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## The North American obligate cave fauna: regional patterns

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**Abstract.** The obligate cave faunas of nine regions of the United States – Florida Lime Sinks, Appalachians, Interior Low Plateaus, Ozarks, Driftless Area, Edwards Aquifer/Balcones Escarpment, Guadalupe Mountains, Black Hills, and Mother Lode – are described and compared. The number of aquatic (stygobitic) species ranged from zero (Black Hills) to 82 (Appalachians), and the number of terrestrial (troglobitic) species ranged from zero (Florida Lime Sinks) to 256 (Interior Low Plateau). Even at the level of genus, overlap between regions is low. Several predictor variables (karst area, number of caves, number of long caves, number of deep caves, distance from the Pleistocene ice margin, distance from the late Cretaceous Sea, and vegetation type – a surrogate for productivity) were assessed using rank order statistics, especially rank order multiple regression with a backward elimination procedure. For both stygobites and trogllobites, only number of caves was a significant predictor. The absence of a karst area effect suggested that the degree of karst development is better described by the number of caves rather than area of karst. There was no evidence that distance to Pleistocene glacial boundaries was important, but there was some support for the importance of distance from late Cretaceous sea margins, a potential source of aquatic subterranean colonists. Finally, there was no indication that surface productivity had an effect on species richness. Analysis was complicated by correlations among predictor variables.

### Introduction

There are nearly 1000 described species and subspecies of animals that are obligate inhabitants of caves within the 48 coterminous states of the United States (Culver et al. 2003). Most, if not all of these species are the product of independent invasion and isolation of past surface-dwelling populations, and their taxonomic range is large – 210 genera in 96 families in 38 orders. As a result, most of these species have highly restricted ranges – more than half are known from a single county. The obligate cave fauna has the highest reported level of endemism of any taxonomic or ecological group of organisms in the United States (L. Master, personal communication). It is this highly vulnerable, ecologically uniform, but evolutionarily diverse, fauna that is the focus of the present study.

Within North America, the appropriate habitat for subterranean faunas is found in distinct regions that are, in some cases, widely separated. Not surprisingly, there appear to be substantial differences in the fauna from region to region. Barr and Reddell (1967) noted the depauperate nature of the fauna of the Carlsbad Caverns region in New Mexico, which they attributed to the aridity of the region. Peck and Christiansen (1990) noted a similar pattern for the Driftless Area, covering parts of Iowa, Illinois, Wisconsin, and Minnesota (Figure 1). They attributed the low diversity to lack of time for colonization and isolation due to the area having been glaciated during the Pleistocene. Barr (1967) compared the beetle fauna of the Appalachians and Interior Low Plateaus and suggested that cave connectivity (and its converse, isolation) explained differences between the two areas.

All of the previous studies of regional differences have been piecemeal and for good reason. Until very recently there has been no comprehensive list of stygobites and troglobites for any area in sufficient detail for such an analysis. In this contribution, we take advantage of the list of stygobites and troglobites for each county in the US that is now available on the world-wide web at [www.karstwaters.org/troglist](http://www.karstwaters.org/troglist) (Culver et al. 2000). Our focus here is on the regional differences in the cave faunas in the coterminous states of the USA. Our previous work has looked at a much smaller scale, that of the county. But patterns at one scale are not necessarily preserved at other, larger or smaller scales. The analysis of cave regions is important because each region, such as the Florida Lime Sinks, has a unique geology, a unique history, and a distinct climate. These kinds of regional scale differences may in turn explain differences in stygobitic and troglobitic richness among the regions.



Figure 1. Map of the karst regions considered in this paper. The Interior Low Plateau is shown in stippling to differentiate it from the Appalachians and the Ozarks.

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Simply put, our goal is to document the faunal differences among nine major cave regions in the United States and to propose historical and ecological explanations for these quantitative differences among cave regions.

### Methods and materials

While there are a significant number of caves in lava flows in the western United States and additional mechanically formed sea caves, we focused only on regions where caves are formed in soluble rock, especially limestone. While lava tubes have an interesting fauna (Peck 1982), they have been very poorly studied in the continental US. Sea caves are unlikely to harbor stygobites and troglobites and in any case have not been studied biologically.

We relied on geological boundaries to define cave regions. In the central and eastern US there are six major cave-bearing (karst) regions:

- Florida Lime Sinks, with flat-bedded limestones of Tertiary age.
- Appalachians, with greatly folded and faulted limestones of Paleozoic age.
- Interior Low Plateaus, with flat-bedded limestones of Paleozoic age.
- Ozarks, with flat-bedded limestones of Paleozoic age.
- Driftless Area, with flat-bedded limestones of Paleozoic age modified by glacial cover.
- Edwards Aquifer and Balcones Escarpment, with flat-bedded limestones of Mesozoic age.

There are three western karst areas of significant size that have been biologically investigated:

- Guadalupe Mountains, with Paleozoic reef limestone.
- Black Hills, with mildly folded limestones of Paleozoic age.
- Mother Lode karst of California, in tectonically modified Paleozoic limestones.

There are additional smaller karst areas, particularly in the west (Davies et al. 1984; Culver 1999). Except for the Mother Lode, none of these smaller areas has received the level of biological attention the nine just mentioned have. While the boundaries of these nine areas are straightforward (cf. Barr and Reddell 1967), several conventions were followed. The Appalachians, which extend into Canada, were truncated at the Maryland–Pennsylvania border. Thus constituted, the Appalachians include nearly the entire region south of the Pleistocene glaciation, and are a much more homogeneous region than would be the case if the northern part were included. Second, the Interior Low Plateaus is actually a complex of plateaus (e.g., Barr 1967), and we have narrowly defined the region as including only the Cumberland Escarpment, Central Basin, Pennyroyal Plateau (and Mitchell Plain), and Inner Bluegrass, excluding the Outer Bluegrass and smaller outlying regions.

A series of physical and geographic characteristics was determined for each region:

1. Area (km<sup>2</sup>) of the karst region was determined from a digitized version of the map in Culver (1999).
2. The number of reported caves in each region was estimated from the number of caves in counties that are wholly or in part within the region. Original data were from the files of various state cave surveys affiliated with the National Speleological Society.
3. The number of caves longer than 1.67 km (1 mile) from the list of long caves maintained by Robert Gulden at [www.pipeline.com/~caverbob](http://www.pipeline.com/~caverbob).
4. The number of caves deeper than 120 m (400 feet) from the list of deep caves maintained by Robert Gulden at [www.pipeline.com/~caverbob](http://www.pipeline.com/~caverbob).
5. The ranks of the distance from the maximum extent of Pleistocene glaciation, using the map in Dawson (1992).
6. The ranks of the distance from the edge of the maximum extent of the southern lobe of the late Cretaceous Seas using the map in Holsinger and Longley (1980).
7. Major habitat zone based on the habitat map of the World Wildlife Fund (Ricketts et al. 1999), including (a) temperate broadleaf and mixed forests, (b) temperate coniferous forests, (c) temperate grasslands, and (d) xeric shrublands.

The first four characteristics (karst area, number of caves, number of long caves, and number of deep caves) are measures of habitat availability. The next characteristic (rank distance from the Pleistocene ice margin) is a measure of the intensity of climate change that may have forced and/or isolated pre-adapted or exapted surface-dwelling terrestrial populations into caves. The sixth characteristic (rank distance from the southern lobe of the Cretaceous Sea) measures opportunity for invasion of aquatic species into caves as a result of receding Cretaceous seas (Holsinger and Longley 1980). Since the Florida Lime Sinks were completely inundated by Cretaceous Seas, it was given a rank of one, while the partially inundated Edwards Plateau/Balcones Escarpment was given a rank of two. Finally the habitat categories were ranked in the order given, which roughly corresponds to productivity differences. Higher productivity on the surface results in more food entering caves and thus may allow for more species.

The basic format of statistical analysis is a multiple regression with area, number of caves, long caves, deep caves, Cretaceous embayment distance, Pleistocene glaciation distance, and habitat zone as independent variables. The dependent variables were number of stygobites and number of troglobites. Aquatic and terrestrial species were analyzed separately because they appear to have quite different patterns (Christman and Culver 2001). Both because of the small number of regions analyzed and uncertainties in the data, rank order statistics methods were used – Spearman's correlation and a rank order multiple regression with a backward elimination procedure (Iman and Conover 1979). The procedure fits the full model with all of the explanatory variables. It then determines which variable contributes least to the predictive capability of the model. If it is not statistically significant, that variable is eliminated. The model is then refitted with all variables but that one and repeats the same procedure with the remaining variables. The

Table 1. Summary of species richness and geophysical parameters for each region (ranks are given in parentheses).

| Region               | Number of stygobites | Number of troglobites | Total species | Number of caves | Area of karst (km <sup>2</sup> ) | No. of long caves (>1 mile) | No. of deep caves (>400') | Cretaceous rank | Pleistocene rank | Habitat |
|----------------------|----------------------|-----------------------|---------------|-----------------|----------------------------------|-----------------------------|---------------------------|-----------------|------------------|---------|
| Florida Lime Sinks   | 20 (5)               | 0 (9)                 | 20 (6)        | 627 (6)         | 27338 (6)                        | 17 (5)                      | 0 (6)                     | 1               | 7                | 5       |
| Appalachians         | 80 (1)               | 181 (2)               | 261 (2)       | 7441 (2)        | 37268 (5)                        | 222 (2)                     | 27 (2)                    | 5               | 3                | 7       |
| Interior Low Plateau | 62 (2)               | 257 (1)               | 319 (1)       | 11928 (1)       | 60612 (3)                        | 389 (1)                     | 64 (1)                    | 3               | 2                | 7       |
| Ozarks               | 46 (4)               | 31 (4)                | 77 (4)        | 6964 (3)        | 110125 (1)                       | 84 (3)                      | 0 (6)                     | 4               | 4                | 7       |
| Edwards/Balcones     | 55 (3)               | 108 (3)               | 163 (3)       | 2011 (4)        | 65586 (2)                        | 19 (4)                      | 1 (5)                     | 2               | 6                | 2       |
| Guadalupes           | 1 (8)                | 13 (6)                | 14 (7)        | 1379 (5)        | 43522 (4)                        | 16 (6)                      | 6 (3)                     | 6               | 9                | 1       |
| Mother Lode          | 3 (6)                | 20 (5)                | 23 (5)        | 179 (8)         | 390 (9)                          | 1 (9)                       | 0 (6)                     | 9               | 8                | 5       |
| Black Hills          | 0 (9)                | 2 (8)                 | 2 (9)         | 160 (9)         | 7272 (8)                         | 6 (8)                       | 2 (4)                     | 8               | 5                | 5       |
| Driftless            | 2 (7)                | 11 (7)                | 13 (8)        | 615 (7)         | 25 222 (7)                       | 7 (7)                       | 0 (6)                     | 7               | 1                | 2       |

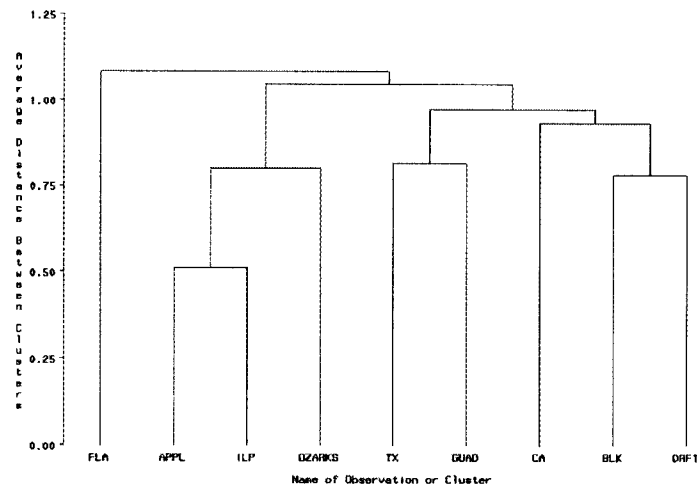


Figure 2 UPGMA of generic differences between regions (see Table 2). Regions are abbreviated as follows: Florida Lime Sinks (FLA); Appalachians (APPL); Interior Low Plateaus (ILP); Ozarks (OZARKS); Edwards Plateau/Balcones Escarpment (TX); Guadalupe Mountains (GUAD); Mother Lode (CA); Black Hills (BLK); and Driftless Area (DRFT).

Table 2. Proportion of genera that overlap between regions.

| Region | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1      | 8     | 0.250 | 0.500 | 0.375 | 0.125 | 0     | 0     | 0     | 0     |
| 2      | 0.030 | 67    | 0.612 | 0.254 | 0.149 | 0.045 | 0.060 | 0.030 | 0.090 |
| 3      | 0.048 | 0.494 | 83    | 0.181 | 0.121 | 0.036 | 0.048 | 0.024 | 0.048 |
| 4      | 0.083 | 0.472 | 0.417 | 36    | 0.194 | 0.056 | 0.111 | 0.028 | 0.167 |
| 5      | 0.017 | 0.170 | 0.170 | 0.119 | 59    | 0.136 | 0.051 | 0.017 | 0.068 |
| 6      | 0     | 0.231 | 0.231 | 0.154 | 0.615 | 13    | 0.154 | 0     | 0.077 |
| 7      | 0     | 0.308 | 0.308 | 0.308 | 0.231 | 0.154 | 13    | 0     | 0.231 |
| 8      | 0     | 1.000 | 1.000 | 0.500 | 0.500 | 0     | 0     | 2     | 0.500 |
| 9      | 0     | 0.545 | 0.364 | 0.545 | 0.364 | 0.091 | 0.273 | 0.091 | 11    |

The diagonal is the number of genera found in the region. Each row contains the proportion of genera in the region associated with that row, and which also are found in the region associated with the column.

procedure is repeated until only statistically significant variables are left in the model. Rank regression is well suited to analyze data that have monotonic, but non-linear, relationships.

Since most species have very small ranges – over half are known from a single county (Culver et al. 2000) – and those species with large ranges were described prior to 1900, suggesting that a taxonomic re-examination is in order (Christman and Culver 2001), we compared faunas at the level of genus by computing the fraction of each region's taxa shared with the region being compared. We also ran a cluster analysis using the unweighted pair-group method with arithmetic averages (UPGMA, Sneath and Sokal 1973) for genera among regions.



## Results

The list of species and subspecies for each region is given in Appendix 1. Only described species and subspecies are included in the analysis. The number of stygobites and troglobites in each region is given in Table 1. The number of troglobites ranged from zero in the Florida Lime Sinks to 261 in the Interior Low Plateau. The median number of troglobitic species was 20. The number of stygobites ranged from zero in the Black Hills to 80 in the Appalachians. The median number of stygobitic species was also 20.

Overlap of genera is summarized in Table 2. Even those regions that are contiguous or nearly so (Appalachians, Interior Low Plateau, and Ozarks) share less than 62% of their genera. For many geographically distant regions, overlap is less than 10%. The UPGMA diagram (Figure 2) indicates that the Appalachians and Interior Low Plateaus are most closely related and that they are in turn most closely related to the Ozarks. The Edwards Plateau/Balcones Escarpment in Texas also shows overlap with the fauna of the Guadalupe Mountains in New Mexico, as does the Black Hills and Driftless Area fauna. In both of these comparisons the overlap is largely among terrestrial genera. The most distinct region is the Florida Lime Sinks, in part because it has no terrestrial fauna. All in all, the UPGMA of genera reflects geographic distance between regions.

Rank order correlations between stygobite and troglobite richness and a variety of potential predictor variables are shown in Table 3. We note in passing that stygobite and troglobite numbers are themselves significantly correlated, although there are obvious differences in the pattern between the two. For example, the Florida Lime Sinks has no troglobites and the Black Hills has no stygobites. Stygobites show a significant pairwise correlation with two of the seven variables – number of caves and number of long caves. In addition, the habitat zone (ranked by relative dryness) and distance from the southern lobe of the Eocene embayment are marginally correlated ( $0.05 < P < 0.10$ ) with stygobite numbers. Troglobites also showed a significant correlation with both number of caves and number of long caves. In this case there were no marginally significant correlations.

There were numerous significant correlations among the predictor variables. In particular the number of caves, karst area, number of long caves, and rank distance from Eocene embayment were themselves all significantly correlated (Table 3), with the absolute value of the correlations ranging from 0.62 to 0.97.

The rank order regression with backward elimination yielded very similar results for both stygobites (Table 4) and troglobites (Table 5). In both cases only one variable was found to be a significant predictor of species number, i.e., number of caves. Because of the strong correlation among variables (Table 3), this is not surprising, but it also means that it is difficult to disentangle the separate effects of the independent variables.

The high variability of number of stygobites and number of troglobites suggests another way to analyze the data. Stygobite numbers fall into two very distinct groups: 0–3 and 19–82; and troglobite numbers also fall into two very distinct groups: 0–29 and 105–256 (Table 1). Two-sample Mann–Whitney *U* tests (Table 6) indicated significant differences between low and high diversity stygobite

Table 3. Spearman correlation coefficients (*P*-values italicized and below the estimated correlation).

|                  | Stygo-<br>bites         | Troglo-<br>bites     | Caves                   | Karst<br>area        | Long<br>caves        | Deep<br>caves        | Cretaceous<br>rank   | Pleistocene<br>rank  | Habitat<br>class |
|------------------|-------------------------|----------------------|-------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|------------------|
| Stygobites       | 1.00                    |                      |                         |                      |                      |                      |                      |                      |                  |
| Troglobite:      | 0.80<br><i>0.01</i>     | 1.00                 |                         |                      |                      |                      |                      |                      |                  |
| Caves            | 0.85<br><i>&lt;0.01</i> | 0.82<br><i>0.01</i>  | 1.00                    |                      |                      |                      |                      |                      |                  |
| Karst area       | 0.55<br><i>0.13</i>     | 0.57<br><i>0.11</i>  | 0.80<br><i>0.01</i>     | 1.00                 |                      |                      |                      |                      |                  |
| Long cave:       | 0.85<br><i>&lt;0.01</i> | 0.72<br><i>0.03</i>  | 0.97<br><i>&lt;0.01</i> | 0.78<br><i>0.01</i>  | 1.00                 |                      |                      |                      |                  |
| Deep cave:       | 0.33<br><i>0.38</i>     | 0.56<br><i>0.11</i>  | 0.54<br><i>0.13</i>     | 0.25<br><i>0.51</i>  | 0.52<br><i>0.15</i>  | 1.00                 |                      |                      |                  |
| Eocene rank      | -0.60<br><i>0.09</i>    | -0.22<br><i>0.58</i> | -0.62<br><i>0.08</i>    | -0.68<br><i>0.04</i> | -0.72<br><i>0.03</i> | -0.10<br><i>0.81</i> | 1.00                 |                      |                  |
| Pleistocene rank | -0.38<br><i>0.31</i>    | -0.35<br><i>0.36</i> | -0.37<br><i>0.33</i>    | -0.15<br><i>0.70</i> | -0.45<br><i>0.22</i> | -0.17<br><i>0.65</i> | 0.07<br><i>0.86</i>  | 1.00                 |                  |
| Habitat class    | 0.62<br><i>0.07</i>     | 0.48<br><i>0.19</i>  | 0.51<br><i>0.16</i>     | 0.20<br><i>0.61</i>  | 0.58<br><i>0.10</i>  | 0.21<br><i>0.58</i>  | -0.18<br><i>0.64</i> | -0.46<br><i>0.21</i> | 1.00             |

Table 4. Results of the rank regression backward elimination procedure for stygobites as the response variable.

| Step | Model adj. | Estimated coefficients for the independent variables |                 |                 |                |                 |
|------|------------|--|-----------------|-----------------|----------------|-----------------|
|      | $R^2$      | Caves  | Karst area      | Cretaceous rank | Habitat class  | Long caves      |
| 0    | 0.59:3     | 1.476 (0.2983)                                       | -0.399 (0.4309) | -0.466 (0.3813) | 0.331 (0.4490) | -0.782 (0.6255) |
| 1    | 0.66:9     | 0.892 (0.1065)                                       | -0.399 (0.3746) | -0.287 (0.3697) | 0.203 (0.4961) |                 |
| 2    | 0.69:4     | 1.085 (0.0216)                                       | -0.508 (0.2122) | -0.278 (0.3515) |                |                 |
| 3    | 0.69:6     | 1.139 (0.0130)                                       | -0.361 (0.3114) |                 |                |                 |
| 4    | 0.68:9     | 0.850 (0.0037)                                       |                 |                 |                |                 |

Independent variables were chosen based on Spearman's correlation coefficients for pairwise dependence. *P*-values for testing the null hypothesis that the coefficient is zero are given in parentheses.

Table 5. Results of the rank regression backward elimination procedure for troglobites as the response variable.

| Step | Model adj. | Estimated coefficients for the independent variables |                 |                |                |                |
|------|------------|--|-----------------|----------------|----------------|----------------|
|      | $R^2$      | Caves  | Long caves      | WWF class      | Deep caves     | Karst area     |
| 0    | 0.5254     | 1.942 (0.1540)                                       | -1.556 (0.2491) | 0.337 (0.4439) | 0.244 (0.5258) | 0.108 (0.8486) |
| 1    | 0.6389     | 1.997 (0.0815)                                       | -1.484 (0.1755) | 0.294 (0.3544) | 0.212 (0.4685) |                |
| 2    | 0.6649     | 2.089 (0.0520)                                       | -1.455 (0.1549) | 0.272 (0.3583) |                |                |
| 3    | 0.6637     | 1.890 (0.0563)                                       | -1.110 (0.2150) |                |                |                |
| 4    | 0.6194     | 0.817 (0.0072)                                       |                 |                |                |                |

Independent variables were chosen based on Spearman's correlation coefficients for pairwise dependence. *P*-values for testing the null hypothesis that the coefficient is zero are given in parentheses.

regions with respect to number of caves, karst area, number of long caves, and Eocene distance. There were significant differences between low and high diversity troglobite regions with respect to number of caves, number of long caves,

Table 6. Two sample Mann–Whitney  $U$  test probabilities for differences between two categories of regions in terms of stygobites and troglobites (see text for details).

|             | Number of caves | Karst area | No. of long caves | No. of deep caves | Cretaceous distance | Pleistocene distance | Habitat distance |
|-------------|-----------------|------------|-------------------|-------------------|---------------------|----------------------|------------------|
| Stygobites  | 0.025           | 0.05       | 0.01              | ns                | 0.025               | ns                   | ns               |
| Troglobites | 0.025           | ns         | 0.025             | 0.05              | ns                  | ns                   | ns               |

and number of deep caves. Again, these numbers must be interpreted with caution because of the confounding nature of the correlation among the independent variables.

## Discussion

As is the case with any invertebrate fauna, the question must be raised about the quality of the data on species richness, and whether patterns are the result of sampling intensity. The cave faunas are probably better known than any other group of USA invertebrates, with the exception of butterflies and longhorn beetles (Culver et al. 2000). Nevertheless, new species are being described every year, and some genera, such as *Pseudanopthalmus* carabid beetles and *Pseudotremia* millipedes, are known to have many undescribed species (Peck 1998). In addition, one region – the Edwards Plateau/Balcones Escarpment – may have a higher percentage of undescribed species than other regions (Reddell 1994). It is of course difficult to predict the pattern of description of new species, but recent descriptions of species have been from the ‘well-known’ regions of the Appalachians and the Interior Low Plateau (Lewis 2000) as well as from ‘poorly known’ regions such as the Edwards Plateau (Lewis and Bowman 1996). All regions have been intensively sampled, but we have no direct quantitative measure of sampling intensity. Because we used ranks in our analysis, our results will change only if the ranks of species diversity change among the regions. It seems unlikely that the Edwards Plateau/Balcones Escarpment will surpass the Appalachians and Interior Low Plateau, since species numbers are much greater in the latter (Table 1) and species are being described from all regions. The most likely situation where ranks will change is in the number of stygobites in the western and upper Midwestern areas (Black Hills, Guadalupes, Driftless Area, and the Mother Lode). Each of these regions has fewer than four stygobitic species (Table 1). We believe that the potential for new stygobitic species in these areas is not great, but the discovery of even one or two new species will change their ranks.

The clearest pattern to emerge from the analysis is that for both stygobites (Table 4) and troglobites (Table 5) the rank order number of caves in a region is the best predictor of the rank order of the number of species. Conversely, karst area is not a good predictor, even when considered separately (Table 3). The only suggestion that karst area was important was the difference in karst area between high and low diversity stygobite regions (Table 6). This suggests that it is not size

but rather the degree of karst development that is an important determinant of species number. One measure of karst development – number of long caves – was found to be correlated with both the number of stygobites and troglobites, while yet another measure – the number of deep caves – was not (Table 3). This was somewhat surprising, since the extent of vertical development is possibly more likely to reflect higher habitat diversity than the extent of horizontal development. For example, even in very long caves such as Mammoth Cave, habitats differ most noticeably by their vertical position within the cave rather than distance from the entrance. Examples would include high level sandy floored passages and base level vertical shaft drains. When troglobites and stygobites were divided into two groups, a similar pattern was obtained except that the number of deep caves did significantly differ between low- and high-diversity troglobite areas (Table 6).

A somewhat surprising result is the lack of any evidence that proximity to Pleistocene glacial boundaries was an important factor in determining species numbers, especially for troglobites. We certainly do not claim that the Pleistocene was unimportant in forcing species underground, it is just that distance from the Pleistocene margin showed no significant correlation. Part of the problem may be in the definition of distance from the Pleistocene ice sheet. We used the distance from the main lobe of the Wisconsin glaciation, but actual distance of each region from some ice sheet is quite different given the earlier glaciation and the smaller, isolated glaciers in the American West (Brouillet and Whetstone 1993).

There was weak support for the importance of the Cretaceous Embayment in determining the number of stygobites. Considered in isolation, distance to the Eocene Sea was marginally correlated with stygobite number (Table 3), and low stygobite diversity regions were farther from the Eocene boundary than high stygobite diversity regions (Table 6).

The historical patterns of glaciation and sea embayment may be relatively unimportant in determining species numbers but very important in determining species composition. The aquatic fauna of the Edwards Plateau/Balcones Escarpment is a good example. It is the only area at the margin of Cretaceous Seas (Florida was submerged), but it does not have the most stygobites (Table 1). However, the stygobites present reflect a marine ancestry (Holsinger and Longley 1980), unlike nearly all other stygobites in all other regions. That is, the source of stygobites is different, but not necessarily their number.

The final variable we considered was major habitat zone. The four categories (temperate broadleaf forest, temperate coniferous forest, temperate grasslands, and xeric shrublands) provide a ranking of the productivity of different areas. Since the food in a cave results from secondary production of the surrounding surface area (Rouch 1982), there might be a correlation between the two, because amount of food in a cave may set a limit on the number of species present. In other words, resource level may affect extinction rates just as proximity to the Eocene Sea or the Pleistocene ice sheet may affect colonization rates. However, no relationship was found.

When viewed from the perspective of the individual region, there are plausible explanations for the patterns seen in each. We use Florida as an example. It is close to the late Cretaceous embayment and far from the Pleistocene ice margin, and so

we would expect few troglobites and many stygobites. This is what we observe (Table 1). It is just that, for the most part, these idiopathic explanations do not fit into a coherent whole when viewed from a larger perspective. Only the degree (or quality) of karstification as measured by the number of caves offers a general explanation of differences in species richness. This suggests that habitat constraints (number of caves in particular) are more important than opportunities for colonization in determining species richness. Species composition, on the other hand, may have a stronger historical component.

### Acknowledgements

Support for the creation of the lists of troglobites and stygobites was provided by the Cave Conservancy of the Virginias, the Karst Waters Institute, and The Nature Conservancy.

### Appendix 1

List of species and subspecies by region.

| Class/phylum order                  |                  | Species  |
|-------------------------------------|------------------|--|
| <i>Region 1: Florida Lime Sinks</i> |                  |  |
| Crustacea                           | Amphipoda        | <i>Crangonyx grandimanus</i><br><i>C. hobbsi</i>   |
|                                     | Decapoda         | <i>Palaemonetes cummingi</i><br><i>Procambarus acherontis</i><br><i>P. attiguus</i><br><i>P. delicatus</i><br><i>P. erythroops</i><br><i>P. franzi</i><br><i>P. horsti</i><br><i>P. leitheuseri</i><br><i>P. lucifugus alachua</i><br><i>P. lucifugus lucifugus</i><br><i>P. morrissi</i><br><i>P. orcinus</i><br><i>P. pallidus</i><br><i>Troglocambarus maclanei</i> |
|                                     | Isopoda          | <i>Caecidotea hobbsi</i>   |
| Oligochaeta                         | Podocopida       | <i>Remasellus parvus</i>   |
| <i>Region 2: Appalachians</i>       | Branchiobdellida | <i>Uncinocythere ambophora</i><br><i>Cambarinicola leoni</i>   |
| Amphibia                            | Urodela          | <i>Gyrinophilus palleucus gulolineatus</i><br><i>G. palleucus palleucus</i><br><i>G. subterraneus</i>  |
| Arachnida                           | Acari            | <i>Foveacheles parallelseta</i><br><i>Poecilophysis wolmsdorfensis</i><br><i>Rhagidia cavernarum</i><br><i>R. varia</i>  |

## Appendix 1. (continued)

| Class/phylum order     |                             | Species  |
|------------------------|-----------------------------|--|
|                        | Araneae                     | <i>Anthrobia mammothia</i><br><i>Bathyphantes weyeri</i><br><i>Islandiana muma</i><br><i>I. speophila</i><br><i>Liocranoides unicolor</i><br><i>Nesticus barri</i><br><i>N. barrowsi</i><br><i>N. dilutus</i><br><i>N. furtivus</i><br><i>N. georgia</i><br><i>N. holsingeri</i><br><i>N. paynei</i><br><i>N. tennesseensis</i><br><i>Phanetta subterranea</i><br><i>Porrhomma cavernicola</i>   |
|                        | Pseudoscorpiones            | <i>Apochthonius coecus</i><br><i>A. holsingeri</i><br><i>A. paucispinosus</i><br><i>Chitrella regina</i><br><i>Ch. superba</i><br><i>Hesperochernes mirabilis</i><br><i>Kleptochthonius affinis</i><br><i>K. anophthalmus</i><br><i>K. binoculatus</i><br><i>K. gertschi</i><br><i>K. henroti</i><br><i>K. hetricki</i><br><i>K. infernalis</i><br><i>K. lutzi</i><br><i>K. orpheus</i><br><i>K. proserpinae</i><br><i>K. proximusetus</i><br><i>K. regulus</i><br><i>K. similis</i><br><i>Microcreagris subatlantica</i><br><i>M. valentinei</i><br><i>Mundochthonius holsingeri</i><br><i>Tyrannochthonius chamberlini</i> |
| Chilopoda<br>Crustacea | Geophilomorpha<br>Amphipoda | <i>Nampabius turbator</i><br><i>C. antennatus</i><br><i>C. dearolfi</i><br><i>Stygobromus abditus</i><br><i>S. ackerlyi</i><br><i>S. allegheniensis</i><br><i>S. baroodyi</i><br><i>S. barryi</i><br><i>S. biggersi</i><br><i>S. conradi</i><br><i>S. cooperi</i><br><i>S. culveri</i><br><i>S. cumberlandus</i><br><i>S. dicksoni</i><br><i>S. emarginatus</i><br><i>S. ephemerus</i><br><i>S. estesi</i><br><i>S. exilis</i><br><i>S. fecundus</i>   |

## Appendix 1. (continued)

| Class/phylum order | Species                                  |
|--------------------|--|
|                    | <i>S. fergusonii</i>                     |
|                    | <i>S. finleyi</i>                        |
|                    | <i>S. franzi</i>                         |
|                    | <i>S. gracilipes</i>                     |
|                    | <i>S. grandis</i>                        |
|                    | <i>S. hoffmani</i>                       |
|                    | <i>S. inexpectatus</i>                   |
|                    | <i>S. interitus</i>                      |
|                    | <i>S. leensis</i>                        |
|                    | <i>S. mackini</i>                        |
|                    | <i>S. minutus</i>                        |
|                    | <i>S. morrisoni</i>                      |
|                    | <i>S. mundus</i>                         |
|                    | <i>S. nanus</i>                          |
|                    | <i>S. nortoni</i>                        |
|                    | <i>S. parvus</i>                         |
|                    | <i>S. pollostus</i>                      |
|                    | <i>S. pseudospinosus</i>                 |
|                    | <i>S. redactus</i>                       |
|                    | <i>S. sparsus</i>                        |
|                    | <i>S. spinatus</i>                       |
|                    | <i>S. stegerorum</i>                     |
| Decapoda           | <i>Cambarus nerterius</i>                |
|                    | <i>Orconectes australis australis</i>    |
| Isopoda            | <i>Amergoniscus curvatus</i>             |
|                    | <i>Am. georgiensis</i>                   |
|                    | <i>Am. henroti</i>                       |
|                    | <i>Am. nicholasi</i>                     |
|                    | <i>Am. paynei</i>                        |
|                    | <i>Am. proximus</i>                      |
|                    | <i>Antrolana lira</i>                    |
|                    | <i>Ca. cannula</i>                       |
|                    | <i>Ca. circulus</i>                      |
|                    | <i>Ca. cyrtorhynchus</i>                 |
|                    | <i>Ca. franzi</i>                        |
|                    | <i>Ca. henroti</i>                       |
|                    | <i>Ca. holsingeri</i>                    |
|                    | <i>Ca. incurva</i>                       |
|                    | <i>Ca. nortoni</i>                       |
|                    | <i>Ca. pricei</i>                        |
|                    | <i>Ca. recurvata</i>                     |
|                    | <i>Ca. richardsonae</i>                  |
|                    | <i>Ca. scypha</i>                        |
|                    | <i>Ca. simonini</i>                      |
|                    | <i>Ca. sinuncus</i>                      |
|                    | <i>Ca. vandeli</i>                       |
|                    | <i>Ligidium elrodii chatoogaensis</i>    |
|                    | <i>L. elrodii hancockensis</i>           |
|                    | <i>L. elrodii leensis</i>                |
|                    | <i>L. elrodii scottensis</i>             |
|                    | <i>Lirceus culveri</i>                   |
|                    | <i>Lir. usdagalun</i>                    |
|                    | <i>Miktoniscus racovitzai racovitzai</i> |

## Appendix 1. (continued)

| Class/ phylum order    |                              | Species  |
|------------------------|------------------------------|--|
| Crustacea<br>Diplopoda | Podocopida                   | <i>Donnaldsoncythere tuberosa</i>  |
|                        | Callipodida<br>Chordeumatida | <i>Tetracion jonesi</i><br><i>Pseudotremia aeacus</i><br><i>Ps. cavernarum</i><br><i>Ps. deprehendor</i><br><i>Ps. eburnea</i><br><i>Ps. fulgida</i><br><i>Ps. lusciosa</i><br><i>Ps. nodosa</i><br><i>Ps. tuberculata</i><br><i>Ps. valga</i><br><i>Scoterpes austrinus austrinus</i><br><i>Trichopetalum krekeleeri</i><br><i>T. packardi</i><br><i>T. weyeriensis</i><br><i>T. whitei</i>   |
| Insecta                | Julida                       | <i>Ameractis satis</i>   |
|                        | Collembola                   | <i>Arrhopalites caedus</i><br><i>Ar. carolynae</i><br><i>Ar. clarus</i><br><i>Ar. commorus</i><br><i>Ar. lacuna</i><br><i>Ar. marshalli</i><br><i>Ar. pavo</i><br><i>Ar. sacer</i><br><i>Ar. silvus</i><br><i>Oncopodura hubbardi</i><br><i>Onychiurus janus</i><br><i>Pseudosinella bona</i><br><i>Pse. certa</i><br><i>Pse. christianseni</i><br><i>Pse. erehwon</i><br><i>Pse. extra</i><br><i>Pse. gisini gisini</i><br><i>Pse. gisini virginia</i><br><i>Pse. granda</i><br><i>Pse. hirsuta</i><br><i>Pse. orba</i><br><i>Pse. spinosa</i><br><i>Pse. testa</i><br><i>Schaefferia hubbardi</i><br><i>Sinella agna</i><br><i>Si. barri</i><br><i>Si. cavernarum</i><br><i>Si. hoffmani</i><br><i>Si. krekeleeri</i><br><i>Typhlogastrura valentini</i> |
|                        | Diplura                      | <i>Litocampa cookei</i><br><i>Lit. fieldingi</i><br><i>Lit. pucketti</i><br><i>Lit. valentinei</i>   |
|                        | Coleoptera                   | <i>Batriasymnodes greeveri</i><br><i>B. parki</i><br><i>B. spelaeus</i><br><i>Batrisodes clypeospecus</i><br><i>Darlingtonia kentuckensis kentuckensis</i>   |



## Appendix 1. (continued)

| Class/ylum order | Species                           |
|------------------|-----------------------------------|
|                  | <i>Horologion speokoites</i>      |
|                  | <i>Nelsonites walteri</i>         |
|                  | <i>Pseudanophthalmus alabamae</i> |
|                  | <i>Pseu. assimilis</i>            |
|                  | <i>Pseu. avernus</i>              |
|                  | <i>Pseu. beakleyi</i>             |
|                  | <i>Pseu. cordicollis</i>          |
|                  | <i>Pseu. deceptivus</i>           |
|                  | <i>Pseu. delicatus</i>            |
|                  | <i>Pseu. digitus</i>              |
|                  | <i>Pseu. egberti</i>              |
|                  | <i>Pseu. engelhardti</i>          |
|                  | <i>Pseu. fastigatus</i>           |
|                  | <i>Pseu. fulleri</i>              |
|                  | <i>Pseu. fuscus</i>               |
|                  | <i>Pseu. georgiae</i>             |
|                  | <i>Pseu. gracilis</i>             |
|                  | <i>Pseu. grandis</i>              |
|                  | <i>Pseu. hadenoecus</i>           |
|                  | <i>Pseu. higginothami</i>         |
|                  | <i>Pseu. hirsutus</i>             |
|                  | <i>Pseu. hoffmani</i>             |
|                  | <i>Pseu. holsingeri</i>           |
|                  | <i>Pseu. hortulanus</i>           |
|                  | <i>Pseu. hubbardi</i>             |
|                  | <i>Pseu. hubrichti</i>            |
|                  | <i>Pseu. hypertrichosis</i>       |
|                  | <i>Pseu. intersectus</i>          |
|                  | <i>Pseu. jonesi</i>               |
|                  | <i>Pseu. krekeleri</i>            |
|                  | <i>Pseu. lallemanti</i>           |
|                  | <i>Pseu. limicola</i>             |
|                  | <i>Pseu. longiceps</i>            |
|                  | <i>Pseu. montanus</i>             |
|                  | <i>Pseu. nelsoni</i>              |
|                  | <i>Pseu. nortoni</i>              |
|                  | <i>Pseu. pallidus</i>             |
|                  | <i>Pseu. paradoxus</i>            |
|                  | <i>Pseu. parvicollis</i>          |
|                  | <i>Pseu. paynei</i>               |
|                  | <i>Pseu. petrunkevitchi</i>       |
|                  | <i>Pseu. pontis</i>               |
|                  | <i>Pseu. potomaca potamaca</i>    |
|                  | <i>Pseu. potomaca senecae</i>     |
|                  | <i>Pseu. praetermissus</i>        |
|                  | <i>Pseu. punctatus</i>            |
|                  | <i>Pseu. pusillus</i>             |
|                  | <i>Pseu. pusio</i>                |
|                  | <i>Pseu. quadratus</i>            |
|                  | <i>Pseu. robustus</i>             |
|                  | <i>Pseu. rotundatus</i>           |
|                  | <i>Pseu. sanctipauli</i>          |
|                  | <i>Pseu. scutillus</i>            |

## Appendix 1. (continued)

| Class/phylum order                     |                 | Species                           |
|--|-----------------|-----------------------------------|
|  |                 | <i>Pseu. seclusus</i>             |
|  |                 | <i>Pseu. sequoyah</i>             |
|  |                 | <i>Pseu. sericus</i>              |
|  |                 | <i>Pseu. sidus</i>                |
|  |                 | <i>Pseu. tennesseensis</i>        |
|  |                 | <i>Pseu. thomasi</i>              |
|  |                 | <i>Pseu. unionis</i>              |
|  |                 | <i>Pseu. vicarius</i>             |
|  |                 | <i>Pseu. virginicus</i>           |
|  |                 | <i>Pseu. wallacei</i>             |
|  |                 | <i>Ptomaphagus fiskei</i>         |
|  |                 | <i>Pt. whiteselli</i>             |
|  |                 | <i>Troglanillus valentinei</i>    |
| Mollusca                               | Diptera         | <i>Spelobia tenebrarum</i>        |
|  | Mesogastropoda  | <i>Antrorbis breweri</i>          |
|  |                 | <i>Fontigens tartarea</i>         |
|  |                 | <i>F. turritella</i>              |
|  |                 | <i>Holsingeria unthanksensis</i>  |
|  | Stylommatophora | <i>Helicodiscus barri</i>         |
| Oligochaeta                            |                 | <i>Glyphyalinia specus</i>        |
|  | Lumbriculida    | <i>Haplotaxis brinkhursti</i>     |
|  |                 | <i>Spelaedrillus multiporus</i>   |
|  |                 | <i>Stylodrilus beattiei</i>       |
|  |                 | <i>Trichodrilus culveri</i>       |
| Pisces                                 | Percopsiformes  | <i>Typhlichthys subterraneus</i>  |
| Turbellaria                            | Allocozoela     | <i>Geocentrophora cavernicola</i> |
|  | Tricladida      | <i>Macrocotyla hoffmasteri</i>    |
|  |                 | <i>Phagocata angusta</i>          |
|  |                 | <i>Sphalloplana chandleri</i>     |
|  |                 | <i>Sp. consimilis</i>             |
|  |                 | <i>Sp. culveri</i>                |
|  |                 | <i>Sp. georgiana</i>              |
|  |                 | <i>Sp. percoeca</i>               |
|  |                 | <i>Sp. virginiana</i>             |
| <i>Region 3: Interior Low Plateaus</i> |                 |                                   |
| Amphibia                               | Urodela         | <i>G. palleucus necturoides</i>   |
|  |                 | <i>G. palleucus palleucus</i>     |
| Arachnida                              | Acari           | <i>Belba bulbipedata</i>          |
|  |                 | <i>Galumna alata</i>              |
|  |                 | <i>Hamohalacarus subterraneus</i> |
|  |                 | <i>Macrocheles troglodytes</i>    |
|  |                 | <i>R. cavernarum</i>              |
|  |                 | <i>Soldanellonyx chapuisi</i>     |
|  |                 | <i>So. morardi</i>                |
|  |                 | <i>Veigaia bakeri</i>             |
|  |                 | <i>V. wyandottensis</i>           |
|  | Araneae         | <i>An. mammothia</i>              |
|  |                 | <i>Bat. weyeri</i>                |
|  |                 | <i>Cicurina wiltoni</i>           |
|  |                 | <i>I. muma</i>                    |
|  |                 | <i>Leptoneta serena</i>           |
|  |                 | <i>Lio. unicolor</i>              |
|  |                 | <i>N. barri</i>                   |
|  |                 | <i>N. jonesi</i>                  |
|  |                 | <i>N. stygius</i>                 |
|  |                 | <i>N. valentinei</i>              |

## Appendix 1. (continued)

| Class/phylum order     | Species                                |
|------------------------|--|
| Opiliones              | <i>Pha. subterranea</i>                |
|                        | <i>Po. cavernicola</i>                 |
|                        | <i>Bishopella jonesi</i>               |
|                        | <i>Erebomaster flavescens</i>          |
|                        | <i>Hesperonemastoma pallidimaculos</i> |
|                        | <i>Phalangodes appalachius</i>         |
| Pseudoscorpiones       | <i>Ph. armata</i>                      |
|                        | <i>Alabamocreagris mortis</i>          |
|                        | <i>Al. pecki</i>                       |
|                        | <i>Aphrastochthonius pecki</i>         |
|                        | <i>Ap. tenax</i>                       |
|                        | <i>A. indianensis</i>                  |
|                        | <i>A. russelli</i>                     |
|                        | <i>Chitrella archeri</i>               |
|                        | <i>He. mirabilis</i>                   |
|                        | <i>K. attenuatus</i>                   |
|                        | <i>K. barri</i>                        |
|                        | <i>K. cerberus</i>                     |
|                        | <i>K. charon</i>                       |
|                        | <i>K. daemonius</i>                    |
|                        | <i>K. erebicus</i>                     |
|                        | <i>K. hageni</i>                       |
|                        | <i>K. hubrichti</i>                    |
|                        | <i>K. krekeleri</i>                    |
|                        | <i>K. magnus</i>                       |
|                        | <i>K. microphthalmus</i>               |
|                        | <i>K. myopioides</i>                   |
|                        | <i>K. packardi</i>                     |
|                        | <i>K. pluto</i>                        |
|                        | <i>K. rex</i>                          |
|                        | <i>K. stygius</i>                      |
|                        | <i>K. tantalus</i>                     |
|                        | <i>M. eurydice</i>                     |
|                        | <i>M. nickajackensis</i>               |
|                        | <i>M. persephone</i>                   |
|                        | <i>M. pluto</i>                        |
|                        | <i>M. subatlantica</i>                 |
|                        | <i>Ty. aladdinensis</i>                |
| <i>Ty. aralu</i>       |  |
| <i>Ty. archeri</i>     |  |
| <i>Ty. attenuatus</i>  |  |
| <i>Ty. avernicolus</i> |  |
| <i>Ty. barri</i>       |  |
| <i>Ty. binoculatus</i> |  |
| <i>Ty. charon</i>      |  |
| <i>Ty. diabolus</i>    |  |
| <i>Ty. erebicus</i>    |  |
| <i>Ty. felix</i>       |  |
| <i>Ty. fiskei</i>      |  |
| <i>Ty. gnomus</i>      |  |
| <i>Ty. halopotamus</i> |  |
| <i>Ty. hypogeus</i>    |  |
| <i>Ty. infernalis</i>  |  |
| <i>Ty. jonesi</i>      |  |

## Appendix 1. (continued)

| Class/pl ylum order |                                | Species                                  |                                     |
|---------------------|--------------------------------|--|-------------------------------------|
|                     |                                | <i>Ty. nergal</i>                        |                                     |
|                     |                                | <i>Ty. orpheus</i>                       |                                     |
|                     |                                | <i>Ty. osiris</i>                        |                                     |
|                     |                                | <i>Ty. parvus</i>                        |                                     |
|                     |                                | <i>Ty. pecki</i>                         |                                     |
|                     |                                | <i>Ty. pholeter</i>                      |                                     |
|                     |                                | <i>Ty. pluto</i>                         |                                     |
|                     |                                | <i>Ty. satan</i>                         |                                     |
|                     |                                | <i>Ty. sheltae</i>                       |                                     |
|                     |                                | <i>Ty. skeletonis</i>                    |                                     |
|                     |                                | <i>Ty. steevesi</i>                      |                                     |
|                     |                                | <i>Ty. stygius</i>                       |                                     |
|                     |                                | <i>Ty. tartarus</i>                      |                                     |
|                     |                                | <i>Ty. tenuis</i>                        |                                     |
|                     |                                | <i>Ty. torodei</i>                       |                                     |
| Crustacea           | Amphipoda                      | <i>C. antennatus</i>                     |                                     |
|                     |                                | <i>C. packardi</i>                       |                                     |
|                     |                                | <i>S. dicksoni</i>                       |                                     |
|                     |                                | <i>S. exilis</i>                         |                                     |
|                     |                                | <i>S. nortoni</i>                        |                                     |
|                     |                                | <i>S. smithi</i>                         |                                     |
|                     |                                | <i>S. vitreus</i>                        |                                     |
|                     |                                | Copepoda                                 | <i>Bryocampus morrisoni elegans</i> |
|                     |                                |  | <i>Br. morrisoni morrisoni</i>      |
|                     |                                | Cyclopoida                               | <i>Diacyclops clandestinus</i>      |
|                     |                                | <i>D. jeanneli jeanneli</i>              |                                     |
|                     |                                | <i>Megacyclops donaldsoni donaldsoni</i> |                                     |
|                     | Decapoda                       | <i>Cam. hamulatus</i>                    |                                     |
|                     |                                | <i>Cam. jonesi</i>                       |                                     |
|                     |                                | <i>Cam. vitichorum</i>                   |                                     |
|                     |                                | <i>O. australis australis</i>            |                                     |
|                     |                                | <i>O. australis packardi</i>             |                                     |
|                     |                                | <i>O. incomptus</i>                      |                                     |
|                     |                                | <i>O. inermis inermis</i>                |                                     |
|                     |                                | <i>O. inermis testii</i>                 |                                     |
|                     |                                | <i>O. pellucidus</i>                     |                                     |
|                     |                                | <i>O. sheltae</i>                        |                                     |
|                     |                                | <i>Palaemonias alabamae</i>              |                                     |
| <i>Pa. ganteri</i>  |                                |  |                                     |
| <i>P. pecki</i>     |                                |  |                                     |
| Isopoda             | <i>Am. nicholasi</i>           |  |                                     |
|                     | <i>Ca. bicrenata bicrenata</i> |  |                                     |
|                     | <i>Ca. bicrenata whitei</i>    |  |                                     |
|                     | <i>Ca. circulus</i>            |  |                                     |
|                     | <i>Ca. jordani</i>             |  |                                     |
|                     | <i>Ca. nickajackensis</i>      |  |                                     |
|                     | <i>Ca. nortoni</i>             |  |                                     |
|                     | <i>Ca. richardsonae</i>        |  |                                     |
|                     | <i>Ca. stygia</i>              |  |                                     |
|                     | <i>Ca. whitei</i>              |  |                                     |
|                     | <i>Mik. alabamensis</i>        |  |                                     |
|                     | <i>Mik. barri</i>              |  |                                     |
|                     | Lernaeopodoida                 | <i>Cauloxenus stygius</i>                |                                     |
| Podocopida          | <i>Dactyocythere arcuata</i>   |  |                                     |
|                     | <i>Da. prionata</i>            |  |                                     |

## Appendix 1. (continued)

| Class/phylum order      |   | Species                       |  |                        |
|-------------------------|---|-------------------------------|--|------------------------|
| Diplopoda               | Callipodida<br>Callipodida<br>Chordeumatida | <i>Da. steevesi</i>           |  |                        |
|                         |   | <i>Da. susanae</i>            |  |                        |
|                         |   | <i>Pseudocandona jeanneli</i> |  |                        |
|                         |   | <i>Pseud. marengoensis</i>    |  |                        |
|                         |   | <i>Sagittocythere barri</i>   |  |                        |
|                         |   | <i>Sa. stygia</i>             |  |                        |
|                         |   | <i>Do. tuberosa</i>           |  |                        |
|                         |   | <i>Te. jonesi</i>             |  |                        |
|                         |   | <i>Te. tennesseensis</i>      |  |                        |
|                         |   | <i>Conotyla bollmani</i>      |  |                        |
|                         |   | <i>Ps. acheron</i>            |  |                        |
|                         |   | <i>Ps. blacki</i>             |  |                        |
|                         |   | <i>Ps. burnorum</i>           |  |                        |
|                         |   | <i>Ps. cercops</i>            |  |                        |
|                         |   | <i>Ps. conservata</i>         |  |                        |
|                         |   | <i>Ps. cookorum</i>           |  |                        |
|                         |   | <i>Ps. eburnea</i>            |  |                        |
|                         |   | <i>Ps. indianae</i>           |  |                        |
|                         |   | <i>Ps. lethe</i>              |  |                        |
|                         |   | <i>Ps. lictor</i>             |  |                        |
|                         |   | <i>Ps. merops</i>             |  |                        |
|                         |   | <i>Ps. minus</i>              |  |                        |
|                         |   | <i>Ps. nyx</i>                |  |                        |
| <i>Ps. purselli</i>     |   |                               |  |                        |
| <i>Ps. rhadamanthus</i> |   |                               |  |                        |
| <i>Ps. salisae</i>      |   |                               |  |                        |
| <i>Sc. copei</i>        |   |                               |  |                        |
| <i>Sc. ventus</i>       |   |                               |  |                        |
| <i>T. syntheticum</i>   |   |                               |  |                        |
| <i>Amer. satts</i>      |   |                               |  |                        |
| Diplopoda<br>Insecta    | Julida<br>Collembola                        | <i>Ar. altus</i>              |  |                        |
|                         |   | <i>Ar. bimus</i>              |  |                        |
|                         |   | <i>Ony. paro</i>              |  |                        |
|                         |   | <i>Pse. christianseni</i>     |  |                        |
|                         |   | <i>Pse. espanita</i>          |  |                        |
|                         |   | <i>Pse. fonsa</i>             |  |                        |
|                         |   | <i>Pse. hirsuta</i>           |  |                        |
|                         |   | <i>Pse. nata</i>              |  |                        |
|                         |   | <i>Pse. pecki</i>             |  |                        |
|                         |   | <i>Pse. spinosa</i>           |  |                        |
|                         |   | <i>Sch. alabamensis</i>       |  |                        |
|                         |   | <i>Sch. christianseni</i>     |  |                        |
|                         |   | <i>Si. alata</i>              |  |                        |
|                         |   | <i>Si. avita</i>              |  |                        |
|                         |   | <i>Si. barri</i>              |  |                        |
|                         |   | <i>Si. basidens</i>           |  |                        |
|                         |   | <i>Si. cavernarum</i>         |  |                        |
|                         |   | <i>Si. hoffmani</i>           |  |                        |
|                         |   | <i>Tomocerus missus</i>       |  |                        |
|                         |   | Diplura                       |  | <i>Lit. cookei</i>     |
|                         |   |                               |  | <i>Lit. henroti</i>    |
|                         |   |                               |  | <i>Lit. jonesi</i>     |
|                         |   |                               |  | <i>Lit. valentinei</i> |
| Coleoptera              |   | <i>B. jeanneli</i>            |  |                        |
|                         |   | <i>B. quisnamus</i>           |  |                        |
|                         |   | <i>B. spelaeus</i>            |  |                        |
|                         |   | <i>Ba. barri</i>              |  |                        |

## Appendix 1. (continued)

| Class/phy lum order | Species                                |
|---------------------|--|
|                     | <i>Ba. cavernosus</i>                  |
|                     | <i>Ba. clypeospecus</i>                |
|                     | <i>Ba. ferulifer</i>                   |
|                     | <i>Ba. gemmoides</i>                   |
|                     | <i>Ba. gemmus</i>                      |
|                     | <i>Ba. henroti</i>                     |
|                     | <i>Ba. hubrichti</i>                   |
|                     | <i>Ba. jocuvestus</i>                  |
|                     | <i>Ba. jonesi</i>                      |
|                     | <i>Ba. pannosus</i>                    |
|                     | <i>Ba. specus</i>                      |
|                     | <i>Ba. subterraneus</i>                |
|                     | <i>Ba. tumoris</i>                     |
|                     | <i>Ba. valentinei</i>                  |
|                     | <i>Dar. kentuckensis kentuckensis</i>  |
|                     | <i>Neaphaenops tellkampfi henroti</i>  |
|                     | <i>Ne. tellkampfi meridionalis</i>     |
|                     | <i>Ne. tellkampfi tellkampfi</i>       |
|                     | <i>Ne. tellkampfi viator</i>           |
|                     | <i>Ne. walteri</i>                     |
|                     | <i>Pseu. acherontis</i>                |
|                     | <i>Pseu. alladini</i>                  |
|                     | <i>Pseu. audax</i>                     |
|                     | <i>Pseu. bandermani</i>                |
|                     | <i>Pseu. beakleyi</i>                  |
|                     | <i>Pseu. bloomi</i>                    |
|                     | <i>Pseu. catherinae</i>                |
|                     | <i>Pseu. cerberus cerberus</i>         |
|                     | <i>Pseu. cerberus completus</i>        |
|                     | <i>Pseu. ciliaris ciliaris</i>         |
|                     | <i>Pseu. ciliaris colemanensis</i>     |
|                     | <i>Pseu. ciliaris orlindae</i>         |
|                     | <i>Pseu. cumberlandus</i>              |
|                     | <i>Pseu. darlingtoni darlingtoni</i>   |
|                     | <i>Pseu. darlingtoni persimilis</i>    |
|                     | <i>Pseu. distinguens</i>               |
|                     | <i>Pseu. emersoni</i>                  |
|                     | <i>Pseu. eremita</i>                   |
|                     | <i>Pseu. farrelli</i>                  |
|                     | <i>Pseu. fluvialalis</i>               |
|                     | <i>Pseu. fowlerae</i>                  |
|                     | <i>Pseu. globiceps</i>                 |
|                     | <i>Pseu. humeralis</i>                 |
|                     | <i>Pseu. illinoisensis</i>             |
|                     | <i>Pseu. inexpectatus inexpectatus</i> |
|                     | <i>Pseu. inquisitor</i>                |
|                     | <i>Pseu. insularis</i>                 |
|                     | <i>Pseu. leonae</i>                    |
|                     | <i>Pseu. loedingi</i>                  |
|                     | <i>Pseu. loganensis</i>                |
|                     | <i>Pseu. macradei</i>                  |
|                     | <i>Pseu. menetriesii campestris</i>    |
|                     | <i>Pseu. menetriesii menetriesii</i>   |
|                     | <i>Pseu. meridionalis</i>              |

## Appendix 1. (continued)

| Class/phy um order | Species                                |
|--------------------|--|
|                    | <i>Pseu. nickajackensis</i>            |
|                    | <i>Pseu. occidentalis</i>              |
|                    | <i>Pseu. pilosus</i>                   |
|                    | <i>Pseu. princeps</i>                  |
|                    | <i>Pseu. productus</i>                 |
|                    | <i>Pseu. profundus</i>                 |
|                    | <i>Pseu. pubescens intrepidus</i>      |
|                    | <i>Pseu. pubescens pubescens</i>       |
|                    | <i>Pseu. robustus</i>                  |
|                    | <i>Pseu. shilonensis mayfieldensis</i> |
|                    | <i>Pseu. shilonensis shilonensis</i>   |
|                    | <i>Pseu. simplex</i>                   |
|                    | <i>Pseu. simulans</i>                  |
|                    | <i>Pseu. steevesi</i>                  |
|                    | <i>Pseu. striatus</i>                  |
|                    | <i>Pseu. templetoni</i>                |
|                    | <i>Pseu. tenuis blatchleyi</i>         |
|                    | <i>Pseu. tenuis jeanneli</i>           |
|                    | <i>Pseu. tenuis morrisoni</i>          |
|                    | <i>Pseu. tenuis stricticollis</i>      |
|                    | <i>Pseu. tenuis tenuis</i>             |
|                    | <i>Pseu. tiresias</i>                  |
|                    | <i>Pseu. transfluvialis</i>            |
|                    | <i>Pseu. tullahoma</i>                 |
|                    | <i>Pseu. valentinei</i>                |
|                    | <i>Pseu. vanburensis</i>               |
|                    | <i>Pseu. ventus</i>                    |
|                    | <i>Pseu. youngi donaldsoni</i>         |
|                    | <i>Pseu. youngi youngi</i>             |
|                    | <i>Pt. barri</i>                       |
|                    | <i>Pt. chromolithus</i>                |
|                    | <i>Pt. episcopus</i>                   |
|                    | <i>Pt. fecundus</i>                    |
|                    | <i>Pt. hatchi</i>                      |
|                    | <i>Pt. hazelae</i>                     |
|                    | <i>Pt. hirtus</i>                      |
|                    | <i>Pt. hubrichti</i>                   |
|                    | <i>Pt. julius</i>                      |
|                    | <i>Pt. laticornis</i>                  |
|                    | <i>Pt. loedingi</i>                    |
|                    | <i>Pt. longicornis</i>                 |
|                    | <i>Pt. solanum</i>                     |
|                    | <i>Pt. torodei</i>                     |
|                    | <i>Pt. valentinei</i>                  |
|                    | <i>Pt. walteri</i>                     |
|                    | <i>Speleobama vana</i>                 |
|                    | <i>Spe. croceus</i>                    |
|                    | <i>Spe. stygicus</i>                   |
|                    | <i>Spe. synstygicus</i>                |
|                    | <i>Subterrochus eurous</i>             |
|                    | <i>Su. ferus</i>                       |
|                    | <i>Su. steevesi</i>                    |
|                    | <i>Tichobythinus hubrichti</i>         |
|                    | <i>Ti. jonesi</i>                      |

## Appendix 1. (continued)

| Class/phylum order |                   | Species                         |
|--------------------|-------------------|---------------------------------|
|                    |                   | <i>Ti. strinatii</i>            |
|                    |                   | <i>Tro. valentinei</i>          |
|                    |                   | <i>Spel. tenebrarum</i>         |
| Mollusca           | Diptera           | <i>Antroselates spiralis</i>    |
|                    | Mesogastropoda    | <i>Carychium stygium</i>        |
|                    | Stylommatophora   | <i>Gl. pecki</i>                |
|                    |                   | <i>Gl. specus</i>               |
|                    |                   | <i>Hel. barri</i>               |
| Oligochaeta        | Branchiobdellida  | <i>Camb. alienus</i>            |
|                    |                   | <i>Camb. dubius</i>             |
|                    |                   | <i>Camb. marthae</i>            |
|                    |                   | <i>Camb. sheltensis</i>         |
|                    |                   | <i>Camb. steevesi</i>           |
|                    | Lumbriculida      | <i>Tri. allegheniensis</i>      |
| Pisces             | Percopsiformes    | <i>Amblyopsis spelaea</i>       |
|                    |                   | <i>Speoplatyrhinus poulsoni</i> |
|                    |                   | <i>Typhl. subterraneus</i>      |
| Turbellaria        | Tricladida        | <i>Sp. buchanani</i>            |
|                    |                   | <i>Sp. chandleri</i>            |
|                    |                   | <i>Sp. percoeca</i>             |
|                    |                   | <i>Sp. pricei</i>               |
|                    |                   | <i>Sp. weingartneri</i>         |
| Region 4: Ozarks   |                   |                                 |
| Amphibia           | Urodela           | <i>Typhlotriton spelaeus</i>    |
| Arachnida          | Araneae           | <i>Bat. weyeri</i>              |
|                    |                   | <i>I. speophila</i>             |
|                    |                   | <i>Pha. subterranea</i>         |
|                    |                   | <i>Po. cavernicola</i>          |
|                    | Opiliones         | <i>Crosbyella distincta</i>     |
|                    |                   | <i>Cr. roeweri</i>              |
|                    | Pseudoscorpionida | <i>He. occidentalis</i>         |
|                    |                   | <i>A. colecampi</i>             |
|                    |                   | <i>A. diabolus</i>              |
|                    |                   | <i>A. mysterius</i>             |
|                    |                   | <i>A. titanicus</i>             |
|                    |                   | <i>A. typhlus</i>               |
|                    |                   | <i>Mu. cavernicola</i>          |
| Crustacea          | Amphipoda         | <i>Allocrangonyx hubrichti</i>  |
|                    |                   | <i>Bactrurus brachycaudus</i>   |
|                    |                   | <i>Ba. hubrichti</i>            |
|                    |                   | <i>C. packardi</i>              |
|                    |                   | <i>S. clantoni</i>              |
|                    |                   | <i>S. onondagaensis</i>         |
|                    |                   | <i>S. ozarkensis</i>            |
|                    |                   | <i>S. subtilis</i>              |
|                    |                   | <i>Gammarus acherondytes</i>    |
|                    | Cyclopoida        | <i>D. clandestinus</i>          |
|                    | Decapoda          | <i>Cam. aculabrum</i>           |
|                    |                   | <i>Cam. hubrichti</i>           |
|                    |                   | <i>Cam. setosus</i>             |
|                    |                   | <i>Cam. subterraneus</i>        |
|                    |                   | <i>Cam. tartarus</i>            |
|                    |                   | <i>Cam. zophonastes</i>         |
|                    |                   | <i>O. stygocaneyi</i>           |
|                    | Isopoda           | <i>Ca. ancyla</i>               |



## Appendix 1. (continued)

| Class/ptylum order                                   |                | Species                          |
|--|----------------|----------------------------------|
|  |                | <i>Ca. antricola</i>             |
|  |                | <i>Ca. bicrenata whitei</i>      |
|  |                | <i>Ca. dimorpha</i>              |
|  |                | <i>Ca. fustis</i>                |
|  |                | <i>Ca. macropropoda</i>          |
|  |                | <i>Ca. packardi</i>              |
|  |                | <i>Ca. salemensis</i>            |
|  |                | <i>Ca. serrata</i>               |
|  |                | <i>Ca. spatula</i>               |
|  |                | <i>Ca. steevesi</i>              |
|  |                | <i>Ca. stiladactyla</i>          |
|  |                | <i>Ca. stygia</i>                |
|  |                | <i>Ca. whitei</i>                |
|  | Podocopida     | <i>U. pholetera</i>              |
|  |                | <i>U. xania</i>                  |
| Diplopoda  | Chordeumatida  | <i>Sc. dendropus</i>             |
|  |                | <i>Tingupa pallida</i>           |
|  |                | <i>Trigenotyia parca</i>         |
|  |                | <i>Zosteractis interminata</i>   |
| Insecta  | Julida         | <i>Ar. clarus</i>                |
|  | Collembola     | <i>Ar. jay</i>                   |
|  |                | <i>On. hoffi</i>                 |
|  |                | <i>On. iowae</i>                 |
|  |                | <i>Ony. obesus</i>               |
|  |                | <i>Pse. dubia</i>                |
|  |                | <i>Pse. espana</i>               |
|  |                | <i>Si. avita</i>                 |
|  |                | <i>Si. barri</i>                 |
|  |                | <i>Si. cavernarum</i>            |
|  |                | <i>To. missus</i>                |
|  | Coleoptera     | <i>Xenotrechus condei</i>        |
|  |                | <i>X. denticollis</i>            |
|  | Diptera        | <i>Spel. tenebrarum</i>          |
| Mollusca   | Mesogastropoda | <i>Amnicola cora</i>             |
|  |                | <i>Amn. stygia</i>               |
|  |                | <i>Antrobia culveri</i>          |
|  |                | <i>F. antroecetes</i>            |
|  |                | <i>F. proserpina</i>             |
| Pisces   | Percopsiformes | <i>Amb. rosae</i>                |
|  |                | <i>Typhl. subterraneus</i>       |
| Turbellaria  | Tricladida     | <i>Dendrocoelopsis americana</i> |
|  |                | <i>Ma. glandulosa</i>            |
|  |                | <i>Ma. lewisi</i>                |
|  |                | <i>Sp. evaginata</i>             |
|  |                | <i>Sp. hubrichti</i>             |
| <i>Region 5: Edwards Plateau/Balcones Escarpment</i> |                |                                  |
| Amphibia   | Urodela        | <i>Eurycea latitans</i>          |
|  |                | <i>E. neotenes</i>               |
|  |                | <i>E. tridentifera</i>           |
|  |                | <i>E. troglodytes</i>            |
|  |                | <i>Typtomolge rathbuni</i>       |
|  |                | <i>Typ. robusta</i>              |
| Arachnida  | Araneae        | <i>Ci. bandida</i>               |
|  |                | <i>Ci. barri</i>                 |
|  |                | <i>Ci. browni</i>                |
|  |                | <i>Ci. caverna</i>               |

## Appendix 1. (continued)

| Class/phylum order | Species                     |
|--------------------|-----------------------------|
|                    | <i>Ci. cueva</i>            |
|                    | <i>Ci. ellioti</i>          |
|                    | <i>Ci. ezelli</i>           |
|                    | <i>Ci. gruta</i>            |
|                    | <i>Ci. holsingeri</i>       |
|                    | <i>Ci. medina</i>           |
|                    | <i>Ci. menardtia</i>        |
|                    | <i>Ci. orellia</i>          |
|                    | <i>Ci. pablo</i>            |
|                    | <i>Ci. patei</i>            |
|                    | <i>Ci. porteri</i>          |
|                    | <i>Ci. rainesi</i>          |
|                    | <i>Ci. reddelli</i>         |
|                    | <i>Ci. reyesi</i>           |
|                    | <i>Ci. russeli</i>          |
|                    | <i>Ci. selecta</i>          |
|                    | <i>Ci. serena</i>           |
|                    | <i>Ci. sheari</i>           |
|                    | <i>Ci. sprousei</i>         |
|                    | <i>Ci. sutoni</i>           |
|                    | <i>Ci. travisae</i>         |
|                    | <i>Ci. ubicki</i>           |
|                    | <i>Ci. uvalde</i>           |
|                    | <i>Ci. venii</i>            |
|                    | <i>Ci. vespera</i>          |
|                    | <i>Ci. vibora</i>           |
|                    | <i>Ci. wartoni</i>          |
|                    | <i>Ci. watersi</i>          |
|                    | <i>Eidmannella delicata</i> |
|                    | <i>Ei. nasuta</i>           |
|                    | <i>Ei. reclusa</i>          |
|                    | <i>Ei. rostrata</i>         |
|                    | <i>I. unicornis</i>         |
|                    | <i>Neoleptoneta anopica</i> |
|                    | <i>Neo. coeca</i>           |
|                    | <i>Neo. concinna</i>        |
|                    | <i>Neo. devia</i>           |
|                    | <i>Neo. microps</i>         |
|                    | <i>Neo. myopica</i>         |
|                    | <i>Neo. valverde</i>        |
| Opiliones          | <i>Hoplobunus madlae</i>    |
|                    | <i>H. madlae</i>            |
|                    | <i>H. russelli</i>          |
|                    | <i>Texella brevidenta</i>   |
|                    | <i>Te. brevistyla</i>       |
|                    | <i>Te. cokendolpheri</i>    |
|                    | <i>Te. diplospina</i>       |
|                    | <i>Te. grubbsi</i>          |
|                    | <i>Te. hardeni</i>          |
|                    | <i>Te. mulaiki</i>          |
|                    | <i>Te. reddelli</i>         |
|                    | <i>Te. renkesae</i>         |
|                    | <i>Te. reyesi</i>           |

## Appendix 1. (continued)

| Class/pl ylum order    |  | Species   |
|------------------------|--|---|
|                        | Pseudoscorpiones                             | <i>Apocheiridium reddelli</i><br><i>Cheiridium reyesi</i><br><i>Ch. ellioti</i><br><i>Ch. major</i><br><i>Dinocheirus cavicola</i><br><i>He. occidentalis</i><br><i>Leucohya texana</i><br><i>Mexichthonius exoticus</i><br><i>Neallochernes stercoreus</i><br><i>Neoa. stercoreus</i><br><i>Tartarocreagris comanche</i><br><i>Ta. infernalis</i><br><i>Ta. intermedia</i><br><i>Ta. reddelli</i><br><i>Ta. texana</i><br><i>Ty. texanus</i>   |
| Chilopoda<br>Crustacea | Scolopendromorpha<br>Amphipoda               | <i>Theatops phanus</i><br><i>Allotexiweckelia hirsuta</i><br><i>Artesia subterranea</i><br><i>Holsingerius samacos</i><br><i>Hol. smaragdinus</i><br><i>Mexiweckelia hardeni</i><br><i>Parabogidiella americana</i><br><i>Paramexiweckelia ruffoi</i><br><i>Seborgia hershleri</i><br><i>Se. relicta</i><br><i>S. balconis</i><br><i>S. bifurcatus</i><br><i>S. dejectus</i><br><i>S. flagellatus</i><br><i>S. hadenoecus</i><br><i>S. longipes</i><br><i>S. pecki</i><br><i>S. russelli</i><br><i>Texiweckelia texensis</i><br><i>Texiweckeliopsis insolita</i><br><i>Texi. insolita</i> |
|                        | Decapoda                                     | <i>Pal. antrorum</i><br><i>Pal. holthuisi</i>   |
|                        | Isopoda                                      | <i>Brackenridgia cavernarum</i><br><i>Br. reddelli</i><br><i>Ca. bilineata</i><br><i>Ca. reddelli</i><br><i>Cirolanides texensis</i><br><i>Lirceolus bisetus</i><br><i>Lirc. hardeni</i><br><i>Lirc. pilus</i><br><i>Lirc. smithii</i><br><i>Speocirolana hardeni</i><br><i>Sphaeromicola moria</i>   |
| Diplopoda              | Podocopida<br>Thermosbaenacea<br>Polydesmida | <i>Monodella texana</i><br><i>Speodesmus bicornourus</i><br><i>Speod. echinourus</i>  |
|                        | Spirostreptida                               | <i>Cambala speobia</i>  |

## Appendix 1. (continued)

| Class/ylum order              | Species                            |
|-------------------------------|------------------------------------|
| Insecta                       | Collembola                         |
|                               | <i>Ar. texensis</i>                |
|                               | <i>On. fenestra</i>                |
|                               | <i>Si. baca</i>                    |
|                               | Diplura                            |
|                               | <i>Mixojapyx reddelli</i>          |
|                               | Thysanura                          |
|                               | <i>Texoreddellia texensis</i>      |
|                               | Coleoptera                         |
|                               | <i>Ba. grubbsi</i>                 |
|                               | <i>Ba. reyesi</i>                  |
|                               | <i>Ba. texanus</i>                 |
|                               | <i>Ba. venyivi</i>                 |
|                               | <i>Haideoporus texanus</i>         |
|                               | <i>Rhadine austinica</i>           |
|                               | <i>Rh. exilis</i>                  |
|                               | <i>Rh. infernalis ewersi</i>       |
|                               | <i>Rh. infernalis infernalis</i>   |
|                               | <i>Rh. insolita</i>                |
|                               | <i>Rh. koepkei koepkei</i>         |
|                               | <i>Rh. koepkei privata</i>         |
|                               | <i>Rh. noctivaga</i>               |
|                               | <i>Rh. persephone</i>              |
|                               | <i>Rh. russelli crinicollis</i>    |
|                               | <i>Rh. specia gentilis</i>         |
|                               | <i>Rh. specia specia</i>           |
|                               | <i>Rh. subterranea mitchelli</i>   |
|                               | <i>Rh. subterranea subterranea</i> |
|                               | <i>Rh. tenebrosa mckenziei</i>     |
|                               | <i>Rh. tenebrosa tenebrosa</i>     |
|                               | <i>Stygoparnus comalensis</i>      |
|                               | <i>Texamaurops reddelli</i>        |
| Mollusca                      | Mesogastropoda                     |
|                               | <i>Balconorbis waldensis</i>       |
|                               | <i>Phreatoceras conica</i>         |
|                               | <i>Phr. imitata</i>                |
|                               | <i>Phr. taylori</i>                |
|                               | <i>Phreatodrobia coronae</i>       |
|                               | <i>Phre. micra</i>                 |
|                               | <i>Phre. nugax inclinata</i>       |
|                               | <i>Phre. nugax nugax</i>           |
|                               | <i>Phre. plana</i>                 |
|                               | <i>Phre. punctata</i>              |
|                               | <i>Phre. rotunda</i>               |
|                               | <i>Stygopyrus bartonensis</i>      |
| Pisces                        | Cypriniformes                      |
|                               | <i>Satan eurystomus</i>            |
|                               | <i>Trogloglanis patternsoni</i>    |
|                               | <i>Sp. mohri</i>                   |
| Turbellaria                   | Tricladida                         |
| Region 6: Guadalupe Mountains |                                    |
| Arachnida                     | Acari                              |
|                               | <i>Ceuthothrombium cavaticum</i>   |
|                               | Araneae                            |
|                               | <i>Ei. bullata</i>                 |
|                               | Opiliones                          |
|                               | <i>Te. longistyla</i>              |
|                               | <i>Te. welbourni</i>               |
|                               | Pseudoscorpiones                   |
|                               | <i>Ap. pachysetus</i>              |
|                               | <i>Archeolarca guadalupensis</i>   |
|                               | <i>Ch. welbourni</i>               |
|                               | <i>Neoa. incertus</i>              |
| Chilopoda                     | Scolopendromorpha                  |
|                               | <i>Thalkehopus grallatrix</i>      |
| Crustacea                     | Amphipoda                          |
|                               | <i>Ar. welbourni</i>               |
| Diplopoda                     | Polydesmida                        |
|                               | <i>Speod. tugarbius</i>            |

## Appendix 1. (continued)

| Class/phyllum order             |                  | Species  |
|---------------------------------|------------------|--|
| Insecta                         | Spirostreptida   | <i>Camb. speobia</i>   |
|                                 | Collembola       | <i>Pse. vita</i><br><i>On. prietoi</i>   |
| <i>Region 7: Mother Lode</i>    |                  |  |
| Arachnida                       | Acari            | <i>Fo. titanica</i>  |
|                                 | Opiliones        | <i>Banksula ellioti</i><br><i>Ban. grahami</i><br><i>Ban. martinorum</i><br><i>Ban. melones</i><br><i>Ban. tuolumne</i>  |
|                                 | Pseudoscorpiones | <i>Ap. grubbsi</i><br><i>Ap. similis</i><br><i>A. grubbsi</i><br><i>Australinocreagris grahami</i><br><i>Larca laceyi</i><br><i>Neochthonius troglodytes</i><br><i>Neoc. troglodytes</i><br><i>Pseudogarypus orpheus</i> |
| Crustacea                       | Amphipoda        | <i>S. gradyi</i><br><i>S. grahami</i><br><i>S. harai</i>   |
| Diplopoda                       | Chordeumatida    | <i>Speoseya grahami</i><br><i>Striaria eldora</i>  |
| Insecta                         | Collembola       | <i>On. mala</i><br><i>On. tunica</i><br><i>Si. baca</i><br><i>Si. tecta</i>  |
|                                 |                  |  |
| <i>Region 8: Black Hills</i>    |                  |  |
| Insecta                         | Collembola       | <i>Ar. clarus</i><br><i>Entomobrya troglodytes</i>   |
| <i>Region 9: Driftless area</i> |                  |  |
| Arachnida                       | Acari            | <i>Robustocheles occulta</i>   |
|                                 | Araneae          | <i>Po. cavernicola</i><br><i>Bat. weyeri</i>   |
| Crustacea                       | Amphipoda        | <i>S. iowae</i>  |
| Diplopoda                       | Chordeumatida    | <i>Achmenides pectinatus</i>   |
| Insecta                         | Collembola       | <i>Ar. bimus</i><br><i>Ar. dubius</i><br><i>On. iowae</i><br><i>Onychiurus gelus</i><br><i>Ony. obesus</i><br><i>Si. barri</i><br><i>Tullbergia hades</i><br><i>Ma. glandulosa</i>                                       |
|                                 |                  |  |
|                                 |                  |  |
|                                 |                  |  |
|                                 |                  |  |
|                                 |                  |  |
|                                 |                  |  |
| Turbellaria                     | Tricladida       | <i>Ma. glandulosa</i>  |

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