecidotea antricola							
	DL-39	47823.00	0.98	1.00	0.83	0.19	0.74
	DL-74	1982309.00	0.00	1.00	0.83	0.03	0.96
	DL-92	8618.00	1.00	0.00	1.00	0.00	1.00

Species	Site	RWQN_01 Raw	RWQN_01 Scaled	RWQN_02 Raw	RWQN_02 Scaled	RWQN_03 Raw	RWQN_03 Scaled
Caecidotea mackini							
	DL-148	403.00	1.00	0.00	1.00	0.00	1.00
Caecidotea macropropoda							
	AD-8	50379.00	0.98	0.00	1.00	0.00	1.00
	Cave behind Hardwicks house	50379.00	0.98	0.00	1.00	0.00	1.00
	Cave behind old greenhouse	50379.00	0.98	0.00	1.00	0.00	1.00
	Gum Spring	119430.00	0.96	0.00	1.00	0.00	1.00
	Unnamed spring next to Christian School Cave	50379.00	0.98	0.00	1.00	0.00	1.00
Caecidotea simulator							
	AD-54	3019748.00	0.00	0.00	1.00	0.00	1.00
	Carroll's Grotto	1982309.00	0.00	1.00	0.83	0.03	0.96
	Matthews et al. (1983) Spring # 37	169855.00	0.94	0.00	1.00	0.00	1.00
	OT-4	41607.00	0.99	0.00	1.00	0.00	1.00
	Unnamed cave	70805.00	0.98	0.00	1.00	0.00	1.00
Caecidotea steevesi							
	AD-19	51885.00	0.98	2.00	0.50	0.71	0.00
	AD-9	52471.00	0.98	0.00	1.00	0.00	1.00
Caecidotea stiladactyla							
	AD-14	39273.00	0.99	0.00	1.00	0.00	1.00
	Cave near Brush Creek Bridge	16037.00	0.99	0.00	1.00	0.00	1.00
	DL-51	3250.00	1.00	0.00	1.00	0.00	1.00
	DL-59	16008.00	0.99	0.00	1.00	0.00	1.00
	DL-8	66479.00	0.98	0.00	1.00	0.00	1.00
	DL-92	8618.00	1.00	0.00	1.00	0.00	1.00
Cambarus subterraneus							
	Carroll's Grotto	1982309.00	0.00	1.00	0.83	0.03	0.96

Species	Site	RWQN_01 Raw	RWQN_01 Scaled	RWQN_02 Raw	RWQN_02 Scaled	RWQN_03 Raw	RWQN_03 Scaled
	DL-38	60806.00	0.97	3.00	0.50	0.74	0.00
	DL-74	1982309.00	0.00	1.00	0.83	0.03	0.96
	DL-91	128758.00	0.94	0.00	1.00	0.00	1.00
Cambarus tartarus							
	DL-119	254930.00	0.87	3.00	0.50	0.07	0.90
	DL-148	403.00	1.00	0.00	1.00	0.00	1.00
	DL-39	47823.00	0.98	1.00	0.83	0.19	0.74
Dendrocoelopsis americana							
	AD-8	50379.00	0.98	0.00	1.00	0.00	1.00
	Christian School Annex Cave	50379.00	0.98	0.00	1.00	0.00	1.00
	DL-91	128758.00	0.94	0.00	1.00	0.00	1.00
	OT-19	304293.00	0.90	1.00	0.75	0.04	0.94
Eurycea spelaea							
	AD-14	39273.00	0.99	0.00	1.00	0.00	1.00
	AD-8	50379.00	0.98	0.00	1.00	0.00	1.00
	Cave near Brush Creek Bridge	16037.00	0.99	0.00	1.00	0.00	1.00
	CZ-18	6654.00	1.00	0.00	1.00	0.00	1.00
	DL-102	0.00	1.00	0.00	1.00	0.00	1.00
	DL-104	2152.00	1.00	0.00	1.00	0.00	1.00
	DL-105	5033.00	1.00	0.00	1.00	0.00	1.00
	DL-119	254930.00	0.87	3.00	0.50	0.07	0.90
	DL-148	403.00	1.00	0.00	1.00	0.00	1.00
	DL-19	25057.00	0.99	0.00	1.00	0.00	1.00
	DL-21	580233.00	0.71	6.00	0.00	0.10	0.87
	DL-38	60806.00	0.97	3.00	0.50	0.74	0.00
	DL-39	47823.00	0.98	1.00	0.83	0.19	0.74
	DL-47	34563.00	0.99	1.00	0.75	0.24	0.66

Species	Site	RWQN_01 Raw	RWQN_01 Scaled	RWQN_02 Raw	RWQN_02 Scaled	RWQN_03 Raw	RWQN_03 Scaled
	DL-51	3250.00	1.00	0.00	1.00	0.00	1.00
	DL-59	16008.00	0.99	0.00	1.00	0.00	1.00
	DL-64	16037.00	0.99	0.00	1.00	0.00	1.00
	DL-74	1982309.00	0.00	1.00	0.83	0.03	0.96
	DL-8	66479.00	0.98	0.00	1.00	0.00	1.00
	DL-91	128758.00	0.94	0.00	1.00	0.00	1.00
	DL-92	8618.00	1.00	0.00	1.00	0.00	1.00
	Krause Spring	19688.00	0.99	0.00	1.00	0.00	1.00
	Luck Spring	28345.00	0.99	0.00	1.00	0.00	1.00
	OT-19	304293.00	0.90	1.00	0.75	0.04	0.94
	OT-4	41607.00	0.99	0.00	1.00	0.00	1.00
	SQ-1	11042.00	1.00	0.00	1.00	0.00	1.00
	Unnamed spring 5 mi. S of Locust Grove	38253.00	0.99	0.00	1.00	0.00	1.00
	Unnamed spring next to Christian School Cave	50379.00	0.98	0.00	1.00	0.00	1.00
Stygobromus alabamensis							
	AD-14	39273.00	0.99	0.00	1.00	0.00	1.00
	AD-54	3019748.00	0.00	0.00	1.00	0.00	1.00
	AD-7	9658.00	1.00	0.00	1.00	0.00	1.00
	AD-9	52471.00	0.98	0.00	1.00	0.00	1.00
	DL-39	47823.00	0.98	1.00	0.83	0.19	0.74
	Matthews et al. (1983) Spring # 13	124891.00	0.96	0.00	1.00	0.00	1.00
	Matthews et al. (1983) Spring # 37	169855.00	0.94	0.00	1.00	0.00	1.00
	Seeps 4.6 mi. W of Locust Grove	221964.00	0.93	0.00	1.00	0.00	1.00

Species	Site	RWQN_01 Raw	RWQN_01 Scaled	RWQN_02 Raw	RWQN_02 Scaled	RWQN_03 Raw	RWQN_03 Scaled
Stygobromus bowmani							
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	800137.00	0.74	4.00	0.00	0.09	0.87
Stygobromus onondagaensis							
	AD-14	39273.00	0.99	0.00	1.00	0.00	1.00
	AD-24	8818.00	1.00	0.00	1.00	0.00	1.00
	CZ-9	31802.00	0.99	0.00	1.00	0.00	1.00
	DL-39	47823.00	0.98	1.00	0.83	0.19	0.74
	DL-46	27565.00	0.99	0.00	1.00	0.00	1.00
	DL-8	66479.00	0.98	0.00	1.00	0.00	1.00
	Matthews et al. (1983) Spring # 37	169855.00	0.94	0.00	1.00	0.00	1.00
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	800137.00	0.74	4.00	0.00	0.09	0.87
Stygobromus ozarkensis							
	AD-137	29422.00	0.99	0.00	1.00	0.00	1.00
	AD-15	47201.00	0.98	0.00	1.00	0.00	1.00
	AD-9	52471.00	0.98	0.00	1.00	0.00	1.00
	CZ-9	31802.00	0.99	0.00	1.00	0.00	1.00
	DL-39	47823.00	0.98	1.00	0.83	0.19	0.74
	DL-46	27565.00	0.99	0.00	1.00	0.00	1.00
	DL-64	16037.00	0.99	0.00	1.00	0.00	1.00
	DL-92	8618.00	1.00	0.00	1.00	0.00	1.00
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	800137.00	0.74	4.00	0.00	0.09	0.87
	Seeps 4.6 mi. W of Locust Grove	221964.00	0.93	0.00	1.00	0.00	1.00

Table Appendix E-5. Index values and scaled scores for RWQN_04 Raw through RWQH Scaled.

Species	Site	RWQN_04 Raw	RWQN_04 Scaled	RWQN_05 Raw	RWQN_05 Scaled	RWQN Raw	RWQN Scaled
Amblyopsis rosae							
	DL-119	6822900.00	0.68	0.17	0.72	3.68	0.74
	DL-148	450900.00	0.98	0.14	0.76	4.74	0.95
	DL-21	21231900.00	0.00	0.34	0.43	2.00	0.40
	DL-22	21231900.00	0.00	0.34	0.43	2.00	0.40
	DL-38	2404800.00	0.89	0.60	0.00	2.36	0.47
	DL-39	1981800.00	0.91	0.38	0.36	3.82	0.76
	DL-47	1236600.00	0.94	0.30	0.57	3.90	0.78
	DL-48/49	1236600.00	0.94	0.30	0.57	3.90	0.78
	DL-74	16529400.00	0.22	0.47	0.21	2.23	0.45
	DL-91	3316500.00	0.84	0.55	0.08	3.85	0.77
	OT-19	7905600.00	0.59	0.36	0.48	3.66	0.73
Caecidotea ancyla							
	AD-137	492300.00	0.97	0.62	0.09	4.05	0.81
	AD-9	108900.00	0.99	0.04	0.93	4.91	0.98
	CZ-9	201600.00	0.99	0.08	0.89	4.87	0.97
	DL-148	450900.00	0.98	0.14	0.76	4.74	0.95
	DL-19	78300.00	1.00	0.05	0.93	4.92	0.98
	DL-21	21231900.00	0.00	0.34	0.43	2.00	0.40
	DL-39	1981800.00	0.91	0.38	0.36	3.82	0.76
	DL-51	0.00	1.00	0.00	1.00	5.00	1.00
	DL-97	450900.00	0.98	0.14	0.76	4.74	0.95
Caecidotea antricola							
	DL-39	1981800.00	0.91	0.38	0.36	3.82	0.76
	DL-74	16529400.00	0.22	0.47	0.21	2.23	0.45
	DL-92	1116900.00	0.94	0.22	0.67	4.61	0.92

Species	Site	RWQN_04 Raw	RWQN_04 Scaled	RWQN_05 Raw	RWQN_05 Scaled	RWQN Raw	RWQN Scaled
Caecidotea mackini							
	DL-148	450900.00	0.98	0.14	0.76	4.74	0.95
Caecidotea macropropoda							
	AD-8	193500.00	0.99	0.05	0.93	4.90	0.98
	Cave behind Hardwicks house	193500.00	0.99	0.05	0.93	4.90	0.98
	Cave behind old greenhouse	193500.00	0.99	0.05	0.93	4.90	0.98
	Gum Spring	1064700.00	0.95	0.20	0.70	4.61	0.92
	Unnamed spring next to Christian School Cave	193500.00	0.99	0.05	0.93	4.90	0.98
Caecidotea simulator							
	AD-54	4086000.00	0.79	0.40	0.41	3.20	0.64
	Carroll's Grotto	16529400.00	0.22	0.47	0.21	2.23	0.45
	Matthews et al. (1983) Spring # 37	9619200.00	0.51	0.68	0.00	3.45	0.69
	OT-4	5296500.00	0.73	0.56	0.18	3.89	0.78
	Unnamed cave	2573100.00	0.87	0.34	0.51	4.35	0.87
Caecidotea steevesi							
	AD-19	1444500.00	0.93	0.52	0.24	2.65	0.53
	AD-9	108900.00	0.99	0.04	0.93	4.91	0.98
Caecidotea stiladactyla							
	AD-14	108900.00	0.99	0.02	0.97	4.95	0.99
	Cave near Brush Creek Bridge	598500.00	0.97	0.17	0.76	4.72	0.94
	DL-51	0.00	1.00	0.00	1.00	5.00	1.00
	DL-59	68400.00	1.00	0.02	0.97	4.96	0.99
	DL-8	195300.00	0.99	0.03	0.96	4.92	0.98
	DL-92	1116900.00	0.94	0.22	0.67	4.61	0.92

Species	Site	RWQN_04 Raw	RWQN_04 Scaled	RWQN_05 Raw	RWQN_05 Scaled	RWQN Raw	RWQN Scaled
Cambarus subterraneus							
	Carroll's Grotto	16529400.00	0.22	0.47	0.21	2.23	0.45
	DL-38	2404800.00	0.89	0.60	0.00	2.36	0.47
	DL-74	16529400.00	0.22	0.47	0.21	2.23	0.45
	DL-91	3316500.00	0.84	0.55	0.08	3.85	0.77
Cambarus tartarus							
	DL-119	6822900.00	0.68	0.17	0.72	3.68	0.74
	DL-148	450900.00	0.98	0.14	0.76	4.74	0.95
	DL-39	1981800.00	0.91	0.38	0.36	3.82	0.76
Dendrocoelopsis americana							
	AD-8	193500.00	0.99	0.05	0.93	4.90	0.98
	Christian School Annex Cave	193500.00	0.99	0.05	0.93	4.90	0.98
	DL-91	3316500.00	0.84	0.55	0.08	3.85	0.77
	OT-19	7905600.00	0.59	0.36	0.48	3.66	0.73
Eurycea spelaea							
	AD-14	108900.00	0.99	0.02	0.97	4.95	0.99
	AD-8	193500.00	0.99	0.05	0.93	4.90	0.98
	Cave near Brush Creek Bridge	598500.00	0.97	0.17	0.76	4.72	0.94
	CZ-18	1800.00	1.00	0.00	1.00	5.00	1.00
	DL-102	0.00	1.00	0.00	1.00	5.00	1.00
	DL-104	900.00	1.00	0.00	1.00	5.00	1.00
	DL-105	155700.00	0.99	0.05	0.93	4.92	0.98
	DL-119	6822900.00	0.68	0.17	0.72	3.68	0.74
	DL-148	450900.00	0.98	0.14	0.76	4.74	0.95
	DL-19	78300.00	1.00	0.05	0.93	4.92	0.98
	DL-21	21231900.00	0.00	0.34	0.43	2.00	0.40
	DL-38	2404800.00	0.89	0.60	0.00	2.36	0.47

Species	Site	RWQN_04 Raw	RWQN_04 Scaled	RWQN_05 Raw	RWQN_05 Scaled	RWQN Raw	RWQN Scaled
	DL-39	1981800.00	0.91	0.38	0.36	3.82	0.76
	DL-47	1236600.00	0.94	0.30	0.57	3.90	0.78
	DL-51	0.00	1.00	0.00	1.00	5.00	1.00
	DL-59	68400.00	1.00	0.02	0.97	4.96	0.99
	DL-64	598500.00	0.97	0.17	0.76	4.72	0.94
	DL-74	16529400.00	0.22	0.47	0.21	2.23	0.45
	DL-8	195300.00	0.99	0.03	0.96	4.92	0.98
	DL-91	3316500.00	0.84	0.55	0.08	3.85	0.77
	DL-92	1116900.00	0.94	0.22	0.67	4.61	0.92
	Krause Spring	96300.00	1.00	0.04	0.94	4.93	0.99
	Luck Spring	882000.00	0.95	0.15	0.78	4.73	0.95
	OT-19	7905600.00	0.59	0.36	0.48	3.66	0.73
	OT-4	5296500.00	0.73	0.56	0.18	3.89	0.78
	SQ-1	146700.00	0.99	0.04	0.94	4.92	0.98
	Unnamed spring 5 mi. S of Locust Grove	527400.00	0.97	0.32	0.53	4.49	0.90
	Unnamed spring next to Christian School Cave	193500.00	0.99	0.05	0.93	4.90	0.98
Stygobromus alabamensis							
	AD-14	108900.00	0.99	0.02	0.97	4.95	0.99
	AD-54	4086000.00	0.79	0.40	0.41	3.20	0.64
	AD-7	227700.00	0.99	0.21	0.69	4.67	0.93
	AD-9	108900.00	0.99	0.04	0.93	4.91	0.98
	DL-39	1981800.00	0.91	0.38	0.36	3.82	0.76
	Matthews et al. (1983) Spring # 13	753300.00	0.96	0.66	0.04	3.96	0.79
	Matthews et al. (1983) Spring # 37	9619200.00	0.51	0.68	0.00	3.45	0.69
	Seeps 4.6 mi. W of Locust Grove	504000.00	0.97	0.09	0.87	4.78	0.96

Species	Site	RWQN_04 Raw	RWQN_04 Scaled	RWQN_05 Raw	RWQN_05 Scaled	RWQN Raw	RWQN Scaled
Stygobromus bowmani							
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	19509300.00	0.00	0.45	0.34	1.94	0.39
Stygobromus onondagaensis							
	AD-14	108900.00	0.99	0.02	0.97	4.95	0.99
	AD-24	561600.00	0.97	0.58	0.15	4.12	0.82
	CZ-9	201600.00	0.99	0.08	0.89	4.87	0.97
	DL-39	1981800.00	0.91	0.38	0.36	3.82	0.76
	DL-46	962100.00	0.95	0.43	0.38	4.32	0.86
	DL-8	195300.00	0.99	0.03	0.96	4.92	0.98
	Matthews et al. (1983) Spring # 37	9619200.00	0.51	0.68	0.00	3.45	0.69
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	19509300.00	0.00	0.45	0.34	1.94	0.39
Stygobromus ozarkensis							
	AD-137	492300.00	0.97	0.62	0.09	4.05	0.81
	AD-15	756000.00	0.96	0.12	0.83	4.78	0.96
	AD-9	108900.00	0.99	0.04	0.93	4.91	0.98
	CZ-9	201600.00	0.99	0.08	0.89	4.87	0.97
	DL-39	1981800.00	0.91	0.38	0.36	3.82	0.76
	DL-46	962100.00	0.95	0.43	0.38	4.32	0.86
	DL-64	598500.00	0.97	0.17	0.76	4.72	0.94
	DL-92	1116900.00	0.94	0.22	0.67	4.61	0.92
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	19509300.00	0.00	0.45	0.34	1.94	0.39
	Seeps 4.6 mi. W of Locust Grove	504000.00	0.97	0.09	0.87	4.78	0.96

Table Appendix E-6. Index values and scaled scores for RWQS_01 Raw through RWQS_03 Scaled.

Species	Site	RWQS_01 Raw	RWQS_01 Scaled	RWQS_02 Raw	RWQS_02 Scaled	RWQS_03 Raw	RWQS_03 Scaled
Amblyopsis rosae							
	DL-119	27.81	0.37	0.67	0.04	28503900.00	0.91
	DL-148	2.19	0.95	0.69	0.02	2590200.00	0.08
	DL-21	43.81	0.00	0.71	0.00	31338900.00	1.00
	DL-22	43.81	0.00	0.71	0.00	31338900.00	1.00
	DL-38	1.77	0.96	0.44	0.38	1315800.00	0.04
	DL-39	3.60	0.92	0.69	0.02	2999700.00	0.10
	DL-47	2.71	0.90	0.65	0.63	2622600.00	0.13
	DL-48/49	2.71	0.90	0.65	0.63	2622600.00	0.13
	DL-74	20.57	0.53	0.59	0.17	14381100.00	0.46
	DL-91	2.07	0.95	0.34	0.51	2175300.00	0.07
	OT-19	3.73	0.86	0.17	0.91	11661300.00	0.59
Caecidotea ancyla							
	AD-137	0.49	0.98	0.62	0.65	259200.00	0.01
	AD-9	0.83	0.97	0.34	0.81	2035800.00	0.10
	CZ-9	0.10	1.00	0.04	0.98	2157300.00	0.11
	DL-148	2.19	0.95	0.69	0.02	2590200.00	0.08
	DL-19	1.58	0.94	0.96	0.46	1308600.00	0.07
	DL-21	43.81	0.00	0.71	0.00	31338900.00	1.00
	DL-39	3.60	0.92	0.69	0.02	2999700.00	0.10
	DL-51	0.00	1.00	0.00	1.00	1026900.00	0.05
	DL-97	2.19	0.95	0.69	0.02	2590200.00	0.08
Caecidotea antricola							
	DL-39	3.60	0.92	0.69	0.02	2999700.00	0.10
	DL-74	20.57	0.53	0.59	0.17	14381100.00	0.46
	DL-92	0.00	1.00	0.00	1.00	3438000.00	0.17

Species	Site	RWQS_01 Raw	RWQS_01 Scaled	RWQS_02 Raw	RWQS_02 Scaled	RWQS_03 Raw	RWQS_03 Scaled
Caecidotea mackini							
	DL-148	2.19	0.95	0.69	0.02	2590200.00	0.08
Caecidotea macropropoda							
	AD-8	0.87	0.97	0.21	0.88	3281400.00	0.17
	Cave behind Hardwicks house	0.87	0.97	0.21	0.88	3281400.00	0.17
	Cave behind old greenhouse	0.87	0.97	0.21	0.88	3281400.00	0.17
	Gum Spring	2.92	0.89	0.56	0.69	2988900.00	0.15
	Unnamed spring next to Christian School Cave	0.87	0.97	0.21	0.88	3281400.00	0.17
Caecidotea simulator							
	AD-54	3.79	0.86	0.38	0.79	1847700.00	0.09
	Carroll's Grotto	20.57	0.53	0.59	0.17	14381100.00	0.46
	Matthews et al. (1983) Spring # 37	2.42	0.91	0.17	0.90	3703500.00	0.19
	OT-4	3.18	0.88	0.34	0.81	3132900.00	0.16
	Unnamed cave	6.21	0.77	0.81	0.54	4501800.00	0.23
Caecidotea steevesi							
	AD-19	3.63	0.87	1.30	0.27	1236600.00	0.06
	AD-9	0.83	0.97	0.34	0.81	2035800.00	0.10
Caecidotea stiladactyla							
	AD-14	3.39	0.87	0.58	0.67	5477400.00	0.28
	Cave near Brush Creek Bridge	1.03	0.96	0.28	0.84	2336400.00	0.12
	DL-51	0.00	1.00	0.00	1.00	1026900.00	0.05
	DL-59	2.14	0.92	0.74	0.58	2206800.00	0.11
	DL-8	4.56	0.83	0.71	0.60	5692500.00	0.29
	DL-92	0.00	1.00	0.00	1.00	3438000.00	0.17
Cambarus subterraneus							
	Carroll's Grotto	20.57	0.53	0.59	0.17	14381100.00	0.46

Species	Site	RWQS_01 Raw	RWQS_01 Scaled	RWQS_02 Raw	RWQS_02 Scaled	RWQS_03 Raw	RWQS_03 Scaled
	DL-38	1.77	0.96	0.44	0.38	1315800.00	0.04
	DL-74	20.57	0.53	0.59	0.17	14381100.00	0.46
	DL-91	2.07	0.95	0.34	0.51	2175300.00	0.07
Cambarus tartarus							
	DL-119	27.81	0.37	0.67	0.04	28503900.00	0.91
	DL-148	2.19	0.95	0.69	0.02	2590200.00	0.08
	DL-39	3.60	0.92	0.69	0.02	2999700.00	0.10
Dendrocoelopsis americana							
	AD-8	0.87	0.97	0.21	0.88	3281400.00	0.17
	Christian School Annex Cave	0.87	0.97	0.21	0.88	3281400.00	0.17
	DL-91	2.07	0.95	0.34	0.51	2175300.00	0.07
	OT-19	3.73	0.86	0.17	0.91	11661300.00	0.59
Eurycea spelaea							
	AD-14	3.39	0.87	0.58	0.67	5477400.00	0.28
	AD-8	0.87	0.97	0.21	0.88	3281400.00	0.17
	Cave near Brush Creek Bridge	1.03	0.96	0.28	0.84	2336400.00	0.12
	CZ-18	0.00	1.00	0.00	1.00	2554200.00	0.13
	DL-102	0.00	1.00	0.00	1.00	407700.00	0.02
	DL-104	2.69	0.90	1.41	0.21	1754100.00	0.09
	DL-105	0.00	1.00	0.00	1.00	2867400.00	0.14
	DL-119	27.81	0.37	0.67	0.04	28503900.00	0.91
	DL-148	2.19	0.95	0.69	0.02	2590200.00	0.08
	DL-19	1.58	0.94	0.96	0.46	1308600.00	0.07
	DL-21	43.81	0.00	0.71	0.00	31338900.00	1.00
	DL-38	1.77	0.96	0.44	0.38	1315800.00	0.04
	DL-39	3.60	0.92	0.69	0.02	2999700.00	0.10
	DL-47	2.71	0.90	0.65	0.63	2622600.00	0.13

Species	Site	RWQS_01 Raw	RWQS_01 Scaled	RWQS_02 Raw	RWQS_02 Scaled	RWQS_03 Raw	RWQS_03 Scaled
	DL-51	0.00	1.00	0.00	1.00	1026900.00	0.05
	DL-59	2.14	0.92	0.74	0.58	2206800.00	0.11
	DL-64	1.03	0.96	0.28	0.84	2336400.00	0.12
	DL-74	20.57	0.53	0.59	0.17	14381100.00	0.46
	DL-8	4.56	0.83	0.71	0.60	5692500.00	0.29
	DL-91	2.07	0.95	0.34	0.51	2175300.00	0.07
	DL-92	0.00	1.00	0.00	1.00	3438000.00	0.17
	Krause Spring	2.35	0.91	0.94	0.47	1824300.00	0.09
	Luck Spring	3.42	0.87	0.57	0.68	4873500.00	0.25
	OT-19	3.73	0.86	0.17	0.91	11661300.00	0.59
	OT-4	3.18	0.88	0.34	0.81	3132900.00	0.16
	SQ-1	0.24	0.99	0.07	0.96	2979000.00	0.15
	Unnamed spring 5 mi. S of Locust Grove	0.42	0.98	0.26	0.86	765900.00	0.04
	Unnamed spring next to Christian School Cave	0.87	0.97	0.21	0.88	3281400.00	0.17
Stygobromus alabamensis							
	AD-14	3.39	0.87	0.58	0.67	5477400.00	0.28
	AD-54	3.79	0.86	0.38	0.79	1847700.00	0.09
	AD-7	0.03	1.00	0.02	0.99	796500.00	0.04
	AD-9	0.83	0.97	0.34	0.81	2035800.00	0.10
	DL-39	3.60	0.92	0.69	0.02	2999700.00	0.10
	Matthews et al. (1983) Spring # 13	1.15	0.96	1.00	0.44	97200.00	0.00
	Matthews et al. (1983) Spring # 37	2.42	0.91	0.17	0.90	3703500.00	0.19
	Seeps 4.6 mi. W of Locust Grove	2.45	0.91	0.42	0.77	4103100.00	0.21

Species	Site	RWQS_01 Raw	RWQS_01 Scaled	RWQS_02 Raw	RWQS_02 Scaled	RWQS_03 Raw	RWQS_03 Scaled
Stygobromus bowmani							
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	26.99	0.00	0.62	0.65	19827000.00	1.00
Stygobromus onondagaensis							
	AD-14	3.39	0.87	0.58	0.67	5477400.00	0.28
	AD-24	0.13	1.00	0.13	0.93	366300.00	0.02
	CZ-9	0.10	1.00	0.04	0.98	2157300.00	0.11
	DL-39	3.60	0.92	0.69	0.02	2999700.00	0.10
	DL-46	4.02	0.85	1.78	0.00	805500.00	0.04
	DL-8	4.56	0.83	0.71	0.60	5692500.00	0.29
	Matthews et al. (1983) Spring # 37	2.42	0.91	0.17	0.90	3703500.00	0.19
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	26.99	0.00	0.62	0.65	19827000.00	1.00
Stygobromus ozarkensis							
	AD-137	0.49	0.98	0.62	0.65	259200.00	0.01
	AD-15	0.81	0.97	0.12	0.93	5342400.00	0.27
	AD-9	0.83	0.97	0.34	0.81	2035800.00	0.10
	CZ-9	0.10	1.00	0.04	0.98	2157300.00	0.11
	DL-39	3.60	0.92	0.69	0.02	2999700.00	0.10
	DL-46	4.02	0.85	1.78	0.00	805500.00	0.04
	DL-64	1.03	0.96	0.28	0.84	2336400.00	0.12
	DL-92	0.00	1.00	0.00	1.00	3438000.00	0.17
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	26.99	0.00	0.62	0.65	19827000.00	1.00
	Seeps 4.6 mi. W of Locust Grove	2.45	0.91	0.42	0.77	4103100.00	0.21

Table Appendix E-7. Index values and scaled scores from RWQS_04 Raw through RWQ Scaled.

Species	Site	RWQS_04 Raw	RWQS_04 Scaled	RWQS Raw	RWQS Scaled	RWQ Raw	RWQ Scaled
Amblyopsis rosae							
	DL-119	0.69	0.15	1.47	0.52	2.87	0.76
	DL-148	0.82	0.00	1.05	0.37	3.31	0.88
	DL-21	0.50	0.38	1.38	0.49	1.69	0.45
	DL-22	0.50	0.38	1.38	0.49	1.69	0.45
	DL-38	0.33	0.60	1.98	0.70	3.11	0.83
	DL-39	0.58	0.29	1.32	0.47	3.20	0.85
	DL-47	0.63	0.36	2.03	0.72	3.46	0.92
	DL-48/49	0.63	0.36	2.03	0.72	3.46	0.92
	DL-74	0.41	0.50	1.65	0.59	1.63	0.43
	DL-91	0.36	0.56	2.09	0.74	3.25	0.86
	OT-19	0.52	0.47	2.82	1.00	3.61	0.96
Caecidotea ancyla							
	AD-137	0.33	0.67	2.32	0.82	3.58	0.95
	AD-9	0.84	0.15	2.03	0.72	3.66	0.97
	CZ-9	0.82	0.17	2.25	0.80	3.76	1.00
	DL-148	0.82	0.00	1.05	0.37	3.31	0.88
	DL-19	0.80	0.19	1.66	0.59	3.30	0.88
	DL-21	0.50	0.38	1.38	0.49	1.69	0.45
	DL-39	0.58	0.29	1.32	0.47	3.20	0.85
	DL-51	0.85	0.13	2.18	0.77	3.73	0.99
	DL-97	0.82	0.00	1.05	0.37	3.31	0.88
Caecidotea antricola							
	DL-39	0.58	0.29	1.32	0.47	3.20	0.85
	DL-74	0.41	0.50	1.65	0.59	1.63	0.43
	DL-92	0.69	0.30	2.47	0.88	3.73	0.99

Species	Site	RWQS_04 Raw	RWQS_04 Scaled	RWQS Raw	RWQS Scaled	RWQ Raw	RWQ Scaled
Caecidotea mackini							
	DL-148	0.82	0.00	1.05	0.37	3.31	0.88
Caecidotea macropropoda							
	AD-8	0.80	0.18	2.20	0.78	3.71	0.99
	Cave behind Hardwicks house	0.80	0.18	2.20	0.78	3.71	0.99
	Cave behind old greenhouse	0.80	0.18	2.20	0.78	3.71	0.99
	Gum Spring	0.57	0.42	2.15	0.76	3.48	0.92
	Unnamed spring next to Christian School Cave	0.80	0.18	2.20	0.78	3.71	0.99
Caecidotea simulator							
	AD-54	0.18	0.81	2.56	0.91	2.09	0.56
	Carroll's Grotto	0.41	0.50	1.65	0.59	1.63	0.43
	Matthews et al. (1983) Spring # 37	0.26	0.73	2.73	0.97	3.53	0.94
	OT-4	0.33	0.66	2.51	0.89	3.61	0.96
	Unnamed cave	0.59	0.40	1.94	0.69	3.51	0.93
Caecidotea steevesi							
	AD-19	0.44	0.55	1.75	0.62	3.11	0.83
	AD-9	0.84	0.15	2.03	0.72	3.66	0.97
Caecidotea stiladactyla							
	AD-14	0.94	0.05	1.87	0.66	3.63	0.96
	Cave near Brush Creek Bridge	0.64	0.34	2.27	0.80	3.74	0.99
	DL-51	0.85	0.13	2.18	0.77	3.73	0.99
	DL-59	0.76	0.22	1.84	0.65	3.18	0.84
	DL-8	0.88	0.10	1.83	0.65	3.51	0.93
	DL-92	0.69	0.30	2.47	0.88	3.73	0.99

Species	Site	RWQS_04 Raw	RWQS_04 Scaled	RWQS Raw	RWQS Scaled	RWQ Raw	RWQ Scaled
Cambarus subterraneus							
	Carroll's Grotto	0.41	0.50	1.65	0.59	1.63	0.43
	DL-38	0.33	0.60	1.98	0.70	3.11	0.83
	DL-74	0.41	0.50	1.65	0.59	1.63	0.43
	DL-91	0.36	0.56	2.09	0.74	3.25	0.86
Cambarus tartarus							
	DL-119	0.69	0.15	1.47	0.52	2.87	0.76
	DL-148	0.82	0.00	1.05	0.37	3.31	0.88
	DL-39	0.58	0.29	1.32	0.47	3.20	0.85
Dendrocoelopsis americana							
	AD-8	0.80	0.18	2.20	0.78	3.71	0.99
	Christian School Annex Cave	0.80	0.18	2.20	0.78	3.71	0.99
	DL-91	0.36	0.56	2.09	0.74	3.25	0.86
	OT-19	0.52	0.47	2.82	1.00	3.61	0.96
Eurycea spelaea							
	AD-14	0.94	0.05	1.87	0.66	3.63	0.96
	AD-8	0.80	0.18	2.20	0.78	3.71	0.99
	Cave near Brush Creek Bridge	0.64	0.34	2.27	0.80	3.74	0.99
	CZ-18	0.98	0.00	2.13	0.75	3.75	1.00
	DL-102	0.94	0.05	2.07	0.73	3.72	0.99
	DL-104	0.92	0.07	1.26	0.45	3.43	0.91
	DL-105	0.87	0.12	2.26	0.80	3.74	1.00
	DL-119	0.69	0.15	1.47	0.52	2.87	0.76
	DL-148	0.82	0.00	1.05	0.37	3.31	0.88
	DL-19	0.80	0.19	1.66	0.59	3.30	0.88
	DL-21	0.50	0.38	1.38	0.49	1.69	0.45
	DL-38	0.33	0.60	1.98	0.70	3.11	0.83

Species	Site	RWQS_04 Raw	RWQS_04 Scaled	RWQS Raw	RWQS Scaled	RWQ Raw	RWQ Scaled
	DL-39	0.58	0.29	1.32	0.47	3.20	0.85
	DL-47	0.63	0.36	2.03	0.72	3.46	0.92
	DL-51	0.85	0.13	2.18	0.77	3.73	0.99
	DL-59	0.76	0.22	1.84	0.65	3.18	0.84
	DL-64	0.64	0.34	2.27	0.80	3.74	0.99
	DL-74	0.41	0.50	1.65	0.59	1.63	0.43
	DL-8	0.88	0.10	1.83	0.65	3.51	0.93
	DL-91	0.36	0.56	2.09	0.74	3.25	0.86
	DL-92	0.69	0.30	2.47	0.88	3.73	0.99
	Krause Spring	0.73	0.26	1.74	0.62	3.31	0.88
	Luck Spring	0.81	0.17	1.97	0.70	3.63	0.96
	OT-19	0.52	0.47	2.82	1.00	3.61	0.96
	OT-4	0.33	0.66	2.51	0.89	3.61	0.96
	SQ-1	0.89	0.10	2.20	0.78	3.70	0.98
	Unnamed spring 5 mi. S of Locust Grove	0.47	0.52	2.40	0.85	3.69	0.98
	Unnamed spring next to Christian School Cave	0.80	0.18	2.20	0.78	3.71	0.99
Stygobromus alabamensis							
	AD-14	0.94	0.05	1.87	0.66	3.63	0.96
	AD-54	0.18	0.81	2.56	0.91	2.09	0.56
	AD-7	0.75	0.24	2.27	0.80	3.71	0.99
	AD-9	0.84	0.15	2.03	0.72	3.66	0.97
	DL-39	0.58	0.29	1.32	0.47	3.20	0.85
	Matthews et al. (1983) Spring # 13	0.08	0.91	2.31	0.82	3.23	0.86
	Matthews et al. (1983) Spring # 37	0.26	0.73	2.73	0.97	3.53	0.94
	Seeps 4.6 mi. W of Locust Grove	0.70	0.29	2.17	0.77	3.33	0.89

Species	Site	RWQS_04 Raw	RWQS_04 Scaled	RWQS Raw	RWQS Scaled	RWQ Raw	RWQ Scaled
Stygobromus bowmani							
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	0.46	0.53	2.18	0.77	2.37	0.63
Stygobromus onondagaensis							
	AD-14	0.94	0.05	1.87	0.66	3.63	0.96
	AD-24	0.38	0.62	2.56	0.91	3.69	0.98
	CZ-9	0.82	0.17	2.25	0.80	3.76	1.00
	DL-39	0.58	0.29	1.32	0.47	3.20	0.85
	DL-46	0.36	0.64	1.53	0.54	3.36	0.89
	DL-8	0.88	0.10	1.83	0.65	3.51	0.93
	Matthews et al. (1983) Spring # 37	0.26	0.73	2.73	0.97	3.53	0.94
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	0.46	0.53	2.18	0.77	2.37	0.63
Stygobromus ozarkensis							
	AD-137	0.33	0.67	2.32	0.82	3.58	0.95
	AD-15	0.82	0.17	2.34	0.83	3.73	0.99
	AD-9	0.84	0.15	2.03	0.72	3.66	0.97
	CZ-9	0.82	0.17	2.25	0.80	3.76	1.00
	DL-39	0.58	0.29	1.32	0.47	3.20	0.85
	DL-46	0.36	0.64	1.53	0.54	3.36	0.89
	DL-64	0.64	0.34	2.27	0.80	3.74	0.99
	DL-92	0.69	0.30	2.47	0.88	3.73	0.99
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	0.46	0.53	2.18	0.77	2.37	0.63
	Seeps 4.6 mi. W of Locust Grove	0.70	0.29	2.17	0.77	3.33	0.89

Table Appendix E-8. Index values and scaled scores for VULN Raw through RVIA scaled.

Species	Site	VULN Raw	VULN Scaled	SENS Raw	SENS Scaled	RVIP Raw	RVIP Scaled	RVIA Raw	RVIA Scaled
Amblyopsis rosae									
	DL-119	115.50	0.13	0.90	0.62	11284.00	0.68	0.03	0.37
	DL-148	104.73	0.21	1.09	0.76	11472.00	0.67	0.03	0.37
	DL-21	120.70	0.09	0.54	0.38	10093.00	0.71	0.03	0.41
	DL-22	120.70	0.09	0.54	0.38	9920.00	0.72	0.03	0.41
	DL-38	96.87	0.27	1.10	0.77	14244.00	0.59	0.04	0.33
	DL-39	92.12	0.31	1.16	0.81	11982.00	0.66	0.04	0.28
	DL-47	100.34	0.25	1.17	0.81	11771.00	0.66	0.04	0.28
	DL-48/49	100.34	0.25	1.17	0.81	11781.00	0.66	0.04	0.28
	DL-74	97.00	0.27	0.71	0.49	20622.00	0.41	0.04	0.25
	DL-91	106.20	0.20	1.07	0.74	18417.00	0.47	0.04	0.29
	OT-19	95.76	0.28	1.24	0.87	23838.00	0.32	0.05	0.03
Caecidotea ancyla									
	AD-137	133.05	0.00	0.95	0.66	16728.00	0.52	0.04	0.22
	AD-9	122.49	0.08	1.05	0.73	13760.00	0.60	0.03	0.41
	CZ-9	75.44	0.43	1.43	1.00	31687.00	0.09	0.04	0.26
	DL-148	104.73	0.21	1.09	0.76	11472.00	0.67	0.03	0.37
	DL-19	102.64	0.23	1.11	0.77	9961.00	0.71	0.03	0.39
	DL-21	120.70	0.09	0.54	0.38	10093.00	0.71	0.03	0.41
	DL-39	92.12	0.31	1.16	0.81	11982.00	0.66	0.04	0.28
	DL-51	115.21	0.13	1.13	0.79	10604.00	0.70	0.03	0.39
	DL-97	104.73	0.21	1.09	0.76	9519.00	0.73	0.03	0.41
Caecidotea antricola									
	DL-39	92.12	0.31	1.16	0.81	11982.00	0.66	0.04	0.28
	DL-74	97.00	0.27	0.71	0.49	20622.00	0.41	0.04	0.25
	DL-92	81.17	0.39	1.38	0.96	12318.00	0.65	0.03	0.39

Species	Site	VULN Raw	VULN Scaled	SENS Raw	SENS Scaled	RVIP Raw	RVIP Scaled	RVIA Raw	RVIA Scaled
Caecidotea mackini									
	DL-148	104.73	0.21	1.09	0.76	11472.00	0.67	0.03	0.37
Caecidotea macropropoda									
	AD-8	120.16	0.10	1.08	0.76	9096.00	0.74	0.03	0.47
	Cave behind Hardwicks house	120.16	0.10	1.08	0.76	9096.00	0.74	0.03	0.47
	Cave behind old greenhouse	120.16	0.10	1.08	0.76	9096.00	0.74	0.03	0.47
	Gum Spring	95.08	0.29	1.21	0.84	8731.00	0.75	0.03	0.41
	Unnamed spring next to Christian School Cave	120.16	0.10	1.08	0.76	9096.00	0.74	0.03	0.47
Caecidotea simulator									
	AD-54	112.51	0.15	0.71	0.50	14585.00	0.58	0.04	0.29
	Carroll's Grotto	97.00	0.27	0.71	0.49	21171.00	0.39	0.04	0.24
	Matthews et al. (1983) Spring # 37	100.19	0.25	1.19	0.83	14032.00	0.60	0.04	0.27
	OT-4	101.16	0.24	1.20	0.84	13985.00	0.60	0.04	0.28
	Unnamed cave	95.19	0.28	1.22	0.85	22547.00	0.35	0.05	0.10
Caecidotea steevesi									
	AD-19	92.58	0.30	1.13	0.79	14618.00	0.58	0.03	0.36
	AD-9	122.49	0.08	1.05	0.73	13760.00	0.60	0.03	0.41
Caecidotea stiladactyla									
	AD-14	86.96	0.35	1.31	0.91	11701.00	0.66	0.03	0.42
	Cave near Brush Creek Bridge	100.72	0.24	1.24	0.86	10129.00	0.71	0.03	0.37
	DL-51	115.21	0.13	1.13	0.79	10604.00	0.70	0.03	0.39
	DL-59	106.06	0.20	1.05	0.73	9772.00	0.72	0.03	0.39
	DL-8	117.12	0.12	1.05	0.73	10020.00	0.71	0.03	0.39
	DL-92	81.17	0.39	1.38	0.96	12318.00	0.65	0.03	0.39
Cambarus subterraneus									
	Carroll's Grotto	97.00	0.27	0.71	0.49	21171.00	0.39	0.04	0.24

Species	Site	VULN Raw	VULN Scaled	SENS Raw	SENS Scaled	RVIP Raw	RVIP Scaled	RVIA Raw	RVIA Scaled
	DL-38	96.87	0.27	1.10	0.77	14244.00	0.59	0.04	0.33
	DL-74	97.00	0.27	0.71	0.49	20622.00	0.41	0.04	0.25
	DL-91	106.20	0.20	1.07	0.74	18417.00	0.47	0.04	0.29
Cambarus tartarus									
	DL-119	115.50	0.13	0.90	0.62	11284.00	0.68	0.03	0.37
	DL-148	104.73	0.21	1.09	0.76	11472.00	0.67	0.03	0.37
	DL-39	92.12	0.31	1.16	0.81	11982.00	0.66	0.04	0.28
Dendrocoelopsis americana									
	AD-8	120.16	0.10	1.08	0.76	9096.00	0.74	0.03	0.47
	Christian School Annex Cave	120.16	0.10	1.08	0.76	9096.00	0.74	0.03	0.47
	DL-91	106.20	0.20	1.07	0.74	18417.00	0.47	0.04	0.29
	OT-19	95.76	0.28	1.24	0.87	23838.00	0.32	0.05	0.03
Eurycea spelaea									
	AD-14	86.96	0.35	1.31	0.91	11701.00	0.66	0.03	0.42
	AD-8	120.16	0.10	1.08	0.76	9096.00	0.74	0.03	0.47
	Cave near Brush Creek Bridge	100.72	0.24	1.24	0.86	10129.00	0.71	0.03	0.37
	CZ-18	108.31	0.19	1.18	0.83	8280.00	0.76	0.02	0.54
	DL-102	95.77	0.28	1.27	0.89	13444.00	0.61	0.03	0.39
	DL-104	108.38	0.19	1.10	0.77	11274.00	0.68	0.03	0.38
	DL-105	110.12	0.17	1.17	0.82	11095.00	0.68	0.03	0.38
	DL-119	115.50	0.13	0.90	0.62	11284.00	0.68	0.03	0.37
	DL-148	104.73	0.21	1.09	0.76	11472.00	0.67	0.03	0.37
	DL-19	102.64	0.23	1.11	0.77	9961.00	0.71	0.03	0.39
	DL-21	120.70	0.09	0.54	0.38	10093.00	0.71	0.03	0.41
	DL-38	96.87	0.27	1.10	0.77	14244.00	0.59	0.04	0.33
	DL-39	92.12	0.31	1.16	0.81	11982.00	0.66	0.04	0.28
	DL-47	100.34	0.25	1.17	0.81	11771.00	0.66	0.04	0.28

Species	Site	VULN Raw	VULN Scaled	SENS Raw	SENS Scaled	RVIP Raw	RVIP Scaled	RVIA Raw	RVIA Scaled
	DL-51	115.21	0.13	1.13	0.79	10604.00	0.70	0.03	0.39
	DL-59	106.06	0.20	1.05	0.73	9772.00	0.72	0.03	0.39
	DL-64	100.72	0.24	1.24	0.86	10141.00	0.71	0.03	0.37
	DL-74	97.00	0.27	0.71	0.49	20622.00	0.41	0.04	0.25
	DL-8	117.12	0.12	1.05	0.73	10020.00	0.71	0.03	0.39
	DL-91	106.20	0.20	1.07	0.74	18417.00	0.47	0.04	0.29
	DL-92	81.17	0.39	1.38	0.96	12318.00	0.65	0.03	0.39
	Krause Spring	112.05	0.16	1.04	0.72	10483.00	0.70	0.03	0.37
	Luck Spring	110.68	0.17	1.13	0.79	11024.00	0.68	0.03	0.44
	OT-19	95.76	0.28	1.24	0.87	23838.00	0.32	0.05	0.03
	OT-4	101.16	0.24	1.20	0.84	13985.00	0.60	0.04	0.28
	SQ-1	109.83	0.17	1.16	0.81	8366.00	0.76	0.02	0.54
	Unnamed spring 5 mi. S of Locust Grove	126.78	0.05	1.03	0.72	14533.00	0.58	0.03	0.42
	Unnamed spring next to Christian School Cave	120.16	0.10	1.08	0.76	9096.00	0.74	0.03	0.47
Stygobromus alabamensis									
	AD-14	86.96	0.35	1.31	0.91	11701.00	0.66	0.03	0.42
	AD-54	112.51	0.15	0.71	0.50	14585.00	0.58	0.04	0.29
	AD-7	113.38	0.15	1.14	0.79	13944.00	0.60	0.03	0.40
	AD-9	122.49	0.08	1.05	0.73	13760.00	0.60	0.03	0.41
	DL-39	92.12	0.31	1.16	0.81	11982.00	0.66	0.04	0.28
	Matthews et al. (1983) Spring # 13	129.68	0.03	0.89	0.62	34830.00	0.00	0.05	0.00
	Matthews et al. (1983) Spring # 37	100.19	0.25	1.19	0.83	14032.00	0.60	0.04	0.27
	Seeps 4.6 mi. W of Locust Grove	113.33	0.15	1.03	0.72	17954.00	0.48	0.04	0.25

Species	Site	VULN Raw	VULN Scaled	SENS Raw	SENS Scaled	RVIP Raw	RVIP Scaled	RVIA Raw	RVIA Scaled
Stygobromus bowmani									
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	133.11	0.00	0.63	0.44	15810.00	0.55	0.03	0.40
Stygobromus onondagaensis									
	AD-14	86.96	0.35	1.31	0.91	11701.00	0.66	0.03	0.42
	AD-24	106.54	0.20	1.18	0.82	14804.00	0.57	0.03	0.35
	CZ-9	75.44	0.43	1.43	1.00	31687.00	0.09	0.04	0.26
	DL-39	92.12	0.31	1.16	0.81	11982.00	0.66	0.04	0.28
	DL-46	110.04	0.17	1.07	0.74	32088.00	0.08	0.05	0.13
	DL-8	117.12	0.12	1.05	0.73	10020.00	0.71	0.03	0.39
	Matthews et al. (1983) Spring # 37	100.19	0.25	1.19	0.83	14032.00	0.60	0.04	0.27
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	133.11	0.00	0.63	0.44	15810.00	0.55	0.03	0.40
Stygobromus ozarkensis									
	AD-137	133.05	0.00	0.95	0.66	16728.00	0.52	0.04	0.22
	AD-15	114.93	0.14	1.13	0.79	10359.00	0.70	0.03	0.51
	AD-9	122.49	0.08	1.05	0.73	13760.00	0.60	0.03	0.41
	CZ-9	75.44	0.43	1.43	1.00	31687.00	0.09	0.04	0.26
	DL-39	92.12	0.31	1.16	0.81	11982.00	0.66	0.04	0.28
	DL-46	110.04	0.17	1.07	0.74	32088.00	0.08	0.05	0.13
	DL-64	100.72	0.24	1.24	0.86	10141.00	0.71	0.03	0.37
	DL-92	81.17	0.39	1.38	0.96	12318.00	0.65	0.03	0.39
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	133.11	0.00	0.63	0.44	15810.00	0.55	0.03	0.40
	Seeps 4.6 mi. W of Locust Grove	113.33	0.15	1.03	0.72	17954.00	0.48	0.04	0.25

Table Appendix E-9. Index values and scaled scores for RVIX Raw through THREAT Scaled.

Species	Site	RVIX Raw	RVIX Scaled	RVI Raw	RVI Scaled	TAC Raw	TAC Scaled	THREAT Scaled
Amblyopsis rosae								
	DL-119	0.18	0.06	1.10	0.55	1.18	0.62	0.38
	DL-148	0.37	0.11	1.16	0.58	1.34	0.71	0.29
	DL-21	0.03	0.01	1.13	0.56	0.94	0.50	0.50
	DL-22	0.18	0.06	1.18	0.59	0.97	0.51	0.49
	DL-38	0.08	0.02	0.94	0.47	1.24	0.66	0.34
	DL-39	0.16	0.05	0.99	0.49	1.30	0.69	0.31
	DL-47	0.40	0.12	1.07	0.53	1.35	0.71	0.29
	DL-48/49	0.37	0.12	1.06	0.53	1.34	0.71	0.29
	DL-74	0.35	0.11	0.77	0.38	0.88	0.46	0.54
	DL-91	0.71	0.22	0.98	0.49	1.24	0.66	0.34
	OT-19	0.24	0.07	0.42	0.21	1.08	0.57	0.43
Caecidotea ancyla								
	AD-137	0.02	0.01	0.74	0.37	1.04	0.55	0.45
	AD-9	0.53	0.17	1.18	0.59	1.33	0.70	0.30
	CZ-9	0.95	0.30	0.65	0.33	1.33	0.70	0.30
	DL-148	0.37	0.11	1.16	0.58	1.34	0.71	0.29
	DL-19	0.02	0.01	1.11	0.55	1.33	0.70	0.30
	DL-21	0.03	0.01	1.13	0.56	0.94	0.50	0.50
	DL-39	0.16	0.05	0.99	0.49	1.30	0.69	0.31
	DL-51	0.02	0.01	1.09	0.54	1.33	0.71	0.29
	DL-97	0.13	0.04	1.18	0.59	1.35	0.72	0.28
Caecidotea antricola								
	DL-39	0.16	0.05	0.99	0.49	1.30	0.69	0.31
	DL-74	0.35	0.11	0.77	0.38	0.88	0.46	0.54
	DL-92	0.82	0.25	1.29	0.64	1.61	0.85	0.15

Species	Site	RVIX Raw	RVIX Scaled	RVI Raw	RVI Scaled	TAC Raw	TAC Scaled	THREAT Scaled
Caecidotea mackini								
	DL-148	0.37	0.11	1.16	0.58	1.34	0.71	0.29
Caecidotea macropropoda								
	AD-8	0.29	0.09	1.30	0.65	1.41	0.75	0.25
	Cave behind Hardwicks house	0.29	0.09	1.30	0.65	1.41	0.75	0.25
	Cave behind old greenhouse	0.29	0.09	1.30	0.65	1.41	0.75	0.25
	Gum Spring	0.46	0.14	1.31	0.65	1.50	0.79	0.21
	Unnamed spring next to Christian School Cave	0.29	0.09	1.30	0.65	1.41	0.75	0.25
Caecidotea simulator								
	AD-54	0.56	0.17	1.04	0.52	1.02	0.54	0.46
	Carroll's Grotto	0.28	0.09	0.72	0.36	0.85	0.45	0.55
	Matthews et al. (1983) Spring # 37	0.02	0.01	0.88	0.44	1.27	0.67	0.33
	OT-4	0.06	0.02	0.90	0.45	1.28	0.68	0.32
	Unnamed cave	0.99	0.31	0.76	0.38	1.23	0.65	0.35
Caecidotea steevesi								
	AD-19	0.41	0.13	1.07	0.53	1.32	0.70	0.30
	AD-9	0.53	0.17	1.18	0.59	1.33	0.70	0.30
Caecidotea stiladactyla								
	AD-14	0.52	0.16	1.24	0.62	1.54	0.82	0.18
	Cave near Brush Creek Bridge	0.00	0.00	1.08	0.54	1.40	0.74	0.26
	DL-51	0.02	0.01	1.09	0.54	1.33	0.71	0.29
	DL-59	0.02	0.01	1.11	0.56	1.29	0.68	0.32
	DL-8	0.42	0.13	1.23	0.62	1.35	0.72	0.28
	DL-92	0.82	0.25	1.29	0.64	1.61	0.85	0.15
Cambarus subterraneus								
	Carroll's Grotto	0.28	0.09	0.72	0.36	0.85	0.45	0.55

Species	Site	RVIX Raw	RVIX Scaled	RVI Raw	RVI Scaled	TAC Raw	TAC Scaled	THREAT Scaled
	DL-38	0.08	0.02	0.94	0.47	1.24	0.66	0.34
	DL-74	0.35	0.11	0.77	0.38	0.88	0.46	0.54
	DL-91	0.71	0.22	0.98	0.49	1.24	0.66	0.34
Cambarus tartarus								
	DL-119	0.18	0.06	1.10	0.55	1.18	0.62	0.38
	DL-148	0.37	0.11	1.16	0.58	1.34	0.71	0.29
	DL-39	0.16	0.05	0.99	0.49	1.30	0.69	0.31
Dendrocoelopsis americana								
	AD-8	0.29	0.09	1.30	0.65	1.41	0.75	0.25
	Christian School Annex Cave	0.29	0.09	1.30	0.65	1.41	0.75	0.25
	DL-91	0.71	0.22	0.98	0.49	1.24	0.66	0.34
	OT-19	0.24	0.07	0.42	0.21	1.08	0.57	0.43
Eurycea spelaea								
	AD-14	0.52	0.16	1.24	0.62	1.54	0.82	0.18
	AD-8	0.29	0.09	1.30	0.65	1.41	0.75	0.25
	Cave near Brush Creek Bridge	0.00	0.00	1.08	0.54	1.40	0.74	0.26
	CZ-18	1.15	0.36	1.66	0.83	1.66	0.88	0.12
	DL-102	3.20	1.00	2.00	1.00	1.89	1.00	0.00
	DL-104	0.27	0.09	1.14	0.57	1.34	0.71	0.29
	DL-105	0.38	0.12	1.18	0.59	1.41	0.75	0.25
	DL-119	0.18	0.06	1.10	0.55	1.18	0.62	0.38
	DL-148	0.37	0.11	1.16	0.58	1.34	0.71	0.29
	DL-19	0.02	0.01	1.11	0.55	1.33	0.70	0.30
	DL-21	0.03	0.01	1.13	0.56	0.94	0.50	0.50
	DL-38	0.08	0.02	0.94	0.47	1.24	0.66	0.34
	DL-39	0.16	0.05	0.99	0.49	1.30	0.69	0.31
	DL-47	0.40	0.12	1.07	0.53	1.35	0.71	0.29

Species	Site	RVIX Raw	RVIX Scaled	RVI Raw	RVI Scaled	TAC Raw	TAC Scaled	THREAT Scaled
	DL-51	0.02	0.01	1.09	0.54	1.33	0.71	0.29
	DL-59	0.02	0.01	1.11	0.56	1.29	0.68	0.32
	DL-64	0.22	0.07	1.14	0.57	1.43	0.76	0.24
	DL-74	0.35	0.11	0.77	0.38	0.88	0.46	0.54
	DL-8	0.42	0.13	1.23	0.62	1.35	0.72	0.28
	DL-91	0.71	0.22	0.98	0.49	1.24	0.66	0.34
	DL-92	0.82	0.25	1.29	0.64	1.61	0.85	0.15
	Krause Spring	0.20	0.06	1.13	0.57	1.29	0.68	0.32
	Luck Spring	0.05	0.02	1.14	0.57	1.36	0.72	0.28
	OT-19	0.24	0.07	0.42	0.21	1.08	0.57	0.43
	OT-4	0.06	0.02	0.90	0.45	1.28	0.68	0.32
	SQ-1	0.08	0.03	1.32	0.66	1.47	0.78	0.22
	Unnamed spring 5 mi. S of Locust Grove	0.78	0.24	1.24	0.62	1.34	0.71	0.29
	Unnamed spring next to Christian School Cave	0.29	0.09	1.30	0.65	1.41	0.75	0.25
Stygobromus alabamensis								
	AD-14	0.52	0.16	1.24	0.62	1.54	0.82	0.18
	AD-54	0.56	0.17	1.04	0.52	1.02	0.54	0.46
	AD-7	0.52	0.16	1.16	0.58	1.37	0.73	0.27
	AD-9	0.53	0.17	1.18	0.59	1.33	0.70	0.30
	DL-39	0.16	0.05	0.99	0.49	1.30	0.69	0.31
	Matthews et al. (1983) Spring # 13	0.03	0.01	0.01	0.00	0.62	0.33	0.67
	Matthews et al. (1983) Spring # 37	0.02	0.01	0.88	0.44	1.27	0.67	0.33
	Seeps 4.6 mi. W of Locust Grove	0.03	0.01	0.75	0.37	1.09	0.58	0.42

Species	Site	RVIX Raw	RVIX Scaled	RVI Raw	RVI Scaled	TAC Raw	TAC Scaled	THREAT Scaled
Stygobromus bowmani								
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	0.40	0.12	1.07	0.53	0.97	0.52	0.48
Stygobromus onondagaensis								
	AD-14	0.52	0.16	1.24	0.62	1.54	0.82	0.18
	AD-24	0.25	0.08	1.00	0.50	1.33	0.70	0.30
	CZ-9	0.95	0.30	0.65	0.33	1.33	0.70	0.30
	DL-39	0.16	0.05	0.99	0.49	1.30	0.69	0.31
	DL-46	0.23	0.07	0.28	0.14	0.88	0.47	0.53
	DL-8	0.42	0.13	1.23	0.62	1.35	0.72	0.28
	Matthews et al. (1983) Spring # 37	0.02	0.01	0.88	0.44	1.27	0.67	0.33
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	0.40	0.12	1.07	0.53	0.97	0.52	0.48
Stygobromus ozarkensis								
	AD-137	0.02	0.01	0.74	0.37	1.04	0.55	0.45
	AD-15	0.78	0.24	1.45	0.73	1.51	0.80	0.20
	AD-9	0.53	0.17	1.18	0.59	1.33	0.70	0.30
	CZ-9	0.95	0.30	0.65	0.33	1.33	0.70	0.30
	DL-39	0.16	0.05	0.99	0.49	1.30	0.69	0.31
	DL-46	0.23	0.07	0.28	0.14	0.88	0.47	0.53
	DL-64	0.22	0.07	1.14	0.57	1.43	0.76	0.24
	DL-92	0.82	0.25	1.29	0.64	1.61	0.85	0.15
	Seep at Girl Scout Camp 3.2 mi. S of Locust Grove	0.40	0.12	1.07	0.53	0.97	0.52	0.48
	Seeps 4.6 mi. W of Locust Grove	0.03	0.01	0.75	0.37	1.09	0.58	0.42

F. SIGNIFICANT DEVIATIONS: Not applicable.

PREPARED BY: Michael Slay
The Nature Conservancy, Arkansas Field Office)

DATE: November 10, 2016

APPROVED BY: ______________________
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LITERATURE CITED:

Aley, T. 2005. Groundwater recharge area delineation and vulnerability mapping of Star Cave and nearby hydrologically associated springs, Delaware County, Oklahoma. Final Report submitted to Oklahoma Ecological Services Office, USFWS, Tulsa, Oklahoma. 116 pp.

Aley, T. and C. Aley. 1990. Hydrogeology of Ozark Cavefish caves in Oklahoma. Final Report submitted to The Nature Conservancy, Tulsa, Oklahoma. 73 pp.

Aley, T. and C. Aley. 1991. Hydrogeology of Ozark Cavefish caves in Oklahoma, Phase 2 investigations. Final Report submitted to The Nature Conservancy, Tulsa, Oklahoma. 70 pp.

Aller et al, 1987. DRASTIC: A standardized system for evaluating groundwater pollution potential using hydrogeologic settings. USEPA 600/2-87-035, 622pp.

Bidwell, J.R., C. Becker, S. Hensley, R. Stark, and M.T. Meyer. 2010. Occurrence of organic wastewater and other contaminants in cave streams in northeastern Oklahoma and northwestern Arkansas. Archives of Environmental Contamination and Toxicology 58:286-298.

Davis A., et al, 2001. KARSTIC: a sensitivity method for carbonate aquifers in karst terrain. Environmental Geology, DOI 10.1007/s00254-002-0531-1. Environmental Geology (2002) 42:65-72

Elliott, W.R. 2007. Zoogeography and biodiversity of Missouri caves and karst. Journal of Cave and Karst Studies 69:135-162.

Foster, S. and R. Hirata, 1988. Groundwater Pollution Risk Assessment – A Methodology Using Available Data. Pan American Center for Sanitary Engineering and Environmental Science (CEPIS), 73 pp: Lima/Peru.

Graening, G.O. 2005. Trophic structure of Ozark cave streams containing endangered species. Journal of Oceanological and Hydrobiological Studies 34(3):3-17.

Graening, G.O., D.B. Fenolio, and M.E. Slay. 2012. Cave Life of Oklahoma and Arkansas: Exploration and Conservation of Subterranean Biodiversity. University of Oklahoma Press: Norman, Oklahoma. 226 pp.

Graening, G., M. Harvey, W. Puckette, R. Stark, D. Sasse, S. Hensley, and R. Redman. 2011. Conservation status of the endangered Ozark big-eared bat (*Corynorhinus townsendii ingens*) - a 34-year assessment. Publications of the Oklahoma Biological Survey, 2nd series, 11(1):1-16.

Hallman, C., 1997. Prediction of Potential Groundwater Pollution Sites in a Karst Area Utilizing DRASTIC, DRASTIC Modifications and GIS. Department of Geosciences, Murray State University, Murray Kentucky, Thesis for Master of Science

Inlander, E., C. Gallipeau, and M.E. Slay. 2011. Mapping the distribution, habitat, and threats for Arkansas' species of greatest conservation need. Final report submitted to Arkansas Game and Fish Commission, Little Rock, Arkansas. 188 pp.

Klug, J., 2009. Modeling the Risk of Groundwater Contamination Using DRASTIC and Geographic Information Systems in Houston County, Minnesota. Department of Resource Analysis, Saint

Mary's University of Minnesota, Winona , MN 55987 Volume 11, Papers in Resource Analysis. 12 pp. Saint Mary's University of Minnesota University Central Services Press. Winona, MN. Retrieved (03/19/2010) http://www.gis.smumn.edu

Lee et al. 1996. Regional Groundwater Pollution Susceptibility Analysis Using DRASTIC System and Lineament Density. Retrieved 10/07/2010. http://proceedings.esri.com/library/userconf/proc98/proceed/to200/pap171/p171.htm

Margane, A., 2003. Guideline for Groundwater Vulnerability Mapping and Risk Assessment for the Susceptibility of Ground Water Resources to Contamination. Technical Cooperation, Project 1996.2189.7, 4, April 2003, 53 pp., Damascus.

Miller, J.A. 2005. A redescription of *Porrhomma cavernicola* Keyserling (Araneae, Linyphiidae) with notes on Appalachian troglobites. Journal of Arachnology 33:426-438.

Mendoza J.A., G. Barmen, 2006. Assessment of groundwater vulnerability in the Rio Artiguas basin, Nicaragua. Environmental Geology, DOI 10.1007/s00254-006-0233-1

Piscopo, G., 2001. Groundwater vulnerability map explanatory notes Castlereagh Catchment. Department of Land and Water Conservation, New South Wales

Slay, M.E., G.O. Graening, and D.B. Fenolio. 2009. New state record and western range extension for *Pseudosinella dubia* Christiansen (Collembola: Entomobryidae) from Oklahoma, U.S.A. Entomological News 120:545.

Tercafs, R.R. 2001. The Protection of the Subterranean Environment: Conservation Principles and Management Tools. University of Liege. 400pp.

USGS. 2001. Circular 1224--Assessing Ground-Water Vulnerability to Contamination: Providing Scientifically Defensible Information for Decision Makers. Retrieved 10/07/2010. http://pubs.usgs.gov/circ/2002/circ1224/html/overview.html