NATURAL RESOURCES AND KARST ECOSYSTEMS

The Effects of Land-Use Change on an Ozark Cave System: A Paired Study of Civil War and Copperhead Caves

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Abstract

Much of the Ozark Plateaus is characterized by shallow mantled karst. In this setting, caves typically are hydraulically well-connected to the land surface and show a rapid response to the quantity and quality of water infiltrating through their recharge area. In a natural setting, this connection simply means the amount of water in the cave increases rapidly with rain events. However, in a developed setting, this connection may dramatically change the quantity and quality of recharge to the cave. Civil War Cave, located in northwestern Arkansas, is located in an area that is experiencing change from agricultural land use (mainly pasture) to urban land use. With no record of pre-development water quality, the effects of land use change on water quality could not be evaluated quantitatively. To better understand the impact of land-use change on cave water quality, a comparison was made between Civil War Cave and Copperhead Cave, a cave in the same region with similar geology and hydrology, but with no urban development and little human activity. Copperhead Cave is located within the boundaries of the Buffalo National River and is surrounded by undeveloped forest.

The geology of Civil War and Copperhead Caves is similar, with Civil War Cave being entirely in the Mississippian-age Boone Formation, and the part of Copperhead Cave considered in this study also being contained in the Boone Formation. The Boone Formation crops out across the entire recharge area of Civil War Cave (Glick, 1974). In the area of Copperhead Cave, the Boone Formation crops out (Hudson and Murray, 2003). The general hydrology is similar, with both caves recharged through the Boone Formation of the Springfield Plateau aquifer. In both caves, the ground –water recharge area is larger than the topographic recharge area. The topographic recharge areas are 0.18 square kilometers for Civil War Cave and 0.35 square kilometers for Copperhead Cave. Using a normalized base-flow method (Brahana, 1997), the ground-water recharge area was determined to be approximately 7.5 square kilometers for Civil War Cave and approximately 1.75 square kilometers for Copperhead Cave. In both cases, the regional flow is enhanced by fractures and karst features.

During recent (2005-2006) urban development in the vicinity of Civil War Cave, increased sedimentation was observed in Civil War Cave. The sedimentation is likely a result of surface excavation in the immediate recharge area and has decreased since the completion of excavation activities. Streamflow and dye-tracing data suggest the complex flow system recharging Civil War Cave may have been altered by recent development.

Water-quality data also suggest that Civil War Cave is affected by land use within the recharge area. Examination of water-quality data indicates both caves are recharged through the Springfield Plateau Aquifer. Because nitrate has low background concentrations and is enriched by human activity, it serves as an indicator of human impact (Adamski, 1997; Davis and Bell, 1998; Hem, 1985). Ground water from the Springfield Plateau aquifer in northwestern Arkansas commonly has nitrate concentrations exceeding 2 milligrams per liter as nitrogen in areas where the recharge is affected by human activity (Adamski, 1997), and generally has a nitrate concentration of 0.2 milligrams per liter as nitrogen or less (Steele, 1983) in unimpacted areas. Ground water nitrate concentrations indicate that Civil War Cave is impacted by human activity; with nitrate concentrations averaging 6.3 milligrams per liter as nitrogen in the upper level of Civil War Cave and 6.5 milligrams per liter as nitrogen in the lower level of Civil War Cave. Copperhead Cave is not impacted by human activity, with nitrate concentrations averaging less than 0.2 milligrams per liter nitrate as nitrogen.

The main threats to cave and karst communities include hydrologic threats, land development, nutrient stress, exotic or pest species, chemical pollution, human interaction, and isolation (Elliot, 2000). At Civil War Cave, human activity and urban development in the ground-water recharge area appears to have altered the hydrology, increased nutrient concentrations, and temporarily increased sedimentation within the cave system. The only impact observed in Copperhead Cave was the result of human interference within the cave.

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