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The Ecological Effects of Lock and Dam No. 6 in Mammoth Cave National Park

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Introduction

As a conservation agency, the overriding mission of the National Park Service is to manage park resources such that they will remain unimpaired for future generations. Given the tremendous growth in the U.S. population, the highest rates of material and energy consumption per individual in the world, and the increasing demands for recreation in the national park system, this is a challenging mission. In our efforts to carry out this mission, it is important to bear in mind that people are part of ecosystems, and the health of our economy is absolutely linked to ecosystem health.

Mammoth Cave National Park is the core of an international biosphere reserve, which is simply recognition by the United Nations Education, Scientific, and Cultural Organization (UNESCO) as a special place in the world. One of the primary functions of the park and biosphere reserve is the conservation of native plants and animals, including the habitats where they live. The park consists of 52,830 acres and is somewhat like an island refuge in a sea of intensively used land. Vegetation communities in the park have exceptional diversity with over 1,100 species of flowering plants including 82 species of trees. As well, 203 species of birds, 43 of mammals, 29 of amphibians, and 38 of reptiles have been reported in the park.

The park is part of a regional karst landscape, which is characterized by subterranean drainage, springs, and caves. At 367 miles charted to date, Mammoth Cave is the longest known cave system in the world. Park cave ecosystems, both aquatic and terrestrial, possess one of the most diverse faunal assemblages in the world, with over 130 regularly occurring species. The Green River runs east to west through the park, and is joined by the Nolin River from the north near the park's western border. These rivers support a highly diverse fish (82 species) and invertebrate fauna (250 species), of which over 50 species are freshwater mussels.

Protection of cave streams and surface rivers has consistently been a high priority for the park. Six million dollars were contributed toward creation of a regional sewage treatment facility, removal of an 1,100-foot-long creosote-treated boardwalk in River Styx by National Speleological Society volunteers is nearly complete, runoff and spill retention/filtration structures along Interstate 65 have been negotiated with the Kentucky Transportation Cabinet, and agricultural best management practices have been supported through the Natural Resources Conservation Service.

History and current status of Lock and Dam No. 6

Located at the west edge of Mammoth Cave National Park, Lock and Dam No. 6 was built in 1904–1905 to allow navigation of barges carrying natural asphalt from mines near Nolin River. Normal flow in 16 miles of Green River and 7 miles of the Nolin River in the

park has been retarded by the dam since then. Highway transport and the demise of the natural asphalt business resulted in the facility being decommissioned in 1951. In both 1951 and 1980 the Secretary of the Interior directed efforts to effect removal of the dam, and in 1989 repairs were undertaken to stem infiltration of water beneath the dam, which was partially successful. The Kentucky Natural Resources and Environmental Protection Cabinet, Division of Water, has designated Green River and its subterranean tributaries as an Outstanding Resource Water, and the Green River has also been declared a Kentucky Wild River. Together with the Kentucky State Nature Preserves Commission, the cabinet recommends removal of the dam. Likewise, organizations such as the Cave Research Foundation, National Speleological Society, National Parks and Conservation Association, and the Sierra Club have strongly endorsed restoration of free flow.

Recent investigations including Lock and Dam No. 6

Funded in 1995, the U.S. Army Corps of Engineers (USACE) conducted a disposition study for derelict locks and dams on Green and Barren Rivers in order to make recommendations on deauthorization or disposal of the properties (USACE 2001). The following points have been extracted from the report:

- Trash and old campfires on the site indicate public safety issues such as "drinking, partying, and firearms" at the site by people trespassing despite posted signs (p. 9).
- There is a safety concern for boaters; in 1998 a family nearly went over the dam (p. 20).
- Of the five sites examined, Lock and Dam No. 6 was "by far in the worst condition" due to active undermining of the lock chamber with sinkholes evident nearby (p. 20). The estimated cost of stabilizing Lock and Dam No. 6 is $758,900 (p. 24).
- Removing the dam would nearly eliminate public safety concerns and the possible failure of the lock abutment, which could cause siltation at the Edmonson County Water District intake nearby (p. 21).
- Ferries on Green River in the park can continue operations by extending ramps at Houchins Ferry, and by annually dredging a channel at Green River Ferry (pp. 22–23).
- Removal of the dam would restore the cave aquatic and Green River ecosystems by returning free-flowing conditions, and also enhance recreational opportunities (p. 23).
- The *Miss Green River* excursion boat could operate on the Lock and Dam No. 5 pool at Brownsville (p. 23).

As part of the USACE disposition study, the U.S. Fish and Wildlife Service completed a coordination act report (Widlak1999). Major points from this report are listed below:

- Under free-flowing conditions, the Green and Barren Rivers supported approximately 151 species of fishes, but with the dam-related shift to slower, warmer water conditions, fish populations shifted, which increased "rough" species such as carp, gar, and shad (p. 6).
- The Kentucky cave shrimp is found only in the Mammoth Cave vicinity, and impoundment of Green River is implicated as a causative factor in the reduced populations of this

rare and endangered species (p. 8).
- Dam construction has reduced quantity and quality of freshwater mussel habitat (p. 7). Green River may be the only place where the orange-footed pearly, ring pink, and purple catspaw mussels are still reproducing (p. 9).
- Restoration of free flow would allow recolonization by fish such as darters that help disperse larval mussels, and ultimately enhance mussel populations (p. 11).

More recently, the USACE prepared an environmental assessment, which resulted in a recommendation for removal of the dam and restoration of free flow (USACE 2004). In this environmental assessment, USACE described several dam-related impacts and beneficial effects of removing the dam, which are summarized below:

- The dam has changed the river from a cool, free-flowing state to a slow-flowing and warmer condition with loss of riffle and shoal habitat types. Many native species declined in the pool created, and the altered habitat also caused an increase in rough fish (p. 25).
- Of the 71 species of freshwater mussels found in Green River, more than a third are considered rare, threatened, or endangered at the state or federal level, and the most significant factor is habitat loss caused by dams (p. 25). None of the six federally endangered mussels known from the park have been found in the pool behind Lock and Dam No. 6 (p. 27).
- Populations of the federally endangered Kentucky cave shrimp, which is found only in the Mammoth Cave area, have been affected by the impoundment of Green River behind Lock and Dam No. 6. Roaring River in Mammoth Cave is designated by the U.S. Fish and Wildlife Service as critical habitat for this imperiled endemic shrimp species, and normal flow in this cave stream is affected by the impoundment (p. 26).
- Removal of the dam would benefit the aquatic community overall: fish species that serve as hosts for larval mussels (glochidia) would recolonize restored habitat and enhance mussel reproduction, which is the key to de-listing for any endangered species (p. 52).
- Restoration of free flow would reduce sedimentation in Mammoth Cave's underground rivers, and this would restore habitat for the endangered Kentucky cave shrimp (p. 52).
- Removal of the dam would increase aeration of water in former pooled areas and therefore result in higher dissolved oxygen levels; stream water quality should improve when the stream reaches equilibrium after restoration of free flow (p. 47).
- For people using the river, restoration of free flow would not preclude operation of the ferries within the park (p. 42); canoe rental revenue could increase by $30,000 to $70,000, not counting all the other purchases made by canoeists (p. 41); and fishing for smallmouth bass would likely improve (p. 52).

Ecological effects

According to Cicerello and Hannan (1991), "The park freshwater fish fauna is perhaps the most diverse in the National Park System." Free-flowing conditions, which create riffle, run, and pool habitats, are what existed prior to impoundment, and are extremely important

for conservation of fishes. For example, darters and madtoms require the highly oxygenated conditions found in flowing streams (Cicerello and Hannan 1991:35). Loss of this habitat has put many species at risk; the crystal darter *(Crystallaria asprella)* was last collected in the park in 1929, but is now considered extirpated. Other species in decline with similar habitat requirements include the spotted darter *(Etheostoma maculatum),* Tippecanoe darter *(Etheostoma tippecanoe),* stargazing minnow *(Phenacobius uranops),* orangefin darter *(Etheostoma bellum),* which is endemic to Green River, and the mountain madtom *(Noturus eleutherus)* (Cicerello and Hannan 1991).

With documentation on 51 species of freshwater mussels, the Green River within Mammoth Cave National Park has one of the most diverse assemblages of these shellfish in North America (Cicerello and Hannan 1990:1). Both this diversity of mussels and their unfortunate decline are impressive. Just within park boundaries, 6 of the 51 species are listed as endangered by the U.S. Fish and Wildlife Service. One of these, known as the ringpink *(Obovaria retusa),* has declined to the point that it is now known only from Mammoth Cave National Park vicinity. The precarious position of mussels on the verge of extinction has compelled Mammoth Cave National Park and Tennessee Tech University to initiate a mussel restoration project, which will begin in 2005. The offspring produced through this project will be stocked into the Green River in an attempt to restore fragmented and dwindling populations of endangered mussel species (Surgenor 2005). Many more mussels are considered imperiled in the state of Kentucky (see Table 1).

Table 1. Mussels listed as endangered or as species of special concern by the U.S. Fish and Wildlife Service, plus additional species in decline identified by the Kentucky State Nature Preserves Commission. Species extirpated from Kentucky are marked with an asterisk.

Endangered mussels (U.S. Fish and Wildlife Service)
Cyprogenia stegaria (fanshell)
Epioblasma torulosa rangiana (northern riffleshell)
Obovaria retusa (ringpink or golfstick)
Pleurobema clava (clubshell)
Pleurobema plenum (rough pigtoe)
Hemistena lata (cracking pearlymussel)*
Endangered mussels (Kentucky State Nature Preserves Commission)
Cumberlandia monodonta (spectaclecase)
Lampsilis ovata (pocketbook)
Pleurobema pyramidatum (rubrum) (pyramid pigtoe)
Threatened mussels (Kentucky State Nature Preserves Commission)
Quadrula cylindrical cylindrical (rabbitsfoot)
Villosa ortmanni (Kentucky creekshell)
Special concern mussels (Kentucky State Nature Preserves Commission)
Epioblasma triquetra (snuffbox)
Plethobasus cyphyus (sheepnose)

It is well established that most mussel species require shoal or riffle habitat. Cicerello and Hannan (1990) found an overwhelming difference in diversity and abundance of mussels in the free-flowing and impounded sections of Green River within the park. Layzer (2002) found no (zero) mussels in deep pool habitats, but documented 26 species totaling 1,471 individuals from shoal habitats in the park. One reason for such stark differences is that shoals or riffles function as a unit or community. Fish such as darters that live in riffles serve a key role in the life cycle of mussels. After a female mussel's eggs are fertilized, they grow to a small larval stage called "glochidia" before being released. The glochidia must attach to the gills of certain host fish for a variable period of time (4 to 30 weeks or more) before they leave their host fish. The host fish both feed and disperse these tiny mussels, so without the host fish they cannot reproduce. Many of the host fish for mussels have not been identified, and this is an important reason to restore habitat for fish that live in riffles, even if they are not yet listed as endangered (Surgenor 2005).

In addition to mussels, many other species of invertebrates live in the gravels and sands of swift-water shoals. There are approximately 200 invertebrate species exclusive of the mussels known from Green River within Mammoth Cave National Park (Schuster et al. 1996), and these populations are also severely affected by the Lock and Dam No. 6 impoundment. Species richness, diversity, distributions, and proportions of functional feeding groups were affected by the change from fast to slow flow. One major secondary driver for these changes is the high degree of siltation in the slack-water reaches of the impounded zone. Bioassessment of Green River via many indices and metrics all had similar results. Water quality progressively declines from "good" to "fair" or "poor" in the free-flowing, transition, and impounded zone respectively according to the Ohio Invertebrate Community Index, which combines the results of many other indices (Schuster et al. 1996).

Biologically, the Mammoth Cave system is renowned for the diversity of species adapted to the rigors of life underground (Culver et al. 1999). Of the 130 regularly occurring species, the Kentucky cave shrimp is particularly special since it is found only in the Mammoth Cave area. It is also in danger of extinction and therefore was listed as endangered in 1983 (U.S. Fish and Wildlife Service 1988). Poulson (1992) determined that the loss of free-flow conditions has resulted in siltation of shrimp habitat, which has buried the sand and gravel substrates where shrimp feed, and also hinders downstream transport of organic matter. Long-term monitoring of Kentucky cave shrimp populations began in 1993 as part of an effort to develop an index of biological integrity for the aquatic cave ecosystem (Pearson and Jones 1998).

Conclusion

There are many reasons to remove the dam and preserve the lock at Brownsville. The U.S. Fish and Wildlife Service has concluded that habitat for seven endangered aquatic species will be restored. As well, conditions for many species in decline can be improved, and future listings prevented. The U.S. Army Corps of Engineers has agreed that such restoration is the best option for the needs of both wildlife and people, and that removal of the dam is the best way to save the lock from being undermined and destabilized.

Both ferries on Green River in the park will continue operations if the dam is removed,

and an engineered channel will allow operation during periods of low water. With restoration of free flow, the ability of river biota to clean water will be enhanced, and therefore water quality at the intake for the city of Brownsville will improve. Smallmouth bass fishing will improve, and populations of rough fish, such as carp and gar, will decrease. Recreational opportunities, particularly canoeing, will increase, with significant economic benefits for Edmonson County. With the dam removed and the lock stabilized, a county park could be developed. Here, the history of navigation on Green and Nolin rivers could be shared with the visiting public via interpretive signs and the *Miss Green River* tour boat.

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