MISSOURI'S CAVE FOCUS AREAS

William R. Elliott
Missouri Department of Conservation
Resource Science Division
PO Box 180
Jefferson City, MO 65102-0180

Abstract

In 2004 the author developed a set of "Cave Focus Areas" for the Missouri Department of Conservation's "Comprehensive Wildlife Conservation Strategy," using cave biodiversity values, important bat caves, cavefish sites, and major karst springs in a multidimensional GIS study. The basis of the study was the Missouri Cave Life Database. I shall discuss some aspects of the Database, which I developed with several contributing research partners. The Database is used for biogeographic and biodiversity analyses, checklists for cave studies, and the like. I derived 97 Cave Focus Areas, which became polygon shapefiles in ArcMap®. Each focus area takes in one or more caves or springs based on multiple scores. The Cave Focus Areas were melded into larger Conservation Opportunity Areas, and will include dye tracing studies, cave studies, cave management work, and cooperative work with private and public landowners.

Introduction

In this paper I will discuss how I developed a set of "Cave Focus Areas" for statewide wildlife planning within the Missouri Department of Conservation using data from several sources, and how the areas were integrated into Missouri Department of Conservation's "Comprehensive Wildlife Conservation Strategy."

Missouri karst lies mostly in the Ozark Plateau Region, but some caves are in the northeastern Hannibal Karst and the eastern St. Louis and Perryville karsts. The latter two areas can be considered a physiographic extension of the Interior Lowland Plateaus of Kentucky, Tennesee, and Illinois; indeed there are some cave biogeographic affinities with eastern American karst (Elliott and Ashley 2005). In Missouri, the St. Louis and Perryville karsts are classified ecologically as part of the Ozark Highlands (Nigh and Schroeder 2002). The Missouri Speleological Survey has recorded more than 6,000 caves, second in the USA after Tennessee.

Methods

I created the Missouri Cave Life Database (formerly the Missouri Biospeleological Database) in 1998 at the Missouri Department of Conservation to assemble all known species checklists and data sources on the subterranean species of Missouri into a relational database. The database, which is maintained in Microsoft Access®, can be used to produce checklists for any county or cave, or a list of caves for any species. The Cave Life Database is used for recording the many published and unpublished records from the scientific literature, agency reports, gray literature, databases, and unpublished records from reliable observers and biologists. The Cave Life Database is used for tracking field collections to museums and taxonomists, tracking trends in wildlife populations, biogeographic and biodiversity analysis, planning, updating the Missouri Natural Heritage Database, and education.

Currently the Cave Life Database contains data on about 1,150 caves, 107 "cave springs" (air-filled caves issuing springs), 147 other springs, six mines, six wells, and about 40 other sites. Represented are more than 12,000 observations and collections of 976 species, including 81 troglobites (Culver *et al.* 2003; Elliott and Ashley, 2005).

I developed a cave biodiversity index based on three elements: SR (species richness or number of species in the cave), T (number of troglobites or obligate cave-dwelling species, including stygobites, or aquatic troglobites), and SE ("site endemism," which is a measure of troglobite endemism or rarity on a statewide basis).

SE = $\sum e$ where e (endemism) = 1/number of known Missouri sites

For example, the famous Grotto salamander, *Eurycea spelaea* (formerly *Typhlotriton spelaeus*), is the most widespread Ozark troglobite, with 173 known sites in Missouri, so

e = 1/173 = 0.00578.

In contrast, the Tumbling Creek cavesnail, *Antrobia culveri*, is a severely endangered species known from one cave, so

e = 1/1 = 1.00000.

Tumbling Creek Cave, has an SE value of 4.01, representing the aggregate endemism of 12 species of troglobites, at least three of which are unique to that cave. So, the more endemic a cave's fauna is, the higher the SE value.

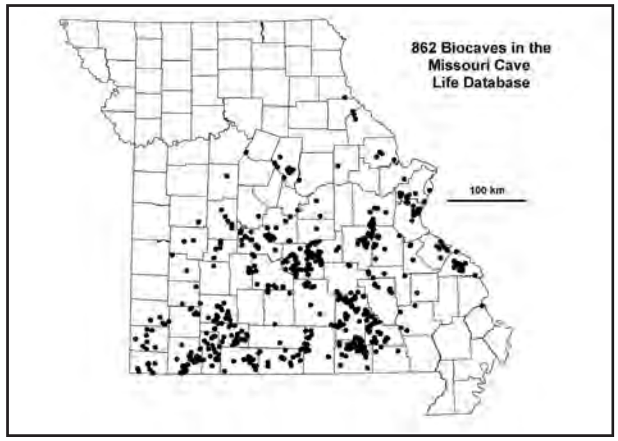
To represent all three elements in one score for each cave I multiplied them to obtain

Biodiversity index = SR x T x SE

which I use for ranking important caves for biodiversity.

(One could add SR, T, and SE, however they do not scale the same. One could transform the SE value by multiplying by 10, to obtain a value range in the same order of magnitude as SR and T. However, then adding SR, T, and SE results in a index that ranks just the same as multiplying the three factors.)

In this study, the term "biocave" is a cave for which at least five species were recorded in the Cave Life Database. I considered five to be the minimum number of species indicating that there had been some bioinventory instead of a cursory check or a single-species survey. Beginning with a set of about 1,200 caves with biological records, I derived a subset of 862 "biocaves" (Figure 1).



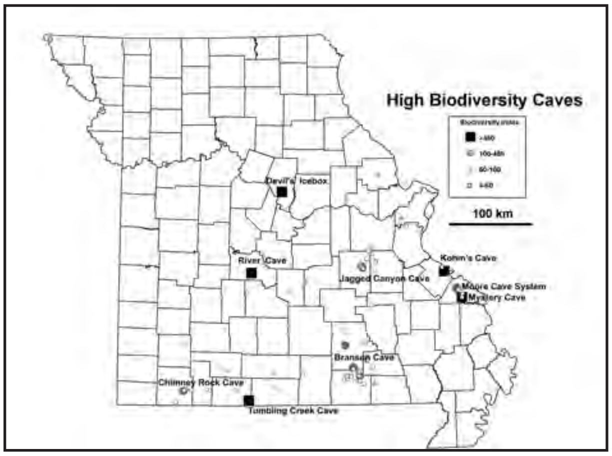
Fugure 1. 862 biocaves in the Missouri Cave Life Database. Over 6,000 caves are recorded in Missouri.

The Cave Life Database does not contain geographic coordinates of caves. I relied instead on the Missouri Department of Conservation Cave Database (220 caves), Missouri Natural Heritage Database (200 important caves), and a partnership with the Missouri Speleological Survey (more than 6,000 caves), to which we contribute data.

I temporarily created a relation between a table of biocaves and a table of cave locations using decimal degree coordinates, developed with the help of Hal Baker. Decimal degree coordinates were easier to use in Missouri, where there are two UTM zones, which make the use of UTM coordinates somewhat more difficult for statewide maps. I added some decimal degree coordinates to the data set from the Missouri Speleological Survey, Missouri Department of Conservation cave database, and the Heritage Database.

The Cave Focus Areas derived for this study do not pinpoint caves, but are polygons typically two to five miles in diameter, including one or more important caves or springs. Once the polygon shapefiles were created in ESRI's ArcMap®, the Cave Focus Areas could be included in an overall GIS for wildlife planning without revealing specific cave locations. Researchers and conservationists may obtain individual cave locations from the Heritage Database or the Missouri Speleological Survey on a need-to-know basis, with written justification.

I ranked caves for biodiversity, and I used the biodiversity index as an attribute in ArcMap to examine the geographic distribution of important biocaves. I created point files of caves with high biodiversity (Figure 2), priority 1 and 2 gray bat and Indiana bat caves (Figure 3), and cavefish sites



Fugure 2. High biodiversity caves in Missouri. The top ten biocaves are labeled, including Berome Moore and Tom Moore caves in the Moore Cave System.

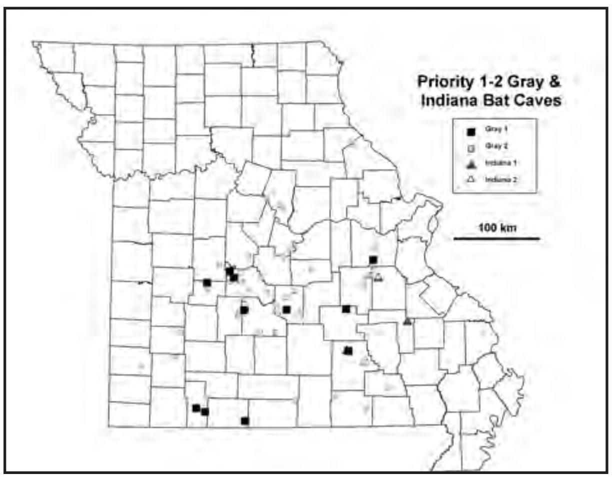


Figure 3. High priority gray bat and Indiana bat caves in Missouri. Most of the caves shown are gray bat maternity roosts, but some are hibernacula for one or both species.

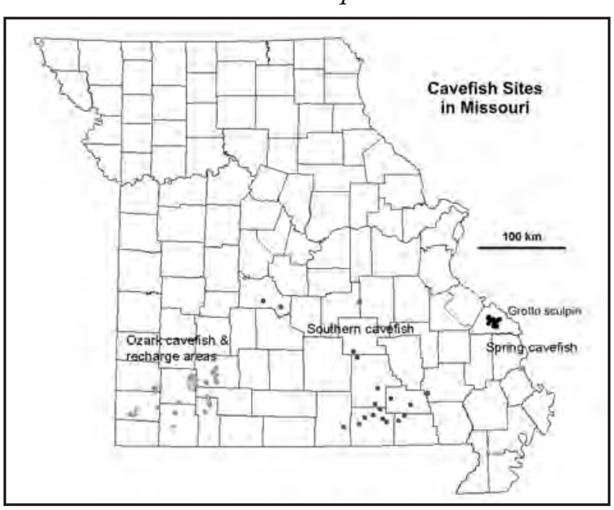


Figure 4. Cavefish sites in Missouri.

(Figure 4), with attributes for higher values.

The final step in delineating Cave Focus Areas was to create data layers in ArcMap of the above elements. I then manually drew polygon shapefiles around clusters of important caves and magnitude 1 karst springs. The latter springs often contain important groundwater species and represent hydrological connections over long distances, up to 65 kilometers in the case of Big Spring, Carter County, which flows about 12 m^3/sec (276 million gallons per day), with a peak flow of 37 m^3/sec (840 million gallons per day, Figure 5).

Results

The resulting 97 Cave Focus Areas are represented in Figure 6. The smallest areas represent single caves or springs, the largest represents the Perryville Karst and adjacent areas, about 15 x 65 kilometers in extent with roughly 700 caves. Overall, at least 350 biocaves and springs were included. More than 1,000 caves could be included if all areas were implemented.

Missouri Department of Conservation held a series of planning meetings in which many biologists pooled their knowledge and mapped potential Conservation Opportunity Areas. I contributed the Cave Focus Areas to that process. Many of the 33 identified Conservation Opportunity Areas in Missouri incorporate Cave Focus Areas. At least 12 of the 18 areas in the Ozark Highlands Ecoregion contain caves and karst: Bonne Femme Karst, Bryant Creek, Current River Hills, Eleven Point Hills, Manitou Bluffs, Middle Meramec, North Fork, Roaring River, Spring River, Tumbling Creek Cave Ecosystem, Upper Gasconade River Hills, and White River Glades and Woodlands.

Discussion

In Missouri, caves and karst have been mainstreamed into long-term wildlife conservation planning. The Missouri Comprehensive Wildlife Conservation Strategy will have multiple funding sources, including SWG (State Wildlife Grants through the U.S. Fish & Wildlife Service), LIP (Landowner Incentive Program), cost-sharing, partner money and others. Since 2001, the Missouri Department of Conservation has received a total of about $7 million in federal reimburse-

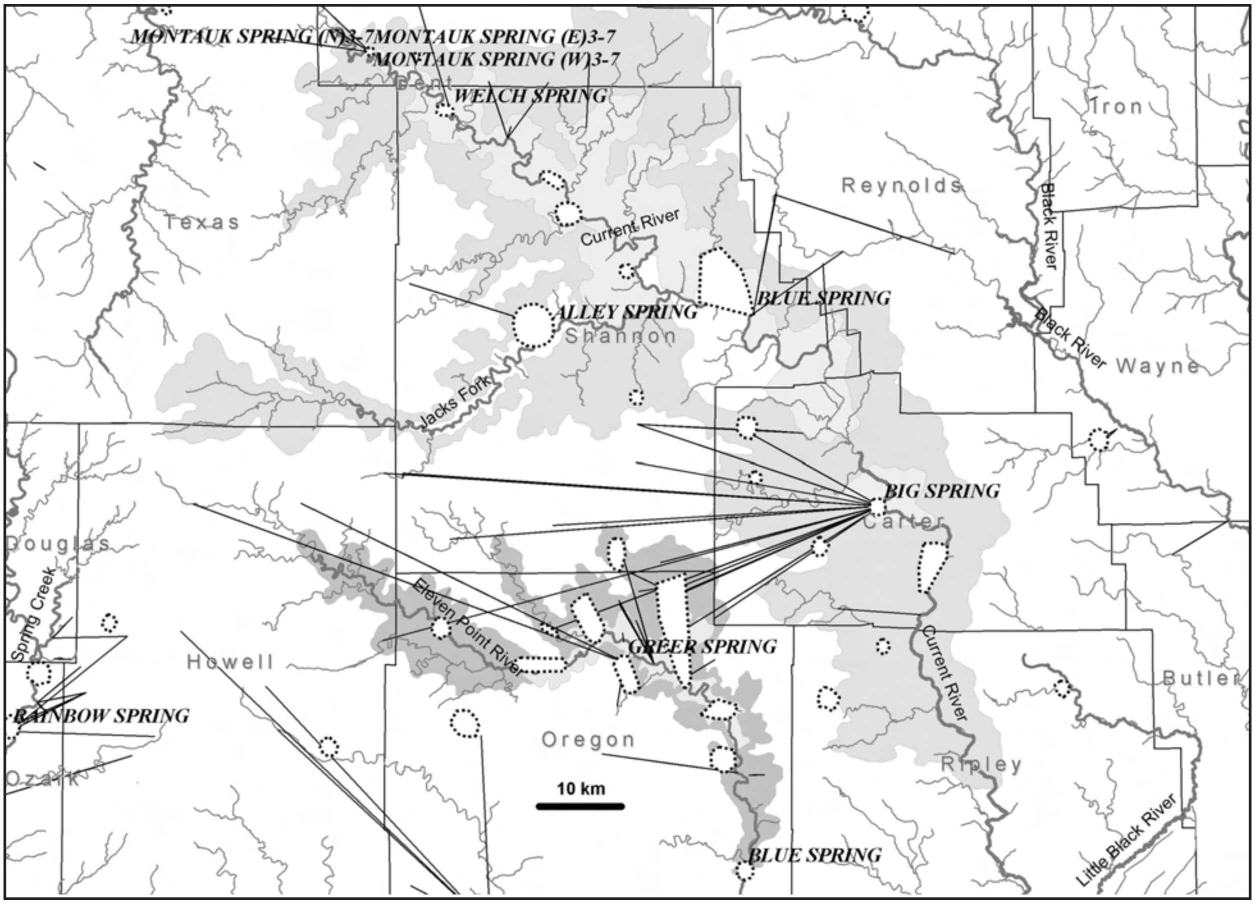


Figure 5. The Missouri Cave Focus Areas include magnitude 1 springs, such as this part of southeastern Missouri. Dye traces are shown as thin lines and cave focus areas as dotted outlines. Much of the flow of the Eleven Point River is pirated underground to Big Spring and the Current River.

ments, matched by a similar amount from the state and partners. Some of the funding has gone to caves and karst, mainly for gating important caves and assisting private cave owners. For the future, caves and karst will receive increased funding for cave protection, dye-tracing studies, bioinventory and census work, planning, land remediation, and landowner assistance.

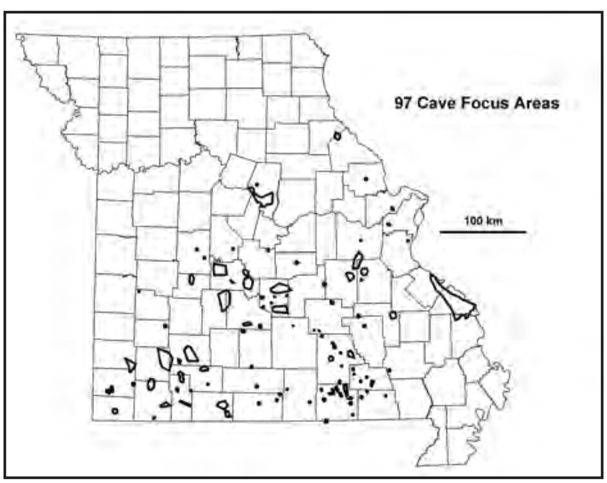


Figure 6. The 97 Missouri Cave Focus Areas.

Acknowledgments

I am grateful to my Cave Life Database partners for the use of their published and unpublished data: Michael R. Sutton, David C. Ashley, Mike Slay, Steve Samoray, Jim Kaufmann, Lawrence Ireland, and Scott House. Our combined efforts have allowed us to prioritize cave protection efforts through the Missouri Cave Protection Working Group. I thank the Missouri Speleological Survey for the temporary loan of cave location data, and the Missouri Natural Heritage Database staff for their assistance and many other cave location data. I am especially grateful to Hal Baker, Missouri Caves & Karst Conservancy, for

his assistance in developing a GIS-friendly table of biocaves for this study.

Literature Cited

Culver, David.C.; Mary C. Christman; William R. Elliott; Horton H. Hobbs; and James R. Reddell. 2003. The North American obligate cave fauna: Regional patterns. *Biodiversity and Conservation*. 12:441–468.

Elliott, William R., and David C. Ashley. 2005. Caves and Karst. pp. 474–491 i*n* Nelson, Paul, *The Terrestrial Natural Communities of Missouri*, third ed. Missouri Natural Areas Committee. 550 pp.

Nigh, Timothy A., and Walter A. Schroeder. 2002. Atlas of Missouri Ecoregions. Missouri Department of Conservation, 212 pp.