

SURVEY OF THE FRESHWATER UNIONIDS (MUSSELS)
(BIVALVIA: MARGARITIFERIDAE AND UNIONIDAE)
IN THE GREEN RIVER IN
MAMMOTH CAVE NATIONAL PARK, KENTUCKY

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ABSTRACT

The Green River in Mammoth Cave National Park was surveyed during 1987, 1988, and 1989 in order to determine the distribution and status of freshwater unionids (mussels) in the Park. Forty-seven species were collected from 42 sites sampled, but only 13 species were found in the river segment impounded by lock and dam 6. Living and fresh-dead specimens of 46 taxa were collected, including seven taxa that are federally listed or candidates for listing (*Cumberlandia monodonta*, *Cyprogenia stegaria*, *Epioblasma rangiana*, *Obovaria retusa*, *Pleurobema clava*, *P. plenum*, and *Villosa ortmanni*) and five additional species considered rare in Kentucky (*Epioblasma triquetra*, *Fusconaia subrotunda*, *Lampsilis ovata*, *Plethobasus cyphyus*, and *Pleurobema pyramidatum*). Acceptable literature and museum records for four species that may be rediscovered increase the unionid fauna of the Park to 51. The Green River in Mammoth Cave National Park supports one of the most diverse unionid communities known in North America.

INTRODUCTION

The Green River of Kentucky is recognized as supporting one of the most diverse freshwater unionid or mussel faunas in North America (Stansbery 1965, Isom 1974). Of the 104 taxa comprising the Kentucky fauna, 71 are known from the Green River drainage (Kentucky State Nature Preserves Commission 1990). Although much of the Green River fauna is extant, a large segment (34%) is considered rare or endangered at the federal or state level because of human alteration of the land and water. Seven species (*Epioblasma torulosa*, *Hemistena lata*, *Lampsilis abrupta*, *Obovaria retusa*, *Plethobasus cooperianus*, *Pleurobema plenum*, and *Potamilus capax*) are listed as endangered by the United States Fish and Wildlife Service (USFWS) (1989a, b, c) under the Endangered Species Act of 1973, as amended, ten are candidates or have been proposed for listing by the

USFWS (1989d), and seven additional taxa have been assigned conservation statuses by the Kentucky Academy of Science-Kentucky State Nature Preserves Commission (Warren et al. 1986). Many of these rare unionids are known from the Green River up- and downstream from Mammoth Cave National Park (MCNP), or are known historically from the Park (Walker 1925, Ortman 1926, Kentucky State Nature Preserves Commission 1990). However, a thorough survey of the Park's unionid fauna has never been published.

As one of our Nation's principal conservation agencies, the National Park Service (NPS) plays an important role in protecting fish and wildlife resources through the wise use and preservation of National Park land and water. In order to protect and conserve the unionid fauna residing in the 25 mile reach of the Green River in MCNP, the National Park Service must have current information regarding the fauna that occurs in the Park. The National Park Service, therefore, contracted with the Kentucky State Nature Preserves Commission through the Eastern National Park and Monument Association to undertake an examination of the freshwater unionids of the Green River within MCNP. The primary objectives of the study were to

1. conduct a qualitative field inventory of the unionids in the Green River within MCNP, with special emphasis on USFWS listed (1989a, b, c) and candidate (1989d) taxa;
2. review the literature regarding the historic and recent distribution of unionids in MCNP, with special emphasis on USFWS listed and candidate taxa;
3. provide locations of USFWS listed and candidate taxa in MCNP, including evidence of reproduction, and observations regarding general abundance and habitat quality for these taxa; and
4. determine the unionid fauna of the pool upstream from lock and dam 6.

STUDY AREA DESCRIPTION

Mammoth Cave National Park is located in Barren, Edmonson, and Hart counties in south-central Kentucky (Fig. 1). The Park lies in the Shawnee Hills Mammoth Cave Plateau Subsection of the Interior Low Plateaus Physiographic Province (Quarterman and Powell 1978). To the north, the area is bounded by the Ohio River Hills and Lowland Subsection, and to the south by the Pennyroyal Plain Subsection of the Highland Rim. The Green River meanders approximately 40 km (25 mi) from east to west through the Park and is deeply entrenched in Mississippian age limestone. Surface lithology throughout the Park is composed of

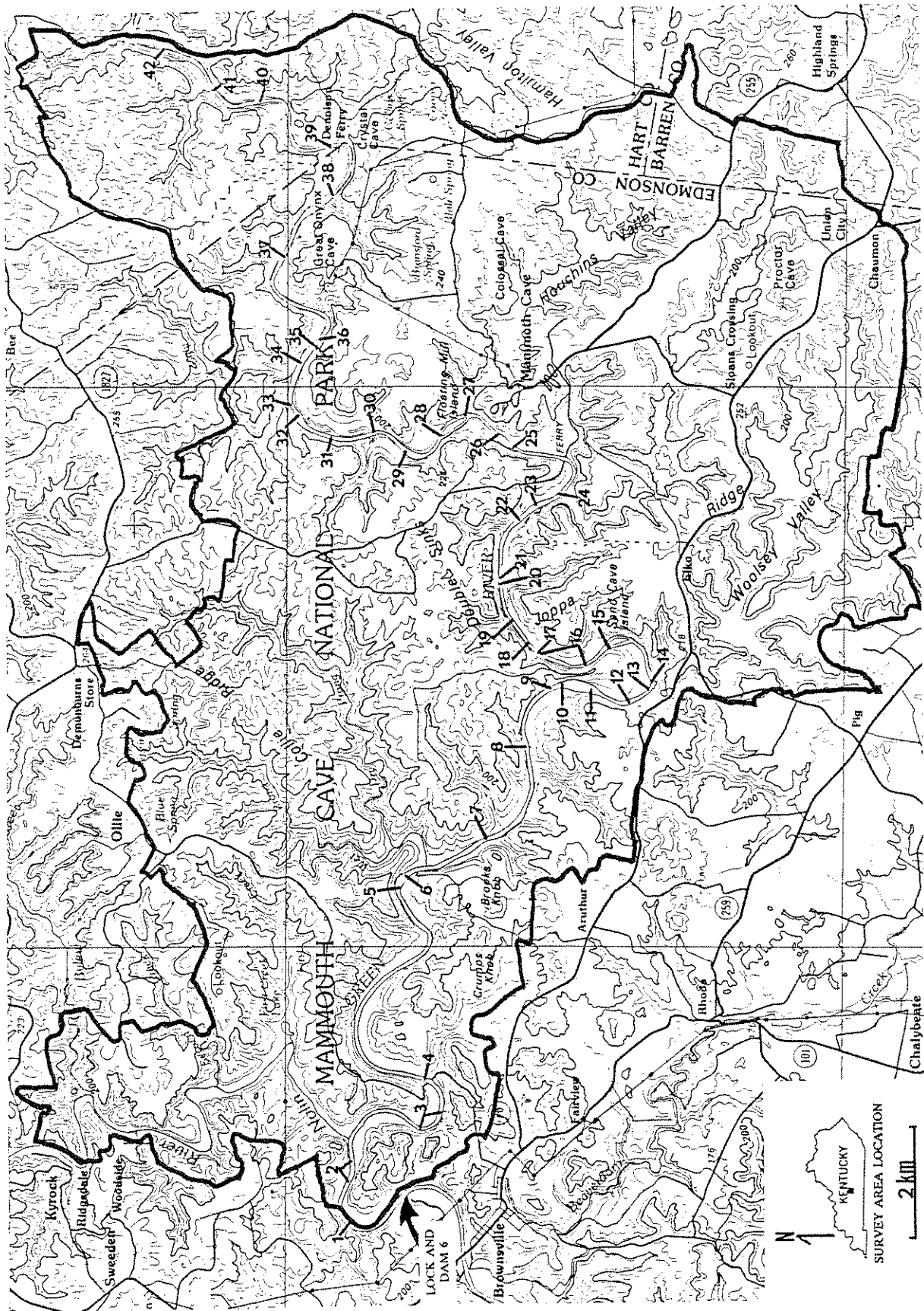


Figure 1. Mammoth Cave National Park and Green River collection sites, 1987-1989.

soluble limestone, but ridgetops mainly north of the river and west of Turnhole Bend are capped with Mississippian and Pennsylvanian age sandstone and siltstone. The vast majority of the Park is densely covered with second-growth deciduous forest.

Flowing surface streams in the Park are limited to northern tributaries to the Green River, chiefly the Nolin River, which is impounded approximately 12 km (7.5 mi) above its mouth, Buffalo Creek, Ugly Creek, and Cub Run. Because of extensive karst development south of the river in the Pennyroyal Plain and Mammoth Cave Plateau, surface streams are essentially nonexistent in this area of the Park (McGrain 1962, Kuehne 1966). Water moves down through the soluble limestone, reaches beds that dip gently northward, and flows toward the Green River. The development of the extensive Mammoth Cave system has been tied to this process and the downcutting of the Green River. All of these underground streams ultimately emerge as numerous springs along the river.

The Green River is impounded by lock and dam 6 located immediately downstream from the Park at approximate mile 181.7 (Fig. 1). The structure was constructed in 1906 and 1907 (National Park Service 1983) and has been deactivated by the United States Army Corps of Engineers (1981). It presently is in disrepair and near failure. The extent to which the Green River is impounded in the Park is variable but is affected by the discharge of Nolin River and Green River reservoirs, the latter of which is approximately 160 km (100 mi) upstream from the Park (National Park Service 1983). During normal high water, the pool extends upstream to the vicinity of Mammoth Cave Ferry and Cave Island (mile 197.1-197.8) (K. Kern pers. comm., pers. obs.). As river discharge declines, deep, slow-moving riverine habitat extends downstream several kilometers. Such habitat extended almost to Sand Cave Island in late summer 1989 and to Boardcut Island (site 11) during the drought of 1988 (K. Kern pers. comm.). It appears that under "normal flow conditions" and with the dam in disrepair, the river is essentially permanently impounded from lock and dam 6 upstream to just above Sand Cave Island. A transitional area whose character is determined by discharge extends from this area upstream to approximately Cave Island (vicinity of Mammoth Cave Ferry). It should be noted that the United States Army Corps of Engineers recently began repair efforts to stabilize leaks in the dam and is also studying the feasibility of removing this structure from the river (G. Gregory, pers. comm.). Repair of the dam will extend the permanently impounded section of the river upstream from Sand Cave Island and reduce the transitional area. Upstream from Cave Island, the river is characterized by alternating riffle, run, pool habitat. Gravel and sand substrates predominate, but bedrock underlies some impounded sections of the river.

From its headwaters in Casey County, Kentucky, the Green River flows west approximately 280 km (175 mi) to MCNP. This drainage area encompasses approximately 5136 sq km (1983 sq mi) (Bowers and Jackson 1981, Kentucky

Division of Water 1986). Within this area land use is highly varied but includes much agricultural land, several small to medium-sized communities, and a major impoundment, Green River Reservoir. Several major Kentucky highways and Interstate 65 cross the river upstream from the Park. Although the Green River generally meets all designated uses based on water quality standards (Kentucky Division of Water 1986), the river was badly polluted with oilfield brine and associated wastes in the 1960's (Charles 1964). Sinkholes in the vicinity of MCNP have long been used as waste dumps by individuals and communities, a practice that continues today.

METHODS

Freshwater unionids were collected from 33 sites in the Green River in Mammoth Cave National Park from 29 August to 14 September 1989 and supplemented with collections made at several of the same sites and nine additional sites in 1987 and 1988 (Table 1, Fig. 1). Unionids were collected qualitatively by hand from all habitats available at each site, including riffles, runs, back channels of islands, and shallow margins of impounded stream segments. Stream margins were searched for muskrat (*Ondatra zibethicus*) midden, and gravel bars and islands examined for unionid shells. These methods were used because they provide an efficient and quick means of determining the fauna of an area. Additional specimens were collected with a five-foot crowfoot brail employed primarily in pooled habitats extending from the downstream Park boundary upstream to Fishtrap Hollow (mile 195). All live specimens were identified, tallied in a field notebook, and returned to the river. Shells found at all sites were retained for deposition at Ohio State University Museum of Zoology (OSUMZ). Fresh shells (i.e., those with tissue and/or intact periostracum or lustrous nacre) were of primary interest because they indicate that additional members of the taxon are probably extant in the stream. However, weathered-dry and subfossil specimens were also collected. Shell length was measured with calipers along the anterior-posterior axis parallel with the hinge line. Age was estimated by counting growth annuli. The nomenclature in this report follows Turgeon et al. (1988), except that *Actinonaias ligamentina carinata* and *A. l. ligamentina* are recognized and *Epioblasma rangiana* is considered a full species.

LITERATURE AND MUSEUM RECORD REVIEW

Published accounts of the Green River unionid fauna in Mammoth Cave National Park include contributions by Walker (1925), Ortmann (1926), Williams (1969), and Clarke (1981a, 1983). Walker (1925) described *Villosa ortmanni* based on specimens collected from the Green River at Mammoth Cave and near Great Onyx Cave. *Villosa ortmanni* was named after the eminent malacologist A. E. Ortmann and is the only endemic Green River and Kentucky unionid. Ortmann

Table 1. Green River collection site locations by river mile in Mammoth Cave National Park, Kentucky. (Edmonson County unless indicated otherwise).

Site	Location
1.	182.5, SE bank; 2.8 km NNE Brownsville. 29 Aug 1989.
2.	182.9-183.2, S bank; 2.5 km NNE Brownsville. 13 Sep 1989.
3.	184.5-184.8; 5.4 km NNW Rhoda. 13 Sep 1989.
4.	185.3, NW bank; 3.0 km NE Brownsville. 14 Sep 1989.
5.	188.5, N bank; 6.0 km NNE Rhoda. 8 Sep 1989.
6.	188.6 at Crump Island; 6.2 km ENE Brownsville. 29 Aug 1989.
7.	189.5; 5.2 km NE Rhoda. 12 Sep 1989.
8.	190.8, N bank; 5.9 km NE Rhoda. 8 Sep 1989.
9.	191.6, E bank; 6.6 km ENE Rhoda. 12 Sep 1989.
10.	191.8, E bank; 6.5 km ENE Rhoda. 12 Sep 1989.
11.	192.1 at upstream end Boardcut Island; 6.5 km ENE Rhoda. 12 Sep 1989.
12.	192.5, E bank; 6.0 km ENE Rhoda. 8, 12 Sep 1989.
13.	192.7, SW bank; 5.9 km ENE Rhoda. 6 Sep 1989.
14.	192.8, N bank; 6.0 km ENE Rhoda. 6 Sep 1989.
15.	193.7 at upstream end Sand Cave Island; 10.6 km ESE Brownsville. 1 Sep 1989.
16.	194-194.5; 10.4 km ESE Brownsville. 11 Sep 1989.
17.	194.5, SE bank; 10.4 km ESE Brownsville. 6, 11 Sep 1989.
18.	194.7, NW bank; 10.5 km ESE Brownsville. 1, 6, 8, 12 Sep 1989.
19.	195, NW bank; 10.7 km ESE Brownsville. 1 Sep 1989.
20.	195.4, S bank; 11.6 km E Brownsville. 6, 11 Sep 1989.
21.	195.5, N bank; 11.7 km E Brownsville. 1, 6, 11 Sep 1989.
22.	196.1, SW bank; 12.6 km E Brownsville. 6 Sep 1989.
23.	196.3, NE bank; 2 km W Mammoth Cave. 11 Sep 1989.
24.	196.7, SW bank; 13.1 km ESE Brownsville. 6 Sep 1989.
25.	197.8 at downstream end Cave Island. 19 Aug 1988.
26.	198.1 at upstream end Cave Island; 14 km E Brownsville. 30 Aug, 12 Sep 1989.
27.	198.6 at downstream end Floating Mill Island; 14.2 km E Brownsville. 30 Aug 1989.
28.	198.9 at upstream end Floating Mill Island; 14 km E Brownsville. 19 Aug 1988, 30 Aug 1989.
29.	199.4 at upstream end unnamed island; 14 km ENE Brownsville. 19 Aug 1988, 31 Aug 1989.
30.	199.9, W bank; 14.5 km ENE Brownsville. 18 Aug 1988, 31 Aug 1989.
31.	200.4; 0.6 km downstream Sank Hollow. 18 Aug 1988.
32.	200.8, N bank; 15 km ENE Brownsville. 18 Aug 1988, 31 Aug 1989.
33.	201.05 at downstream end unnamed island; 15.3 km ENE Brownsville. 31 Aug 1989.
34.	201.4 at downstream end unnamed island; 4.1 km NNE Mammoth Cave. 18 Aug 1987.
35.	201.6, SW bank; 3.8 km N Mammoth Cave. 18 Aug 1988, 7 Sep 1989.
36.	201.7, NE bank; 3.8 km N Mammoth Cave. 7 Sep 1989.
37.	203.1 at upstream end unnamed island; 6.6 km W Northtown. 18 Aug 1988.
38.	204 at upstream end Three Sisters Island. 18 Aug 1987, 18 Aug 1988.
39.	204.8; 4.4 km W Northtown. 18 Aug 1988. Hart County.
40.	206; 3.8 km NW Northtown. 16 Sep 1987, 18 Aug 1988. Hart County.
41.	206.6; 4.0 km NW Northtown. 17 Aug 1988. Hart County.
42.	207.4 at upstream end unnamed island. 17 Aug 1988. Hart County.

(1926) studied the unionids of the Green River, including sites at the downstream end of Cave Island and near Great Onyx Cave, to clarify the zoogeographic relationships of the fauna. He concluded that the fauna was typical of the Ohioan or widespread Interior Basin group, and reported 31 taxa from the Park. Various aspects of commercially valuable unionid populations in the Green River were examined by Williams (1969), who divided the river into three parts based on habitat differences. Approximately 43 unionid taxa and the introduced Asian Clam (*Corbicula fluminea*) were collected from the two segments that included the Park. However, the taxa collected from the Park cannot be identified because collection sites and results were not presented. Finally, Clarke (1981a, 1983) sampled three sites in the Park (i.e., Dennison Ferry, Mammoth Cave Ferry to Cave Island, and the upstream end of Cave Island) and collected 25 unionid taxa and *Corbicula fluminea* while attempting to determine the distribution and abundance of extant populations of *Pleurobema plenum*. In addition to these publications, other information regarding the Green River unionid fauna exclusive of the Park was presented by Rafinesque (1820, 1831), Price (1900), Simpson (1914), Clench (1926), Clench and van der Schalie (1944), Charles (1964), Stansbery (1965), Isom (1974), Patch (1976), Harker et al. (1981), Sickel (1983), Taylor (1983), and Warren and Call (1983).

Museum records for the Park were gleaned from the following institutions: Academy of Natural Sciences of Philadelphia (ANSP), Carnegie Museum (CM), Harvard University Museum of Comparative Zoology (MCZ), Ohio State University Museum of Zoology (OSUMZ), National Museum of Natural History (NMNH), and University of Michigan Museum of Zoology (UMMZ) (Table 2). Records for 45 taxa were found, including many referable to Walker (1925) and Ortmann (1926). The numerous collections made by R. E. Call were probably made in the 1890's. The total number of taxa recorded for MCNP from literature and museum records is 46 and includes several federally listed or candidate species (i.e., *Cumberlandia monodonta*, *Cyprogenia stegaria*, *Epioblasma rangiana*, *Hemistena lata*, *Obovaria retusa*, *Pleurobema clava*, *Pleurobema plenum*, and *Villosa ortmanni*). This information constitutes an invaluable resource for evaluating the distribution and status of unionids in the Green River in Mammoth Cave National Park.

RESULTS

Forty-seven taxa were collected from 42 sites sampled in the Green River within Mammoth Cave National Park during 1987-1989 (Table 3). Five additional taxa (*A. marginata*, *A. viridis*, *H. lata*, *V. ellipsiformis*, and *V. lienosa*) are known from museum collections, but the record for *V. ellipsiformis* is questionable. A total of 46 taxa were collected alive or fresh-dead and totalled 3221 1/2 specimens (Table 3). Numerous additional weathered-dry and subfossil specimens were collected. Individuals of seven of the 46 taxa (*Quadrula pustulosa* (13.78%), *Q. quadrula* (11.66%), *Amblema plicata* (11.08%), *Obliquaria reflexa* (10.54%),

Table 2. Museum records for freshwater unionids collected from the Green River in Mammoth Cave National Park (MCNP). (ANSP = Academy of Natural Sciences of Philadelphia, CM = Carnegie Museum, MCZ = Harvard University Museum of Comparative Zoology, NMNH = National Museum of Natural History, OSUMZ = Ohio State University Museum of Zoology, and UMMZ = University of Michigan Museum of Zoology.) (? = apparent collector or repository).

Actinonaias ligamentina carinata

Mammoth Cave - MCZ 5532, 4 specimens, R. E. Call; OSUMZ 5252, 4 specimens, C. B. Stein, 22 Sep 1961.

Great Onyx Cave - CM 61.11456, 3 specimens, A. E. Ortmann, 9 Sep 1922.

Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.

First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Alasmidonta marginata

Mammoth Cave - NMNH 677476, 1 specimen, [J. F. Boepple?], 9 Dec 1908; MCZ 6365, numerous specimens, R. E. Call; NMNH 152012, 3 specimens, R. E. Call.

Alasmidonta viridis

Mammoth Cave - OSUMZ 5248, 1 specimen, C. B. Stein, 22 Sep 1961.

Amblema plicata

Mammoth Cave - CM 61.11166, 2 specimens, A. E. Ortmann, 6 Sep 1921; OSUMZ 5239, 2 specimens, C. B. Stein, 22 Sep 1961.

Mile 200.5 - OSUMZ?, 1 fresh specimen, G. J. Fallo, 3 Sep 1984

Great Onyx Cave - CM 61.11389, 2 specimens, A. E. Ortmann, 9 Sep 1922.

First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Cumberlandia monodonta

Mile 200.5 - OSUMZ?, 1 specimen, G. J. Fallo, 3 Sep 1984.

Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.

First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Cyclonaias tuberculata

Mammoth Cave - CM 61.11180, 2 specimens, A. E. Ortmann, 6 Sep 1921; MCZ 5444, many specimens, R. E. Call; MCZ 6271, 5 specimens, R. E. Call.

Great Onyx Cave - CM 61.11402, 1 specimen, A. E. Ortmann, 9 Sep 1922.

Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.

First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Cyprogenia stegaria

Mammoth Cave - CM 61.11222, 4 specimens, A. E. Ortmann, 6 Sep 1921; MCZ 5486, many specimens, R. E. Call; NMNH 152004, 7 specimens, R. E. Call.

Table 2 (continued).

Mile 200.5 - OSUMZ?, 1 fresh specimen, G. J. Fallo, 3 Sep 1984.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
Three Sisters Island - OSUMZ, 1 specimen, G. J. Fallo, K. Camburn, and M. L. Warren, Jr., 4 Jul 1981.
Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Ellipsaria lineolata

Mammoth Cave - OSUMZ 5254, 1 specimen, C. B. Stein, 22 Sep 1961.
Mile 200.5 - OSUMZ?, 1 specimen, G. J. Fallo, 3 Sep 1984.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
Three Sisters Island - OSUMZ, 1/2 specimen, G. J. Fallo, K. Camburn, and M. L. Warren, Jr., 4 Jul 1981.

Elliptio crassidens

Mammoth Cave - CM 61.11191, 1 specimen, A. E. Ortmann, 6 Sep 1921; NMNH 677399, 1 specimen, J. F. Boepple, 9 Dec 1908; NMNH 677400, 1 specimen J. F. Boepple, 10 Dec 1908; MCZ 78253, 1 specimen.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Elliptio dilatata

Mammoth Cave - MCZ 21175, 1 specimen, F. W. Putnam, Oct 1874; CM 61.11194, 5 specimens, A. E. Ortmann, 6 Sep 1921; OSUMZ 5247, 3 specimens, C. B. Stein, 22 Sep 1961; MCZ 5389, 6 specimens, R. E. Call; MCZ 69854, 1 specimen.
Great Onyx Cave - CM 61.11420, 3 specimens, A. E. Ortmann, 9 Sep 1922.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
6 miles above Mammoth Cave - MCZ 69866, 1 specimen.
Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Epioblasma rangiana

Mammoth Cave - MCZ 5752, 12 specimens, R. E. Call.
Mile 200.5 - OSUMZ?, 1/2 specimen, G. J. Fallo, 3 Sep 1984.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Epioblasma triquetra

Mammoth Cave - OSUMZ 5260, 1 specimen, C. B. Stein, 22 Sep 1961; MCZ 6156, 6 specimens, R. E. Call.

Table 2 (continued).

Great Onyx Cave - CM 61.11494, 2 specimens, A. E. Ortmann, 9 Sep 1922.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Fusconaia flava

Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.

Fusconaia subrotunda

Mammoth Cave - MCZ 21173, 1 specimen, F. W. Putnam, Oct 1874; NMNH 677458, 1 specimen, J. F. Boepple, 10 Dec 1908; CM 61.11153, 4 specimens, A. E. Ortmann, 6 Sep 1921; MCZ 5294, 15 specimens, R. E. Call; OSUMZ 34970, 8 specimens, R. E. Call.
Great Onyx Cave - CM 61.11380, 1 specimen, A. E. Ortmann, 9 Sep 1922.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Hemistena lata

Mammoth Cave - MCZ 6327, 11 specimens, R. E. Call; NMNH 152032, 1 specimen, R. E. Call.

Lampsilis cardium

Mammoth Cave - CM 61.11259, 1/2 specimen, A. E. Ortmann, 6 Sep 1921.
Great Onyx Cave - CM 61.11486, 1 specimen, A. E. Ortmann, 9 Sep 1922.

Lampsilis fasciola

Island 2.5 mi below Mammoth Cave - OSUMZ 5261, 1 specimen, Mrs. Self, 1950-1954.
Mammoth Cave - MCZ 5038, 8 specimens, R. E. Call; NMNH 152003, 3 specimens, R. E. Call.
Great Onyx Cave - CM 61.11491, 2 specimens, A. E. Ortmann, 9 Sep 1922.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.

Lampsilis ovata

Mammoth Cave - CM 61.11256, 2 specimens, A. E. Ortmann, 6 Sep 1921; OSUMZ 5259, 1 specimen, C. B. Stein, 22 Sep 1961; MCZ 5699, 10 specimens, R. E. Call.
Great Onyx Cave - CM 61.11480, 2 specimens, A. E. Ortmann, 9 Sep 1922.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Table 2 (continued).

Lampsilis siliquoidea

Mammoth Cave - CM 61.11753, 1 specimen, A. E. Ortmann, 6 Sep 1921.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.

Lampsilis teres

Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.

Lasmigona costata

Mammoth Cave - MCZ 6381, 4 specimens, R. E. Call.
Great Onyx Cave - CM 61.11426, 1 specimen, A. E. Ortmann, 9 Sep 1922.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Leptodea fragilis

Mammoth Cave - OSUMZ 5255, 9 specimens, C. B. Stein, 22 Sep 1961.
Great Onyx Cave - CM 61.11402, 1 specimen, A. E. Ortmann, 9 Sep 1922.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Ligumia recta

Mammoth Cave - CM 61.11247, 2 specimens, A. E. Ortmann, 6 Sep 1921.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Megalonaias nervosa

Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Obliquaria reflexa

Mammoth Cave - OSUMZ 5250, 7 specimens, C. B. Stein, 22 Sep 1961.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
Three Sisters Island - OSUMZ, 1/2 specimen, G. J. Fallo, K. Camburn, and M. L. Warren, Jr., 4 Jul 1981.
Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Obovaria retusa

Mammoth Cave - OSUMZ 34976, 29 specimens, R. E. Call; MCZ 5944, several specimens, R. E. Call; NMNH 152011, 5 specimens, R. E. Call.
Great Onyx Cave - CM 61.11450, 4 specimens, A. E. Ortmann, 9 Sep 1922.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Table 2 (continued).

Obovaria subrotunda

- Mammoth Cave - NMNH 677535, 1 specimen, J. F. Boepple, 10 Dec 1908; OSUMZ 5251, 8 specimens, C. B. Stein, 22 Sep 1961; MCZ 5065, several specimens, R. E. Call.
- Cave Island - OSUMZ 27197, 1 specimen, J. M. Condit and T. G. Frazier, 22 Oct 1977.
- Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
- Three Sisters Island - OSUMZ, 1/2 specimen, G. J. Fallo, K. E. Camburn, and M. L. Warren, Jr., 4 Jul 1981.
- First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Plethobasus cyphus

- Mammoth Cave - NMNH 677556, 1 specimen, J. F. Boepple, 8 Dec 1908; OSUMZ 5244, 1 specimen, C. B. Stein, 22 Sep 1961; MCZ 4939, 1 specimen, R. E. Call.
- Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
- Three Sisters Island - OSUMZ, 1/2 specimen, G. J. Fallo, K. Camburn, and M. L. Warren, Jr., 4 Jul 1981.
- Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.
- First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Pleurobema clava

- Mammoth Cave - NMNH 677397, J. F. Boepple, 16 Dec 1908; NMNH 677402, 4 specimens, J. F. Boepple, 10 Dec 1908; MCZ 5088, many specimens, R. E. Call; MCZ 16260, 2 specimens, R. E. Call; NMNH 151995, 12 specimens, R. E. Call.
- Great Onyx Cave - CM 61.11418, 2 specimens, A. E. Ortmann, 9 Sep 1922.
- Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.

Pleurobema coccineum

- Mammoth Cave - CM 61.11185, 5 specimens, A. E. Ortmann, 6 Sep 1921; OSUMZ 5246, 1 specimen, C. B. Stein, 22 Sep 1961; UMMZ 79697, 5 specimens, B. Walker; OSUMZ 34971, 30 specimens, R. E. Call; NMNH 151994, 3 specimens, R. E. Call; NMNH 152004, R. E. Call.
- Mile 200.5 - OSUMZ?, 1 specimen, G. J. Fallo, 3 Sep 1984.
- Great Onyx Cave - CM 61.11411, 5 specimens, A. E. Ortmann, 9 Sep 1922.
- Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
- Three Sisters Island - OSUMZ, 1 specimen, G. J. Fallo, K. Camburn, and M. L. Warren, Jr., 4 Jul 1981.
- Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.
- First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Table 2 (continued).

Pleurobema cordatum

Mammoth Cave - NMNH 677487, 1 specimen, J. F. Boepple, 8 Dec 1908; CM 61.11184, A. E. Ortmann, 6 Sep 1921; OSUMZ 5245, 1 specimen, C. B. Stein, 22 Sep 1961; MCZ 16262, 1 specimen, R. E. Call, MCZ 16264, 1 specimen, R. E. Call; MCZ 16266, several specimens, R. E. Call; MCZ 16267, several specimens, R. E. Call; MCZ 28758, 1 specimen, B. Walker; MCZ 78254, many specimens, R. E. Call.

Great Onyx Cave - CM 61.11408, 2 specimens, A. E. Ortmann, 9 Sep. 1922.

Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.

Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.

First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Pleurobema plenum

Mammoth Cave - OSUMZ 34973, 16 specimens, R. E. Call.

Three Sisters Island - OSUMZ, 2/2 specimen, G. J. Fallo, K. Camburn, and M. L. Warren, Jr., 4 July 1981.

Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.

Pleurobema pyramidatum

Mammoth Cave - NMNH 677267, 1/2 specimen, [J. F. Boepple], 8 Dec 1908; CM 61.11188, 2 specimens, A. E. Ortmann, 6 Sep 1921; UMMZ 80975, 3 specimens, R. E. Call; NMNH 677487a, 1 specimen.

Great Onyx Cave - CM 61.11413, 4 specimens, A. E. Ortmann, 9 Sep 1922.

Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.

Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.

First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Potamilus alatus

Mammoth Cave - CM 61.11237, 3 specimens, A. E. Ortmann, 6 Sep 1921; OSUMZ 5256, 5 specimens, C. B. Stein, 22 Sep 1961.

Three Sisters Island - OSUMZ, 1/2 specimen, G. J. Fallo, K. Camburn, and M. L. Warren, Jr., 4 Jul 1982.

First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Ptychobranhus fasciolaris

Mammoth Cave - CM 61.11218, 3 specimens, A. E. Ortmann, 6 Sep 1921; OSUMZ 5249, 1 specimen, C. B. Stein, 22 Sep 1961; NMNH 152006, 4 specimens, R. E. Call; MCZ no number, 9 specimens, F. W. Putnam.

Great Onyx Cave - CM 61.11446, 3 specimens, A. E. Ortmann, 9 Sep 1922.

Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.

Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.

First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Table 2 (continued).

Quadrula cylindrica

- Mammoth Cave - OSUMZ 5242, C. B. Stein, 22 Sep 1961; MCZ 5235, 8 specimens, R. E. Call.
- Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
- Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.
- First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Quadrula metanevra

- Mammoth Cave - NMNH 677489, 1 specimen, J. F. Boepple, 8 Dec 1908; MCZ 5601, 9 specimens, R. E. Call.
- Mile 200.5 - OSUMZ?, 1 specimen, G. J. Fallo, 3 Sep 1984.
- Three Sisters Island - OSUMZ, 1/2 specimen, G. J. Fallo, K. Camburn, and M. L. Warren, Jr., 4 Jul 1981.
- Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.
- First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Quadrula pustulosa

- Mammoth Cave - CM 61.11169, A. E. Ortmann, 6 Sep 1921; OSUMZ 5241, 1 specimen, C. B. Stein, 22 Sep 1961; MCZ 78256, 1 specimen.
- Mile 200.5 - OSUMZ?, 1 fresh specimen, G. J. Fallo, 3 Sep 1984.
- Great Onyx Cave - CM 61.11392, 1 specimen, A. E. Ortmann, 9 Sep 1922.
- Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
- Three Sisters Island - OSUMZ, 2 specimens, G. J. Fallo, K. Camburn, and M. L. Warren, Jr., 4 Jul 1981.
- Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.
- First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Quadrula quadrula

- Mammoth Cave - OSUMZ 5240, 1 specimen, C. B. Stein, 22 Sep 1961.
- Cave Island - OSUMZ 27196, 1 specimen, J. Condit and T. G. Frazier, 22 Oct 1971.
- Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
- Three Sisters Island - OSUMZ, 1 specimen, G. J. Fallo, K. Camburn, and M. L. Warren, Jr., 4 Jul 1981.
- First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Strophitus undulatus

- Mammoth Cave - MCZ 6577, 10 specimens, R. E. Call.
- Great Onyx Cave - CM 61.11443, 2 specimens, A. E. Ortmann, 9 Sep 1922.

Table 2 (continued).

Tritogonia verrucosa

- Mammoth Cave - CM 61.11175, 2 specimens, A. E. Ortmann, 6 Sep 1921; MCZ 6188, 6 specimens, R. E. Call; MCZ 78255, 1 specimen, A. E. Ortmann [?].
Great Onyx Cave - CM 61.11397, 7 specimens, A. E. Ortmann, 9 Sep 1922.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.

Truncilla truncata

- Mammoth Cave - OSUMZ 5253, 2 specimens, C. B. Stein 1961; MCZ 5303, 3 specimens, R. E. Call.
Great Onyx Cave - CM 61.11460, 1 specimen, A. E. Ortmann, 9 Sep 1922.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
Three Sisters Island - OSUMZ, 1 specimen, G. J. Fallo, K. Camburn, and M. L. Warren, Jr., 4 Jul 1981.
Dennison Ferry - OSUMZ?, G. J. Fallo, 5 Jul 1982.

Venustaconcha ellipsiformis

- Mammoth Cave - NMNH 152009, 1 specimen, R. E. Call.

Villosa lienosa

- Mammoth Cave - OSUMZ 5258, C. B. Stein, 22 Sep 1961; MCZ 16265, 2 specimens, R. E. Call.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.

Villosa ortmanni

- Mammoth Cave - NMNH 677593 (677644), 4 specimens, J. F. Boepple; OSUMZ 5257, C. B. Stein, 22 Sep 1961; NMNH 151997, 5 specimens, R. E. Call; NMNH 152010, 5 specimens, R. E. Call; MCZ 16270, 15 1/2 specimens, B. Walker; MCZ 167702, 1 specimen, B. Walker; MCZ 167703, 1 specimen, B. Walker; MCZ 167705, 1 specimen, B. Walker; UMMZ 81652, 5 specimens, B. Walker; UMMZ 85453, 1 specimen, B. Walker; ANSP 149518, 2 specimens, R. E. Call.
Near mile 203 - OSUMZ?, G. J. Fallo, 5 Jul 1982.
First island west MCNP boundary - OSUMZ?, G. J. Fallo, 4 Jul 1982.
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Table 3. Species composition and number of live or fresh-dead specimens collected by site from the Green River in Mammoth

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
<i>A. l. carinata</i>	-	-	-	-	W	W	-	-	W	-	W	W	-	-	-	1	2	1	1	3
<i>A. l. ligamentina</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>A. plicata</i>	-	-	-	-	-	-	-	0.5	-	-	5	1	-	-	-	-	45	13	12	28
<i>A. grandis</i>	-	-	-	-	-	-	-	-	-	-	-	W	-	-	-	-	2.5	3	-	-
<i>A. imbecillis</i>	-	4	-	2	-	-	-	-	-	-	W	W	-	-	W	-	1	3.5	-	-
<i>A. suborbiculata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
<i>C. monodonta</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>C. tuberculata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	W
<i>C. stegaria</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-	4
<i>E. lineolata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	W	2	4
<i>E. crassidens</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>E. dilatata</i>	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	1	-	3
<i>E. rangiana</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>E. triquetra</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>F. flava</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>F. subrotunda</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>L. cardium</i>	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-
<i>L. fasciola</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>L. ovata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
<i>L. siliquoidea</i>	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	1	-	-	-
<i>L. teres</i>	-	-	-	-	-	W	-	-	W	-	W	-	-	-	-	-	-	W	-	-
<i>L. complanata</i>	-	-	-	-	-	W	-	-	-	-	W	-	-	-	-	-	1	-	-	1
<i>L. costata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>L. fragilis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3.5	-	-
<i>L. recta</i>	-	-	-	-	-	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>M. nervosa</i>	-	1	1	-	-	W	-	W	W	-	1	1	-	-	-	-	-	-	1	-
<i>O. reflexa</i>	-	-	1	-	-	W	-	W	W	-	W	-	-	-	-	-	45.5	14.5	4	41
<i>O. retusa</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>O. subrotunda</i>	-	-	-	-	-	W	-	-	-	1	-	-	-	-	-	-	5.5	5	-	3
<i>P. cyphus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	W	-	-	-	-	-	1
<i>P. clava</i>	-	-	-	-	-	-	-	-	-	-	-	W	-	-	-	-	-	-	-	-
<i>P. coccineum</i>	-	-	-	-	-	W	-	-	-	-	-	-	-	-	-	-	2	1	2	11
<i>P. cordatum</i>	-	-	-	-	-	-	-	-	-	-	-	W	-	-	-	-	4	1	1	5
<i>P. plenum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>P. pyramidatum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W	-	-
<i>P. alatus</i>	1	W	-	-	-	W	-	-	-	-	1	W	-	-	-	-	4.5	7	1	1
<i>P. fasciolaris</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	W	-
<i>Q. cylindrica</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Q. metanevra</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	3
<i>Q. nodulata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Q. pustulosa</i>	-	-	-	-	-	-	-	-	W	-	1	-	-	-	-	-	33.5	9.5	3	37
<i>Q. quadrula</i>	-	W	2	-	W	1	1	W	W	-	1	-	-	W	-	-	77.5	43.5	10	25
<i>S. undulatus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>T. verrucosa</i>	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	14	4	1	4
<i>T. donaciformis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>T. truncata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38	2	9	24
<i>V. ortmanni</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of individuals	1	5	4	2	-	1	1	1.5	-	1	14	2	1	-	-	1	299	116.5	48	201
Taxa live or fresh-dead	1	2	3	1	-	1	1	2	-	1	8	2	1	-	-	1	22	19	13	20
Taxa W or S	-	2	-	-	2	9	-	3	6	-	5	6	-	2	1	-	-	3	1	1
Total taxa	1	4	3	1	2	10	1	5	6	1	13	8	1	2	1	1	22	22	14	21

Cave National Park during 1987, 1988, 1989. (W=Weathered-dry, S=Subfossil).

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	Total Specimens
2	8	2	-	5	23	77	2	15	101	2	3	2	-	12	-	-	1.5	1	9	1	-	274.5
-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
45	11	15	W	2	17	25	4	11	50	2	19	3	-	36.5	2	-	1	1	7	1	-	357
-	-	-	-	2	1	1	W	1	-	1	-	-	-	0.5	-	-	-	-	-	-	-	12.0
6	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.5
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
-	-	-	W	-	1	W	1	1	1	-	-	1	W	W	-	-	W	-	-	-	-	5
6.5	W	1	-	7	-	-	W	W	2	6	20	-	-	11	W	-	-	1	8	1	-	66.5
8	4	6	-	15	1	4	W	W	6	11	25	W	-	3	11	1	-	-	23	-	-	126
23	10	20	S	4	-	-	-	-	-	3	8	-	-	6	-	-	1	1	3	1	-	96
-	-	-	-	W	2	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	4
6	3	1	-	5	1	5	W	-	9	2	10.5	W	-	62	1	-	1	1	8	1	-	123.5
S	-	-	-	W	-	-	-	W	-	S	0.5	-	-	W	-	-	-	W	W	-	-	0.5
W	-	-	-	W	-	-	-	-	W	2	-	-	-	1	1	-	W	W	1	-	-	5
-	-	-	-	-	-	W	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2
1	2	-	-	W	-	5	-	W	4	1	1	W	-	12	-	-	2	W	4	1	-	34
W	-	-	-	2	3	-	-	-	-	-	-	W	-	W	-	-	-	1	2	-	-	10
-	-	-	-	1	-	-	-	-	W	-	1	-	-	6	-	-	-	-	W	-	-	8
-	-	-	W	1	1	11	-	W	7	1	-	-	-	W	-	3	W	-	1	1	1	28
-	-	-	-	W	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	6
-	-	-	-	W	1	-	-	-	W	1	-	-	-	-	-	-	-	W	-	-	-	2
-	-	-	-	-	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
-	-	-	-	5	-	1	-	-	2	1	1	-	-	2	-	-	-	-	2	-	-	14
0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	6.0
-	W	-	-	1	-	-	W	1	-	-	-	-	-	-	-	-	-	1	1	1	-	5
-	-	-	-	1	2	1	-	W	1	1	1	-	-	-	-	-	1	1	1	1	-	16
78.5	51	53	W	5	2	-	-	1	1	7	8	2	-	16	1	-	-	8	-	-	-	339.5
-	-	-	-	-	-	-	W	W	W	-	-	-	-	-	-	-	W	W	W	-	-	1
9.5	6.5	8	-	2	W	1	-	-	-	-	W	-	-	-	-	-	-	-	-	-	-	41.5
2	-	1	-	1	-	W	W	0.5	2	1	3.5	-	-	2	-	-	1	1	1	1	1	19.0
W	W	-	-	-	-	-	-	W	W	-	-	W	-	-	-	W	-	-	1	-	W	1
15	9	11	-	11	1	3	W	1	4	5	30	1	-	40	1	-	-	W	12	1	-	161
5	1	2	-	2	-	2	-	-	3	2	11	1	-	23	-	-	-	1	4	-	-	68
1	-	1	-	-	-	-	-	-	W	-	-	-	-	1	2	-	-	W	3	-	-	8
1	4	S	-	W	-	-	-	W	W	1	-	-	-	2	1	-	-	W	2	-	-	11
3	4	1	-	4	1	4	1	-	-	1	W	-	-	2	W	-	-	-	2	-	-	38.5
2	4	1	-	2	5	13	-	-	11	W	W	-	-	9	-	-	1.5	1	4	1	-	56.5
-	-	-	-	-	-	-	-	-	W	-	W	-	-	-	-	-	-	-	-	-	-	-
3	1	1	-	6	1	1	-	-	2	2	23.5	-	-	11	1	-	1	-	12	1	-	71.5
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
103	56	77.5	-	1	1	7	1	-	10	3	24.5	1	-	49	14	-	1	W	10	1	-	444
76	37	44.5	0.5	1	1.5	3	1.5	-	3	2	30	-	-	7.5	1	-	-	1	5	-	-	375.5
W	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
13	3	2	-	4	-	2	-	1	2	5	21	-	-	9	-	-	-	1	5	1	-	95
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2
48	16	31	-	12	-	1	-	1	2	2	21.5	-	-	26	1	W	-	W	11	-	-	245.5
-	-	-	-	-	-	-	-	-	-	1	1	-	-	11.5	1	-	-	-	2	-	-	16.5
459	230.5	280	0.5	101	68.5	170	11.5	32.5	224	67	265	11	-	363	38	4	12	13	155	15	2	3221.5
25	18	20	1	24	21	21	7	9	21	26	22	7	-	26	13	2	10	13	30	15	2	
4	3	1	5	7	2	3	7	10	8	2	4	5	1	4	2	2	4	10	3	-	1	
29	21	21	6	31	23	24	14	19	29	28	26	12	1	30	15	4	14	23	33	15	3	

Actinonaias ligamentina carinata (8.52%), *Truncilla truncata* (7.62%), and *Pleurobema coccineum* (5.00%)) comprised 68.2% of the specimens collected (Table 3). Twenty taxa were represented by 10 or fewer individuals each, including six species for which only single specimens were found (*Anodonta suborbiculata*, *Epioblasma rangiana*, *Obovaria retusa*, *Pleurobema clava*, *Quadrula nodulata*, and *Strophitus undulatus*).

Only 13 taxa represented by a total of 34 1/2 live or fresh-dead specimens were collected from sites 1-16. Sites 17-42 yielded 46 taxa represented by 3187 live or fresh-dead specimens. Faunal richness was greatest at site 40 where 30 taxa were collected alive or fresh-dead and three additional species were represented by weathered-dry shells. Seven United States Fish and Wildlife Service (1989a, b, c, d) listed or candidate taxa (*Cumberlandia monodonta*, *Cyprogenia stegaria*, *Epioblasma rangiana*, *Obovaria retusa*, *Pleurobema clava*, *P. plenum*, and *Villosa ortmanni*) and three species (*Lampsilis ovata*, *Plethobasus cyphus*, and *Pleurobema pyramidatum*) monitored by the Kentucky Academy of Science-Kentucky State Nature Preserves Commission (KAS-KSNPC) (Warren et al. 1986) were collected. *Quadrula cylindrica*, another KAS-KSNPC listed species, was collected only as weathered-dry shells.

SPECIES ACCOUNTS

The following accounts discuss the historical and recent distribution and status of each unionid bivalve known from the Green River in MCNP. Species are discussed in alphabetical order within each of six categories: federal endangered species, proposed federal endangered species, federal candidate species, Kentucky Academy of Science-Kentucky State Nature Preserves Commission (KAS-KSNPC) listed species, other species, and introduced species. All comments refer to live or fresh-dead specimens unless otherwise indicated.

FEDERAL ENDANGERED SPECIES

Hemistena lata (Rafinesque, 1820). Cracking pearlymussel.

H. lata is known from MCNP based only on 12 specimens (MCZ 6327, NMNH 152032) collected at Mammoth Cave by R. E. Call. The only other records for the drainage are those of Clench (1926) from Rio, and Stansbery (1965) from Munfordville. The latter record is the last known collection of *H. lata* from the state. It typically inhabits riffles and shoals with moderate to swift current over sand, gravel, and rubble (Wilson and Clark 1914, Ahlstedt 1984), but has been found in the mud and gravel of bars (Call 1900). Specimens tend to be deeply buried in the substrate and are difficult to locate (Call 1900, Ahlstedt 1984). The

Green River, including MCNP, appears to provide excellent habitat and offers perhaps the best opportunity to rediscover *H. lata* in Kentucky.

Obovaria retusa (Lamarck, 1819). Ring pink.

Ortmann (1926) reported that the ring pink was not rare at Great Onyx Cave. Another indication that *O. retusa* was more common in MCNP historically than today is the 34+ specimens collected at Mammoth Cave by R. E. Call (OSUMZ 34976, MCZ 5944, NMNH 152011). More recently, Williams (1969) reported three specimens that may have come from MCNP, and G. J. Fallo collected what were apparently weathered-dry shells from three MCNP sites in 1982 (OSUMZ?). In addition to weathered-dry shells collected at several sites in the Park during this study, one fresh-dead 60.1 mm (2.4 in) specimen estimated to be approximately 14 years old was collected from a muskrat midden at mile 195.4 (site 20). The river at this site is influenced by lock and dam 6. Even during low flow conditions (depth gauge=0.6 m, 1.95 ft) when the specimen was found, the current is slow and depth increases to 2m+ a short distance from the shoreline. According to Parmalee and Klippel (1982), *O. retusa* inhabits deep stretches of rivers with swift current, and coarse sand and gravel substrates. Although the Green River in the vicinity of site 20 may constitute only marginal habitat, additional intensive sampling should be undertaken in this area and in suitable habitat upstream to locate extant individuals or populations. Other Green River locations of importance to the conservation of *O. retusa* include Munfordville, where D. H. Stansbery collected fresh-dead specimens in 1972 (OSUMZ 33283), and the river just upstream from MCNP, where one fresh-dead and three weathered-dry specimens were found in 1987. In addition to the remnant populations in the lower Tennessee (Sickel 1985) and middle Cumberland (Parmalee and Klippel 1982) rivers, specimens from the Green River are the only known sources of genetic material for captive rearing if active recovery efforts are undertaken.

Pleurobema plenum (I. Lea, 1840). Rough pigtoe.

Sixteen specimens (OSUMZ 34973) collected at Mammoth Cave by R. E. Call represent the first record for the rough pigtoe in MCNP. Ortmann (1926) collected specimens near Great Onyx Cave and considered it rare in the Green River. Subsequently, Clark (1981a) secured "empty shells" from the head of Cave Island, and G. J. Fallo collected what were apparently weathered-dry shells at Three Sisters Island and Dennison Ferry (OSUMZ?). Other sites in the drainage where live or fresh-dead specimens have recently been collected include the Barren River in Warren County (OSUMZ), the Green River at lock and dam 5 (Clarke 1981a), the Green River just upstream from the Park (OSUMZ), and the Green River at Munfordville (OSUMZ). A total of 8 fresh-dead specimens were collected from five sites (21, 23, 35, 36, and 40) in the Park during 1987 and 1989. Six of the specimens were measured and were similar in size (67.7-78.7 mm, 2.7-3.8 in) and approximate age (13-18 years). The preferred habitat of *P. plenum*, shoals

with sand and gravel substrates (Neel and Allen 1964, Bogan and Parmalee 1983, Ahlstedt 1984), is common in MCNP.

PROPOSED FEDERAL ENDANGERED SPECIES

Cyprogenia stegaria (Rafinesque, 1820). Fanshell.

R. E. Call collected the fanshell at Mammoth Cave and deposited enough specimens in museums to suggest that it was not rare (MCZ 5486, many specimens; NMNH 152004, 7 specimens). Ortmann (1926) also collected specimens at Mammoth Cave (CM 61.11222) and additionally near Great Onyx Cave, and indicated that when found it was "...mostly present in good numbers". During this study, the fanshell was collected, with few exceptions, from sites 17-40, and probably occurs in suitable habitat throughout the Green River in MCNP. Live specimens were collected at sites 26, 27, 30, 31, 32, and 35. Based on the number of fresh specimens collected (and numerous weather-dry not indicated), in many cases from muskrat midden, sites 25, 31, 32, 35, 36, and 40 appear to support large populations. The range in size and age of 39 specimens was 37.3-64.7 mm (1.5-2.6 in) and 4-18 years, respectively. Age estimates should be viewed with caution because many specimens had eroded umbos and tightly crowded annuli. Recent reproductive success is indicated by the presence of a total of 11 small specimens (37.3-44.7 mm, 1.5-1.8 in) in what appear to be age groups 4-6 at sites 20, 21, 23, and 32. The fanshell occurs in medium to large-sized rivers with moderate to swift current, and coarse substrates (Ortmann 1919, Parmalee 1967). MCNP specimens were taken from swift flowing riffles and the area immediately above them. Substrates consisted of sand, gravel, and occasionally cobble, and depths reached 1 m. An abundance of such habitat is present in MCNP, which should be considered essential for the recovery of this once widespread unionid.

FEDERAL CANDIDATE SPECIES

Cumberlandia monodonta (Say, 1829). Spectaclecase.

G. J. Fallo collected the first specimens from three sites on the Green River in MCNP during 1982-1984 (OSUMZ?). The condition of these specimens is unknown. Other collections in the drainage have been made as far downstream as lock and dam 5 and upstream to Munfordville (Stansbery 1965, Kentucky State Nature Preserves Commission 1990). During 1987-1989, single fresh-dead specimens were collected from sites 26, 28, 29, 30, and 33. All the specimens were large, two measuring 120.4 mm (4.7 in) and 142.1 mm (6.0 in), and old, but were too eroded to age. Weathered-dry specimens were collected from five other sites, and K. Kern (pers. comm.) collected single fresh-dead and weathered-dry specimens from Cave Island in 1989. The spectaclecase has been collected from

medium to large streams with substrates ranging from mud to boulders (Neel and Allen 1964, Stansbery 1966, Nelson and Freitag 1980) and may often be completely buried in the substrate or lodged under or between boulders (Call 1900). The severe umbonal erosion of specimens collected during this study indicates that they had been living in areas with a moving bed load. With the exception of the Cumberland River below Wolf Creek dam, where a single specimen of *C. monodonta* was recently found (Miller et al. 1984), this federal candidate is known to persist in Kentucky only in the Green River in MCNP (Kentucky State Nature Preserves Commission 1990). Intensive sampling of appropriate habitat upstream from Mammoth Cave Ferry should yield live specimens.

Epioblasma rangiana (I. Lea, 1839). Northern riffleshell.

Two historic collections of the northern riffleshell have been made in MCNP. R. E. Call collected 12 specimens (MCZ 5752) from Mammoth Cave, and Ortmann (1926) reported finding one dead female in the same general area. The last known collection was made by G. J. Fallo, who secured what were probably weathered-dry specimens (OSUMZ?) from four sites during 1982 and 1984. In addition to several weathered-dry or subfossil specimens, one-half fresh-dead male specimen was collected from a muskrat midden at site 32. This badly eroded specimen measured 61.4 mm (2.4 in) and was approximately 10 years old. The only other recent records of live or fresh-dead specimens for Kentucky are from the Green River in Hart County (Stansbery 1965, OSUMZ), one of which was collected in 1989 from a muskrat midden just upstream from the Park. Ortmann (1919) reported always collecting specimens from swift, shallow riffles with firmly packed fine or coarse gravel. In Canada, it occurs in rocky and sandy riffles (Clarke 1981b). Watters (1986), however, indicated that suitable habitat includes runs with moderate current. These habitats are common upstream from Mammoth Cave Ferry where live specimens should be sought.

Pleurobema clava (Lamarck, 1819). Clubshell.

The clubshell was first collected by R. E. Call at Mammoth Cave (MCZ 16260, 2 specimens; NMNH 151995, 12 specimens). In 1908, J. F. Boepple collected in excess of four specimens (USNM 677397, 677402) from the same area. Ortmann (1926) subsequently sampled two MCNP sites in 1921 and 1922 but located only two specimens near Great Onyx Cave. More recently, Williams (1969) reported two specimens that may have come from MCNP, and G. J. Fallo collected *P. clava* of unknown quality near mile 203 in 1982 (OSUMZ?). In addition to weathered-dry specimens collected at several sites during this study, one recently dead specimen was discovered at site 40 in 1987. K. Kern (pers. comm.) also found one rather fresh specimen between Three Sisters Island and Doyles Ford (sites 35 and 38) in 1989. Numerous records representing weathered-dry specimens or dated collections are available for as far downstream in the drainage as the Barren River and upstream to Rio (Ortmann 1926, Clench and van der Schalie

1944, Kentucky State Nature Preserves Commission 1990). However, the only evidence of additional remnant individuals or populations in the state is one fresh-dead specimen (OSUMZ) collected from the Green River, Green County, in 1984 (B. Bay pers. comm.). This rare unionid has been found deeply buried in sand and gravel riffles and runs of small to medium-sized rivers (Ortmann 1919, Goodrich and van der Schalie 1944, Watters 1986). Gordon and Layzer (1989) indicated that it probably occurs in or immediately above riffles. *P. clava* should be sought in appropriate habitat in the upper reaches of the Green River in the Park.

Villosa ortmanni (Walker, 1925). Kentucky creekshell.

Many historic collections of this endemic Kentucky unionid have been made at MCNP and deposited in museums, including several used by Walker (1925) to describe the species (e.g., MCZ 16270, 167702; ANSP 149518). In addition to Mammoth Cave, Ortmann (1926) also reported its historic occurrence near Great Onyx Cave. Recent collections were made at two sites by G. J. Fallo (OSUMZ?). A total of 16 1/2 live or fresh-dead specimens were collected from sites 31, 32, 35, 36, and 40 in 1987-1989, many of which were secured from muskrat midden. The size of females (n=7) ranged from 49.6-59.6 mm (2.0-2.4 in) and males (n=7) ranged from 53.3-62.8 mm (2.1-2.5 in). Severe umbonal erosion precluded age determinations but more than one age group was present. This erosion also indicated that the specimens lived in an area with a moving bed load. The river at these sites included deep flowing riffles and runs with substrates composed of sand, gravel, and some cobble. Such habitat is abundant in the upper third of the river where the specimens were secured. The possibility exists that this unionid is more characteristic of small to medium-sized streams and rivers. In nearby Brush Creek, a cool, spring fed stream in Warren County, nine live and numerous fresh dead and weathered-dry specimens were collected. The stream was approximately 10 m wide and *V. ortmanni* was found lying on or only slightly buried in the sand and small gravel substrate of flowing pools. Further circumstantial evidence include its apparent absence from the Green River downstream from MCNP and penetration into the upper reaches of the Rough (Hardin County), Nolin (Larue County), and Barren rivers (Allen, Logan, and Simpson counties), and the mainstem Green River (Green County) (Kentucky State Nature Preserves Commission 1990).

KENTUCKY ACADEMY OF SCIENCE-
KENTUCKY STATE NATURE PRESERVES COMMISSION SPECIES

Alasmidonta marginata Say, 1818. Elktoe.

The elktoe is considered threatened by the KAS-KSNPC (Warren et al. 1986) and is known from MCNP based on three collections made at Mammoth Cave. R. E. Call deposited three specimens at the UMMZ (152012) and

"numerous" specimens at the MCZ (6365). An additional specimen is housed at the NMNH (677476) and, based on collection date, was probably collected by J. F. Boepple in the early 1900's. This unionid was not collected during this effort, but does persist upstream in the watershed (Stansbery 1965, Kentucky State Nature Preserves Commission 1990). It inhabits clean sand, gravel, and rubble substrates with swift currents in small to large streams (Parmalee 1967, Ahlstedt 1984), and may be found in the Park through additional intensive sampling.

Epioblasma triquetra (Rafinesque, 1820). Snuffbox.

The snuffbox has been collected historically from Mammoth Cave (MCZ 6165) and near Great Onyx Cave (CM 61.11494). Ortmann (1926) found that it was well distributed in the upper Green River but not abundant. Four sites yielded a total of five specimens during this study, including one live specimen secured from a drought isolated sand and gravel bar at site 40. Typical habitat includes small to large rivers with strong current and sand to rubble substrates in which the snuffbox may be deeply buried (Ortmann 1919, Clarke 1981b). The KAS-KSNPC consider this unionid to be of special concern (Warren et al. 1986).

Fusconaia subrotunda (I. Lea, 1831). Long-solid.

Museums possess several historic records, including 25 specimens collected by R. E. Call from Mammoth Cave and those secured by Ortmann (1926) from the same area and near Great Onyx Cave. A total of 34 specimens of this KAS-KSNPC threatened species (Warren et al. 1986) was collected from 11 areas sampled between sites 20 and 42. At sites upstream from Cave Island (site 25), habitat compared well with that described by Ortmann (1919), and consisted of gravel and sand with some cobble in and just above riffles with strong flow. The Green River in MCNP is an important stronghold in Kentucky for this once more widespread unionid (Kentucky State Nature Preserves Commission 1990).

Lampsilis ovata (Say, 1817). Pocketbook.

The pocketbook historically occurred in many of Kentucky's rivers but persists only in the Green and lower Tennessee rivers (Kentucky State Nature Preserves Commission 1990). Ortmann (1926) documented its historic occurrence in the Park and indicated that it was not rare. Ten sites yielded a total of 28 large, badly eroded specimens during this effort. Specimens were always deeply buried in loose or firmly packed sand and gravel in or just above swift riffles. However, a muskrat secured one specimen from site 18 in the area influenced by lock and dam 6. The Green River supports the best population of this KAS-KSNPC endangered species (Warren et al. 1986) in Kentucky and is its last stronghold in the state.

Plethobasus cyphus (Rafinesque, 1820). Sheepnose.

Specimens in the NMNH (677556) and MCZ (4939) demonstrate the historic presence of the sheepnose in MCNP. A total of 19 live specimens, including two juveniles, was collected from 14 sites. This unionid inhabits medium and large-sized rivers, and was collected in the Park from swift riffles with firm gravel and sand substrates. A few specimens were secured from muskrat midden adjacent to the deep, slow-moving area affected by lock and dam 6. The sheepnose is considered of special concern in Kentucky by the KAS-KSNPC (Warren et al. 1986).

Pleurobema pyramidatum (I. Lea, 1840). Pyramid pigtoe.

Historic collections of the pyramid pigtoe were made at Mammoth Cave (CM, NMNH, UMMZ) and near Great Onyx Cave (CM), and Ortmann (1926) reported that it was not rare at either of these sites. Despite its once broad distribution across the state, this unionid is now considered endangered by the KAS-KSNPC (Warren et al. 1986) and its primary stronghold is the upper Green River (Kentucky State Nature Preserves Commission 1990). However, only 11 specimens were collected from six sites during 1987-1989. Although no live specimens were collected, this is a large stream species (Parmalee 1967, Neel and Allen 1964) that probably occurs in sand and gravel substrates in deep water. Although removed from the federal candidate list because of taxonomic confusion (United States Fish and Wildlife Service 1989d), this rare unionid deserves reconsideration to protect remnant populations.

Quadrula cylindrica (Say, 1817). Rabbitsfoot.

This unionid was once widespread in Kentucky, but is now known to exist only in parts of the lower Ohio, lower Tennessee, lower Cumberland, and upper Green rivers (Kentucky State Nature Preserves Commission 1990). For this reason the KAS-KSNPC considers the rabbitsfoot endangered (Warren et al. 1986). R. E. Call collected eight specimens (MCZ 5235) from Mammoth Cave, and Ortmann (1926) observed that the rabbitsfoot was rare in the drainage. Specimens of unknown condition were collected at Mammoth Cave by C. B. Stein in 1961 (OSUMZ 5242), and by G. J. Fallo at three Park sites in 1982 (OSUMZ?). Only weathered-dry specimens were collected during this effort, at sites 30 and 32. The rabbitsfoot inhabits flowing medium to large streams of various depths with sand, gravel, and cobble substrates (Parmalee 1967, Bogan and Parmalee 1983, pers. obs.). Live specimens have recently been collected from the Green River in Hart, Green, and Taylor counties (Kentucky State Nature Preserves Commission 1990), suggesting that the rabbitsfoot may persist in appropriate habitat in MCNP.

Villosa lienosa (Conrad, 1834). Little spectaclecase.

Two specimens of *V. lienosa* were collected from Mammoth Cave by R. E. Call (MCZ 16265). Additional specimens were collected from Mammoth Cave by C. B. Stein in 1961 (OSUMZ 5258), and by G. J. Fallo from near mile 203 in 1982 (OSUMZ?). Intensive sampling in areas with mud and sand bottoms should reveal the presence of this KAS-KSNPC special concern unionid (Warren et al. 1986) in the Park.

OTHER SPECIES

Actinonaias ligamentina carinata (Barnes, 1823). Mucket.

The mucket was the fifth most common species collected and was found at more sites (22) than all but two other taxa.

Actinonaias ligamentina ligamentina (Lamarck, 1819).

This high, rounded, and compressed form of the mucket (*A. l. carinata*) was once widely distributed in the Ohio River and its southern tributaries (St. John 1973). In Kentucky, it apparently only persists in the upper Cumberland and Green rivers (D. H. Stansbery pers. comm., pers. obs.). A total of three live specimens was collected from and returned to the heads of riffles at sites 26 and 27 in 1989. Extant populations in MCNP should be protected from disturbance or collection.

Alasmidonta viridis (Rafinesque, 1820). Slippershell mussel.

The only record for *A. viridis* is one specimen collected at Mammoth Cave by C. B. Stein in 1961 (OSUMZ 5248). This unionid typically inhabits small streams with mud, sand, or gravel substrates. Many records are available for the upper Green River drainage, so a small population may occur in the Park.

Amblyma plicata (Say, 1817). Threeridge.

Common throughout the state, the threeridge was the third most frequently collected species and was found at more sites (25) than any other species.

Anodonta grandis Say, 1829. Giant floater.

Although typically occurring in lowland habitats with little or no flow and soft substrates, *A. grandis* is known from small, headwater streams with rocky substrates, including the upper reaches of the Green River. A total of 12 specimens was collected from eight sites. Further sampling will probably reveal that

A. grandis occurs more commonly in the segment of the river impounded by lock and dam 6.

Anodonta imbecillis Say, 1829. Paper pondshell.

A. imbecillis is typically found in ponds and sloughs and the backwaters or margins of streams and rivers in the western half of the state. It was previously reported from the Green River drainage (Price 1900), but not from MCNP (Kentucky State Nature Preserves Commission 1990). Six sites (2, 4, 17, 18, 21, and 23) yielded specimens during the study, but additional individuals certainly occur in the impounded segment of the river.

Anodonta suborbiculata Say, 1831. Flat floater.

The flat floater is reported for the first time from MCNP based on one specimen collected from a muskrat midden at site 18 in 1989. In Kentucky, this species typically occurs in soft substrates of sloughs and impounded streams from Barkley Reservoir west. There are four additional records for the Green River system (Kentucky State Nature Preserves Commission 1990), including the specimens mentioned by Ortmann (1926) from near Bowling Green, but MCNP is the upstream limit of *A. suborbiculata* in the drainage.

Cyclonaias tuberculata (Rafinesque, 1820). Purple wartyback.

This species was only found upstream from the permanently impounded lower segment of the river and was the 14th most commonly collected species.

Ellipsaria lineolata (Rafinesque, 1820). Butterfly.

The butterfly was the 10th most commonly collected species and occurred throughout much of the river except for the permanently impounded section.

Elliptio crassidens (Lamarck, 1819). Elephant-ear.

Ortmann (1926) reported that this medium to large-river unionid was rare at Mammoth Cave, and few museum records are available for the Park. Only four specimens were collected from three sites (26, 27, and 31) during this study.

Elliptio dilatata (Rafinesque, 1820). Spike.

The spike is common and widely distributed in the Park (sites 11-41), but the total number collected was inflated by numerous specimens found in a muskrat midden at site 35.

Fusconaia flava (Rafinesque, 1820). Wabash pigtoe.

There are no historic MCNP records for this widespread and moderately common unionid. In various forms, this species occurs in small, medium, and large streams and rivers with sand, gravel, and sometimes mud bottoms (Ortmann 1919, Parmalee 1967, Oesch 1984). Although only two specimens were collected during this effort, the adaptability of the Wabash pigtoe suggests that it may be more common in the Park.

Lampsilis cardium (Rafinesque, 1820). Plain pocketbook.

This unionid was collected historically by Ortmann (1926), and is widely distributed and common in the Green River and the eastern half of the state (Kentucky State Nature Preserves Commission 1990). A total of only 10 specimens was located at six widely separated (11, 18, 25, 26, 39, and 40) sites. However, *L. cardium* may be more common in the Park than indicated because numerous weathered-dry specimens were also collected and this adaptable unionid frequently occurs in quiet pools with soft substrates (Ortmann 1919), such as site 11.

Lampsilis fasciola Rafinesque, 1820. Wavy-rayed lampmussel.

Ortmann (1926) reported that this unionid was common near Great Onyx Cave, and museums contain several specimens (MCZ, OSUMZ, NMNH). A total of only eight individuals was found at sites 26, 32, and 35. However, *L. fasciola* typically occurs in riffles with coarse sand and gravel substrates (Ortmann 1919, Parmalee 1967), habitat that is quite common in the Park.

Lampsilis siliquoidea (Barnes, 1823). Fatmucket.

Ortmann (1926) collected specimens from Mammoth Cave and pointed out that this species prefers small streams. However, Parmalee (1967) found that it occurs in large rivers, but less abundantly. The six specimens collected during this study were taken from a variety of habitats, including the pool of lock and dam 6 and quiet water upstream from a riffle. Because of its adaptability, the fatmucket may be more common in the Park than these results indicate.

Lampsilis teres (Rafinesque, 1820). Yellow sandshell.

The yellow sandshell was collected from two sites by G. J. Fallo in 1982 (OSUMZ?) and at Cave Island by Clarke (1981a), but no historic records are available. Only two specimens were found in 1988 and 1989, one of which was a juvenile (site 26). *L. teres* occurs in habitats ranging from small to large rivers with mud to rocky substrates and a variety of current regimes (Wilson and Clark 1914, Parmalee 1967).

Lasmigona complanata (Barnes, 1823). White heelsplitter.

This unionid is widely distributed and common in Kentucky, but was previously known to occur in the Green River upstream only to lock and dam 5 (OSUMZ, Kentucky State Nature Preserves Commission 1990). Live or fresh-dead specimens were collected in 1989 from sites 17 and 20, and weathered-dry specimens were found at sites 6, 11, and 26. *L. complanata* prefers quiet water with mud and sand substrates, but does frequent gravel riffles (Ortmann 1919, Parmalee 1967, Clarke 1981b). The abundant suitable habitat downstream from Mammoth Cave Ferry may support additional individuals.

Lasmigona costata (Rafinesque, 1820). Fluted-shell.

The fluted-shell was described by Ortmann (1926) as being common in the Green River. Although a total of only 14 specimens was collected from seven sites, intensive sampling in and adjacent to gravel/cobble riffles should produce additional representatives.

Leptodea fragilis (Rafinesque, 1820). Fragile papershell.

The limited number of specimens collected from four sites in the Park suggests that this unionid is uncommon. However, all were collected from or adjacent to this species' preferred habitat, areas with little current and soft substrates (Parmalee 1967). Additional effort in these areas, especially downstream from Mammoth Cave Ferry, should prove it to be more common.

Ligumia recta (Lamarck, 1819). Black sandshell.

Five fresh-dead or live specimens of this distinctive unionid were collected from five collection sites (26, 30, 39, 40, and 41). A paucity of historic records and Ortmann (1926) suggest that it is not abundant. However, it lives in a broad variety of habitats (Ortmann 1919, Parmalee 1967, Clarke 1981b) and is represented in several collections from the Green River up- and downstream from the Park (Kentucky State Nature Preserves Commission 1990).

Megalonaias nervosa (Rafinesque, 1820). Washboard.

The washboard was collected infrequently (16 specimens) and occurred sporadically in both impounded and free-flowing stream segments. Ortmann (1926) pointed out its large-river affinities, but the washboard occurs in impoundments and streams of all sizes that have soft substrates and slow current (Parmalee 1967, pers. obs.).

Obliquaria reflexa Rafinesque, 1820. Threehorn wartyback.

This unionid occurs most commonly in Kentucky's larger rivers, but was the fourth most commonly collected species in the Park. Although it occurred throughout the Park, *O. reflexa* was most common in the transition area between the impounded and free-flowing sections of the river (sites 17-25).

Obovaria subrotunda (Rafinesque, 1820). Round hickorynut.

The round hickorynut was collected from nine sites, primarily in the transition zone between the impounded and free-flowing sections of the river (sites 17-25). In Kentucky, this unionid is moderately common and inhabits small to medium-sized rivers east of the Tradewater River. The Green River in MCNP contains abundant suitable sand, gravel, and cobble habitat typically occupied by *O. subrotunda* (Ortmann 1919, Parmalee 1967, Clarke 1981b).

Pleurobema coccineum (Conrad, 1834). Round pigtoe.

The round pigtoe was the 7th most common unionid collected in the Park. All specimens were collected upstream from the permanently impounded section of the river.

Pleurobema cordatum (Rafinesque, 1820). Ohio pigtoe.

Although most common in Kentucky's largest rivers, the Ohio pigtoe was moderately abundant (13th) in the Park. With the exception of the permanently impounded lower section, it occurred throughout the Park.

Potamilus alatus (Say, 1817). Pink heelsplitter.

Distributed statewide in a wide variety of habitats, *P. alatus* was collected at sites throughout the Park, including the impounded section of the river (sites 1 and 11).

Ptychobranthus fasciolaris (Rafinesque, 1820). Kidneyshell.

The kidneyshell is common in small to medium-size streams east of the Tradewater River. Specimens were found in 10 of the 42 sites examined but not in the permanently impounded section of the river. Ortmann (1926) noted the small, humped-shaped specimens present in the Park.

Quadrula metanevra (Rafinesque, 1820). Monkeyface.

Most commonly found in the largest rivers of the state, *Q. metanevra* was the 12th most frequently collected unionid, but was not found in the permanently impounded lower section of the river.

Quadrula nodulata (Rafinesque, 1820). Wartyback.

Williams (1969) reported one specimen that may have been collected from the Park, but was probably collected from the vicinity of lock and dam 4 or 5 where Clarke (1981a, 1983) secured individuals. The single specimen of this typically big river unionid collected from site 21 represents the first confirmed record for MCNP and the upstream limit of *Q. nodulata* in the Green River drainage (Kentucky State Nature Preserves Commission 1990).

Quadrula pustulosa (I. Lea, 1831). Pimpleback.

This unionid is common and widespread in Kentucky and was the most common and one of the most widely distributed species collected.

Quadrula quadrula (Rafinesque, 1820). Mapleleaf.

The mapleleaf is also common statewide and was the second most common species collected. It occurred throughout the river in the Park, including the impounded lower section.

Strophitus undulatus (Say, 1817). Squawfoot.

Historic collection sites of the squawfoot in MCNP include Mammoth Cave (MCZ 6577), where R. E. Call collected ten specimens, and Great Onyx Cave (CM 61.11443), where Ortmann (1926) secured two individuals. Site 25 yielded the only live specimen, and one weathered-dry shell was collected at site 21 in 1989. This unionid is common in small streams to large rivers in the eastern two-thirds of Kentucky, and probably is slightly more common in MCNP than this survey suggests.

Tritogonia verrucosa (Rafinesque, 1820). Pistolgrip.

The pistolgrip occurs in rivers of all sizes across the state. It was common and widely distributed in the Park, including one collection from the impounded section of the river (site 11).

Truncilla donaciformis (I. Lea, 1828). Fawnsfoot.

The fawnsfoot occurs rather sporadically in medium to large rivers in Kentucky, and was not reported previously from MCNP. Two fresh-dead and one weathered-dry specimens were collected at site 40 in 1987. Parmalee (1967) indicated that it thrives in a variety of substrates and currents in shallow and deep water. Further sampling in the Park should yield additional specimens since appropriate habitat is present and the fawnsfoot has been collected up- and downstream in the Green River.

Truncilla truncata Rafinesque, 1820. Deertoe.

The deertoe was one of the most common (6th) taxa collected but was not found in the impounded section of the river in the Park.

Venustaconcha ellipsiformis (Conrad, 1836). Ellipse.

The only record for the Park and Kentucky is one specimen from Mammoth Cave that was collected by R. E. Call (NMNH 152009). The ellipse inhabits streams north of central Illinois and Indiana (Burch 1975) and its occurrence in Kentucky is at best questionable.

INTRODUCED SPECIES

Corbicula fluminea (Muller, 1774). Asian clam.

This member of the Order Veneroida is endemic to southeast Asia and was introduced to Kentucky in 1957 via west coast populations (McMahon 1982). Williams (1969) and Clarke (1981a) previously reported its presence in MCNP. The Asian clam is common throughout the Park. Its presence is of interest because *C. fluminea* has been implicated in the decline of native unionids (Kraemer 1979, Clarke 1988).

DISCUSSION

A total of 51 unionid taxa have been reported from the Green River in MCNP as a result of this survey and accepted literature and museum records. Of the 46 taxa collected alive or fresh-dead during 1987-1989 (Appendix 1), six (*A. l. ligamentina*, *A. grandis*, *A. imbecillis*, *A. suborbiculata*, *L. complanata*, and *T. donaciformis*) were not previously reported. However, all were previously known from elsewhere in the drainage (Ortmann 1926, Clench and van der Schalie 1944, Williams 1969, Kentucky State Nature Preserve Commission 1990), and may have recently invaded the Park but more likely have been overlooked. Five species (*A. marginata*, *A. viridis*, *H. lata*, *V. ellipsiformis*, and *V. lienosa*) have been previously collected but not during 1987-1989 (Appendix 2). *Alasmidonta viridis* and *V. lienosa* were collected recently and probably are extant in the Park. Only very old records are available for *A. marginata* and *H. lata*, but both were reported upstream from the Park fairly recently (Stansbery 1965, Kentucky State Nature Preserve Commission 1990). The record for *V. ellipsiformis* is regarded as questionable. Although only weathered-dry shells of *Q. cylindrica* were collected during this survey, this unionid occurs upstream in the Green River and may be rediscovered in the Park. This qualitative comparison revealed that essentially the entire historic fauna persists in MCNP or may be found there with further

sampling. Several potential additions to the Park fauna are also presented in Appendix 3.

Live or fresh-dead individuals of seven species were found to comprise 68.2% of the total specimens collected. The remaining taxa comprised less than 5% each and totaled 31.8% of the specimens collected. Three of the most commonly collected species in 1987-1989 (*A. l. carinata*, *A. plicata*, and *Q. quadrula*) were among Williams' (1969) ten most abundant Green River unionids. Numerical dominance of communities by a few species is common. Unionid communities are usually dominated by from one (Miller and Payne 1988) to a few (3-5) (e.g., Jenkinson and Ahlstedt 1988a, b; Cummings et al. 1989) taxa. Conversely, the majority of taxa in a community usually account for a very limited number of the individuals in that community.

Based on the distributional information presented in Table 3, the Green River in MCNP can be divided into two sections. The pool behind lock and dam 6 extends upstream to approximately the vicinity of Sand Cave Island (Fig. 1, sites 1-16). The river within this segment provides slow-moving, deep-water habitat similar to that of large rivers and impoundments. Considerable brail and hand sampling effort in this area revealed only the following species:

<i>Actinonaias ligamentina carinata</i>	<i>Amblema plicata</i> *	<i>Anodonta imbecillis</i> *
<i>Elliptio dilatata</i>	<i>Lampsilis cardium</i>	<i>Lampsilis siliquoidea</i>
<i>Megalonaias nervosa</i> *	<i>Obliquaria reflexa</i> *	<i>Obovaria subrotunda</i>
<i>Potamilus alatus</i> *	<i>Quadrula pustulosa</i> *	<i>Quadrula quadrula</i> *
<i>Tritogonia verrucosa</i> *		

These unionids have broad ecological tolerances and may reproduce (*) in deep rivers and/or impoundments (Bates 1962, Williams 1969, Chandler 1982, Ahlshedt 1984, Dennis 1984, Gordon and Layzer 1989). Additional species that may be discovered in this area through further sampling include but are not limited to *A. grandis*, *A. suborbiculata*, *E. crassidens*, *F. flava*, *L. complanata*, *L. fragilis*, *Q. nodulata*, *T. donaciformis*, and *T. truncata*.

The second section includes sites 17-42. The upstream part of this section (sites 26-42) contains flowing riffle-pool-run habitat typical of medium-sized rivers. However, the area between sites 17 and 25 is transitional in nature depending on discharge. During high water conditions, the area is an extension of the pool behind lock and dam 6. At low flow, the area has riverine characteristics. Although these areas (17-25 and 26-42) appear to be physically different, the entire fauna occurs throughout this section with few exceptions (e.g., *E. rangiana*, *E. triquetra*, *V. ortmanni*). Perhaps quantitative sampling will reveal that some species are more abundant in preferred riffle-pool habitat (sites 26-42).

One of the primary differences between the two sections is that none of the species considered rare or endangered by the United States Fish and Wildlife

Service (1989a) or Kentucky Academy of Science-Kentucky State Nature Preserves Commission (Warren et al. 1986) were found alive or fresh-dead downstream from site 17. All but two of these rare unionids are known from the free-flowing segment of the Green River downstream from lock and dam 5 (approximate mile 168), suggesting that they have been eliminated from the area permanently impounded by lock and dam 6.

The total number of species collected and the number of individuals of each species also varied greatly between the two sections and was apparent between adjacent sites (Table 3, sites 16 and 17). From site 17 upstream, unionids were common and shells from muskrat midden added greatly to those collected by hand. Downstream from site 17, brail and hand-collecting efforts were not productive and muskrat midden, though present and active, yielded only a few specimens of *A. plicata*, *A. imbecillis*, and *L. siliquoidea*, but many *C. fluminea*. The reason for this disparity is not known, but the lack of unionids downstream from site 17 may be the result of (1) actual unionid rarity, (2) sampling inefficiency, and/or (3) the inability of muskrats to forage efficiently in deep water.

The occurrence of 46 species of unionids in the Green River in MCNP compares favorably with other rivers or river segments that are known to support the most diverse unionid communities in North America, including the Clinch River at Pendleton Island, Virginia and the Green River at Munfordville, Kentucky (Table 4). Neves (1984) called the Clinch River at Pendleton Island ". . . the most diverse and unique mussel assemblage in the world", and the Green River at Munfordville was described by Stansbery (1965) as ". . . probably the finest representative Ohioan naiad fauna yet in existence . . ."

Table 4. Species diversity of extant unionid communities in high quality rivers or river segments.

River - Location	Number of Species	Source
Licking River-Moores Ferry, KY	30	KSNPC
Lower Tennessee River-Livingston & Marshall cos., KY	36	Sickel 1985
Clinch River-Pendleton Island, VA	40	M. Lipford, pers. comm.
Green River-Mammoth Cave National Park, KY	46	This Study
Green River-Munfordville, KY	47	Stansbery 1965
Clinch River-TN and VA	47	Ahlstedt 1984

In addition to identifying the diverse, extant unionid fauna present in the Green River in MCNP, this study underscores the importance of current and

thorough inventories of the resources in the public domain. At a time when public and private agencies such as the National Park Service, Fish and Wildlife Service, state heritage programs, and The Nature Conservancy are desperately in need of funds to meet elusive conservation objectives and mandates, state and federal lands and waters may harbor significant examples of our rapidly dwindling natural heritage. Information derived from thorough resource inventories can help to direct the expenditure of these funds on the most critical resource needs. They also can preclude the unwitting destruction of significant areas, which is a prevalent problem at the state level.

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Appendix 1. Freshwater unionids collected from the Green River in Mammoth Cave National Park during 1987-1989, with United States Fish and Wildlife Service (USFWS) and Kentucky Academy of Science-Kentucky State Nature Preserves Commission (KAS-KSNPC) conservation status. E=endangered, T=threatened, S=special concern, PE=proposed endangered, and 2=candidate for listing.

Scientific Name	Common Name	Status	
		USFWS	KAS-KSNPC
<i>Actinonaias ligamentina carinata</i>	Mucket	-	-
<i>Actinonaias ligamentina ligamentina</i>	Mucket	-	-
<i>Amblema plicata</i>	Threeridge	-	-
<i>Anodonta grandis</i>	Giant floater	-	-
<i>Anodonta imbecillis</i>	Paper pondshell	-	-
<i>Anodonta suborbiculata</i>	Flat floater	-	-
<i>Cumberlandia monodonta</i>	Spectaclecase	2	E
<i>Cyclonaias tuberculata</i>	Purple wartyback	-	-
<i>Cyprogenia stegaria</i>	Fanshell	PE	T
<i>Ellipsaria lineolata</i>	Butterfly	-	-
<i>Elliptio crassidens</i>	Elephant-ear	-	-
<i>Elliptio dilatata</i>	Spike	-	-
<i>Epioblasma rangiana</i>	Northern riffleshell	2	E
<i>Epioblasma triquetra</i>	Snuffbox	-	S
<i>Fusconaia flava</i>	Wabash pigtoe	-	-
<i>Fusconaia subrotunda</i>	Long-solid	-	T
<i>Lampsilis cardium</i>	Plain pocketbook	-	-
<i>Lampsilis fasciola</i>	Wavy-rayed lampmussel	-	-
<i>Lampsilis ovata</i>	Pocketbook	-	E
<i>Lampsilis siliquoidea</i>	Fatmucket	-	-
<i>Lampsilis teres</i>	Yellow sandshell	-	-
<i>Lasmigona complanata</i>	White heelsplitter	-	-
<i>Lasmigona costata</i>	Fluted-shell	-	-
<i>Leptodea fragilis</i>	Fragile papershell	-	-
<i>Ligumia recta</i>	Black sandshell	-	-
<i>Megalonaias nervosa</i>	Washboard	-	-
<i>Obliquaria reflexa</i>	Threehorn wartyback	-	-
<i>Obovaria retusa</i>	Ring pink	E	E
<i>Obovaria subrotunda</i>	Round hickorynut	-	-
<i>Plethobasus cyphus</i>	Sheepnose	-	S
<i>Pleurobema clava</i>	Clubshell	2	E
<i>Pleurobema coccineum</i>	Round pigtoe	-	-
<i>Pleurobema cordatum</i>	Ohio pigtoe	-	-
<i>Pleurobema plenum</i>	Rough pigtoe	E	E
<i>Pleurobema pyramidatum</i>	Pyramid pigtoe	-	E
<i>Potamilus alatus</i>	Pink heelsplitter	-	-
<i>Ptychobranchus fasciolaris</i>	Kidneyshell	-	-
<i>Quadrula cylindrica</i>	Rabbitsfoot	-	E
<i>Quadrula metanevra</i>	Monkey face	-	-
<i>Quadrula nodulata</i>	Wartyback	-	-
<i>Quadrula pustulosa</i>	Pimpleback	-	-
<i>Quadrula quadrula</i>	Mapleleaf	-	-

Scientific Name	Common Name	Status	
		USFWS	KAS-KSNPC
<i>Strophitis undulatus</i>	Squawfoot	-	-
<i>Tritogonia verrucosa</i>	Pistolgrip	-	-
<i>Truncilla donaciformis</i>	Fawnsfoot	-	-
<i>Truncilla truncata</i>	Deertoe	-	-
<i>Villosa ortmanni</i>	Kentucky creekshell	2	E

Appendix 2. Freshwater unionids previously reported from the Green River in Mammoth Cave National Park but not collected during 1987-1989.

Scientific Name	Common Name
<i>Alasmidonta marginata</i>	Elktoe
<i>Alasmidonta viridis</i>	Slippershell mussel
<i>Hemistena lata</i>	Cracking pearlymussel
<i>Venustaconcha ellipsiformis</i>	Ellipse
<i>Villosa lienosa</i>	Little spectaclecase

Appendix 3. Potential additions to the freshwater unionid fauna of the Green River in Mammoth Cave National Park.

Scientific Name	Common Name
<i>Anodontooides ferussacianus</i>	Cylindrical papershell
<i>Arcidens confragosus</i>	Rock-pocketbook
<i>Epioblasma obliquata</i>	Catspaw
<i>Lampsilis abrupta</i>	Pink mucket
<i>Leptodea leptodon</i>	Scaleshell
<i>Potamilus ohioensis</i>	Pink papershell
<i>Quadrula apiculata</i>	Southern mapleleaf
<i>Simpsonaia ambigua</i>	Salamander mussel
<i>Toxolasma lividus</i>	Purple lilliput
<i>Toxolasma parvus</i>	Lilliput
<i>Unio merus tetralasmus</i>	Pondhorn
<i>Villosa fabalis</i>	Rayed bean
<i>Villosa iris</i>	Rainbow
