THE NATURAL HISTORY OF MAQUOKETA CAVES STATE PARK JACKSON COUNTY, IOWA

edited by Raymond R. Anderson

Geological Society of Iowa

November 10, 2001

Guidebook 72

Cover photograph: Photograph of the Natural Bridge, Maquoketa Caves State Park.

NATURAL HISTORY OF MAQUOKETA CAVES STATE PARK, JACKSON COUNTY, IOWA

edited by:

Raymond R. Anderson
Iowa Dept. Natural Resources
Geological Survey Bureau
Iowa City, IA 52242-1319

with contributions by:

Raymond R. Anderson
Iowa Dept. Natural Resources
Geological Survey Bureau
Iowa City, IA 52242-1319

Joe Alan Artz
Office of the State Archaeologist
700 Clinton Street Building
Iowa City IA 52242-1030

Michael J. Bounk
Iowa Dept. Natural Resources
Geological Survey Bureau
Iowa City, IA 52242-1319

Wayne Buchholtz
Parks, Rec. & Preserves Division
Iowa Dept. Natural Resources
Des Moines, IA 50319

John Pearson
Parks, Rec. & Preserves Division
Iowa Dept. Natural Resources
Des Moines, IA 50319

Stephanie A. Tassier-Surine
Iowa Dept. Natural Resources
Geological Survey Bureau
Iowa City, IA 52242-1319

Brian J. Witzke
Iowa Dept. Natural Resources
Geological Survey Bureau
Iowa City, IA 52242-1319

November 10, 2001

Geological Society of Iowa
Guidebook 72

Additional Copies of this Guidebook or other GSI Guidebooks May be Ordered from the GSI Webpage at
http://www.igsb.uiowa.edu/gsi

TABLE OF CONTENTS

THE NATURAL HISTORY OF MAQUOKETA CAVES STATE PARK, JACKSON COUNTY, IOWA
AN INTRODUCTION TO THE FIELD TRIP

Raymond R. Anderson
Iowa Department of Natural Resources
Geological Survey Bureau
Iowa City, Iowa

Entrance to Dancehall Cave, Maquoketa Caves State Park

> *As you tread the winding trails of this wonderland of caves and arches of stone, it would not be at all surprising to suddenly come upon a mad hatter of Tweedle Dee and Tweedle Dum - - or Alice herself hiding behind a yew tree or a gnarled cedar.*

Maquoketa Caves State Park contains only 0.37 miles of surfaced roads, so to see the marvels of nature preserved in the 191.8 acres of the park, visitors must utilize the many, sometimes rugged trails. At the center of the park is a steep ravine with sheer cliffs ranging up to 75 feet. Within the ravine, a series of trails lead to 13 caves, a balanced rock, and a natural bridge. Trails lead around the top of these cliffs to overlooks that offer spectacular views of the valley. The flora and fauna at Maquoketa Caves is unexcelled in any of Iowa's State Parks at any season of the year. In the spring the whole area is carpeted with hepaticas. Summer sees wildflowers everywhere; fall brings out the bright orange of bittersweet that has been known to climb a tall white pine until it appears to be decorated for Christmas. Winter snows cover the evergreen and aspen with soft beauty, while gnarled cedars in clefts of rock on the cliffs appear as ghostly mountain climbers. This field trip will expose the participants to many aspects of the natural history of this beautiful and historic area, one of Iowa's earliest State Parks. Enjoy your visit.

THE QUATERNARY GEOLOGY OF MAQUOKETA CAVES STATE PARK

Stephanie A. Tassier-Surine
Iowa Department of Natural Resources
Geological Survey Bureau
Iowa City, IA 52242-1319

LANDFORM CHARACTERISTICS

According to the map of Prior (1991), Maquoketa Caves State Park in Jackson County falls within the Southern Iowa Drift Plain (Fig. 1), but this area is bordered very closely to the south and west by the Iowan Surface (Clinton County to the south and Jones County to the west) and by the Paleozoic Plateau to the north in Dubuque County. A thin strip of Iowan Surface is present in Jones, Cedar, and Clinton counties and separates the Southern Iowa Drift Plain in Jackson County from the other (and much larger) portion of this landform area in the southern part of Iowa. The Southern Iowa Drift Plain in the Maquoketa Caves area is described as "moderate loess cover over thin glacial drift" (Prior, 1991).

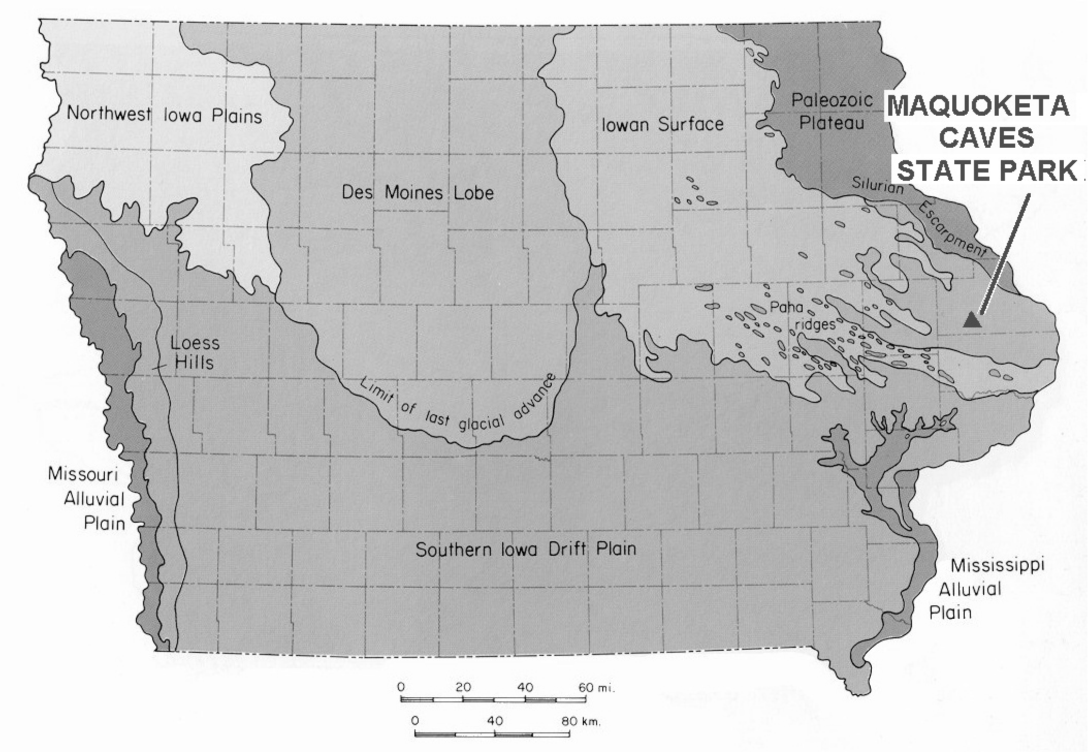


Figure 1. Map of Landforms of Iowa (Prior, 1991) showing location of Maquoketa Caves State Park in the Southern Iowa Drift Plain terrain.

Generally speaking, the Southern Iowa Drift Plain is characterized by a steeply rolling landscape, with the eastern part described as being dominated by tabular uplands (Prior, 1991; Anderson, 1998). In contrast with the Iowan Surface to the south and west, the Southern Iowa Drift Plain was not as severely eroded as the Iowan Surface during the Wisconsinan glacial episode. Both the surfaces of the Southern Iowa Drift Plain and the Iowan Erosion Surface are cut deeply into the Pre-Illinoian glacial drift and are overlain by various thicknesses of Wisconsinan loess. In the area near Maquoketa Caves State Park, the landscape displays more characteristics of the Paleozoic Plateau than elsewhere in the Southern Iowa Drift Plain, as the landscape is more rugged and the Maquoketa River is cut into bedrock (Anderson, 1998).

The Southern Iowa Drift Plain was last glaciated during the Pre-Illinoian (500,000 years ago), and subsequent erosion has eliminated the features typically associated with glacial landscapes (moraines, kames, kettle ponds, lakes, etc.). Alternating periods of rapid erosion and relative landscape stability (which allowed soil profiles to develop in the glacial materials) have shaped the surficial expression we see today. During landscape development a windblown mantle of loess and eolian sand was deposited at the surface. The depth of the loess ranges from 5 to 30 feet and is thickest near sources of windblown material and on broad, uneroded uplands where the most continuous deposition occurred. In the eastern portion of the Southern Iowa Drift Plain, the Peoria Loess comprises most of this mantle (the Peoria overlies the Pisgah and Loveland loess in the west).

QUATERNARY GEOLOGIC HISTORY OF THE AREA

The earliest descriptions of the surficial deposits in this area were conducted by Whitney (1858), McGee (1890), Leverett (1899), and Savage (1906). Later investigations focused on the Illinoian age glaciations which reached to within approximately 15 miles of the Maquoketa Caves area (to the east), and had great influence on the drainage and configuration of several rivers in this region of Iowa. Many were diverted or cut-off as the Mississippi River was blocked by the Illinoian ice front. The Maquoketa River followed the ice margin and joined with the Wapsipinicon River resulting in the Goose Lake Channel (see Bettis, 1987 and Anderson, 1998). The influence that the events of the Illinoian glaciation may have had on Maquoketa Caves and the local drainage configuration is unknown. Further discussion of the Goose Lake Channel and the developmental history of the Maquoketa River Valley can be found in Leverett (1899), Carman (1909), Swenson et al. (1941), Updegraff (1981), Bettis (1987), Hudak (1990), and Ludvigson et al. (1992).

Constraining the deposition of Quaternary materials into Maquoketa Caves and the developmental history of the caves is difficult. The most we can say about the age of cave development is that it began after the most recent glaciation to occur in this area (the Pre-Illinoian) which gives the cave development a maximum age of approximately 500,000 years ago. Neither of the more recent glaciations in Iowa (the Illinoian and the Wisconsinan) reached the Maquoketa Caves area, and therefore do not provide additional information regarding the timing of formation. Loess deposits within the park indicate changes in valley configuration through time and suggest a potentially long and complicated history of drainage formation.

QUATERNARY DEPOSITS

The dominant Quaternary materials within the park consist of loess, colluvial, and alluvial deposits. The loess thickness in this area of Iowa generally falls within the range of 5-10 m. However, the distribution and thickness of loess is extremely variable on the local scale. Brief reconnaissance within the park identified loess thicknesses ranging from <1m to >7m. These differences may occur within very close proximity (such as opposing sides of a slope). Variations over short distances may also suggest the presence of older drainage configurations for the Raccoon Creek. In most areas within the park, the loess lies directly on bedrock, but the presence of older soils (may be observed as a reddish-clay rich horizon) or till underlying the loess is possible.

Colluvial materials and alluvial deposits are present throughout the cave system and on valley floors, but detailed analysis has not been conducted on these materials. The deposits exhibit a wide range of characteristics depending on the mode of deposition. The thickness and stratigraphic relations of these deposits are also unknown, and are likely variable. The history of these materials is presumably complex, with geologic processes either depositing or eroding materials through time depending on conditions.

Information from drilling records in the vicinity of the park indicates the presence of Pre-Illinoian tills, although no exposures have been identified within the park. On the upland areas near Maquoketa Caves State Park, the typical stratigraphy consists of loess overlying Pre-Illinoian till on bedrock. The loess ranges in thickness from 0-20’. Areas with no loess cover typically have soil formed directly on top of bedrock. The maximum thickness of till noted in nearby logs is 45’, but may be thicker in some areas. The maximum thickness to bedrock as noted on drillers’ logs is 54’.

REFERENCES

Anderson, W.I., 1998. Iowa’s Geological Past- Three Billion Years of Change. University of Iowa Press, Iowa City, 424p.

Bettis, E.A., III, 1987. History of the Upper Mississippi Valley. Iowa Geology, 12, p. 12-15.

Carman, J.E., 1909. The Mississippi River between Savanna and Davenport. Illinois Geological Survey, Bulletin 13, 96p.

Leverett, F., 1899. The Illinois Glacial Lobe, U.S. Geological Survey, Monograph 38, 817p.

Hudak, C.M., 1990. Late Quaternary alluvial and eolian events along eastern Iowa tributary valleys to the Mississippi River. Geological Society of America, Abstracts with Programs, v. 22, p.14.

Ludvigson, G.A., Bettis, E.A., III, and Hudak, C.M., 1992. Quaternary drainage evolution of the Maquoketa River Valley. Geological Society of Iowa Guidebook 56, 45p.

McGee, W.J., 1890. Pleistocene History of Northeastern Iowa. U.S. Geological Survey, Eleventh Annual Report.

Prior, J.C., 1991. Landforms of Iowa. University of Iowa Press, Iowa City, 154p.

Savage, T.E., 1906. Geology of Jackson County, Iowa Geological Survey Annual Report 1905, v. 16, p. 561-648.

Swenson, G.A., Dean, H.C., Hays, D., Moine, D.F., and Tiggs, E.W., 1941. Soil Survey of Jackson County, Iowa. U.S. Department of Agriculture, Bureau of Plant Industry, Series 1936, No.6, 51p.

Updegraff, R.A., 1981. The Quaternary History of the Goose Lake Channel Area, Clinton and Jackson Counties, Iowa. MS thesis, University of Iowa, Iowa City, 155p.

Whitney, J.D., 1858. Report on the Geological Survey of the State of Iowa, Embracing the results of investigations made during portions of the years 1855, '56, and '57, Volume I, Part 1: Geology, 472p.

THE SILURIAN BEDROCK SEEN AT MAQUOKETA CAVES STATE PARK

Brian J. Witzke
Iowa Department of Natural Resources
Geological Survey Bureau

SEDIMENT ON THE SILURIAN SEA BOTTOM

Steep exposures of bedrock strata are spectacularly displayed within Maquoketa Caves State Park, within a deeply dissected landscape expressing 200 feet of total vertical relief (elevation 700 feet where the Raccoon Creek crosses the south park boundary, elevation 900 feet along the north upland ridge). The rocks initially formed as deposits of ***lime sediment*** on the bottom of an extensive shallow ***tropical sea*** that covered large areas of the North American continental interior during the early part of the ***Silurian Period*** about ***430 million years ago***. This region, which would one day be known as eastern Iowa, lay in the southern tropics of the Silurian world. A variety of creatures inhabited this warm tropical sea, and their remains can be seen as fossils in the Silurian strata of the park and elsewhere in eastern Iowa.

The sediments on the Silurian sea bottom originally accumulated as a mixture of lime mud and the dead shells and skeletons of various bottom-dwelling animals. Biologically-mediated precipitation of lime sediment from sea water, which formed the shells and mineral precipitates, occurred directly on the sea bottom (and possibly included local inorganic precipitation as well), and these sediments were precipitated and deposited largely in-place on the sea bottom. Bottom currents, especially those generated during tropical storms, episodically transported some of the lime sediments, sorting the sediment grains and sometimes breaking or disarticulating the shells. These lime sediments were remarkably pure, composed almost exclusively of calcium carbonate ($CaCO_3$) with minor quantities of biogenic silica (biologically-precipitated SiO_2). Shorelines lay hundreds of miles north of east-central Iowa, and the influx of terrigenous sediment (clay, quartz) to the shallow seas was almost non-existent across the region. The Silurian strata exposed in the park were deposited at a time when the interior seaway reached its maximum water depths, and shorelines were at their maximum distances from eastern Iowa. The chemical purity of the carbonate rocks in the park attests to the low influx of other kinds of sediments to the region at that time.

THE ROCKS

Today, we see the evidence of these ancient lime sediments expressed as a lithified and chemically-modified rock. The thick layered stack of rock strata seen at Maquoketa Caves is now composed almost entirely of the mineral known as ***dolomite***. Dolomite is a calcium and magnesium carbonate mineral, $CaMg(CO_3)_2$. The original calcium carbonate sediments ($CaCO_3$) were replaced by dolomite through the addition of magnesium ions and the removal of half of the calcium ions by dolomitizing aqueous solutions. Dolomitization of the Silurian lime sediments was pervasive across most of eastern Iowa, likely occurring when mixed-marine groundwaters accompanied the withdrawal of the seas across the region during the later stages of the Silurian.

Dolomitization significantly modified the original lime sediments in a number of important ways. First, the sediments became recrystallized by a mosaic of dolomite crystals. These dolomite crystals vary greatly in size, ranging from microscopic extremely-finely crystalline fabrics to coarsely re-crystallized textures visible to the naked eye (single dolomite crystals which replace crinoid grains reach sizes up to about 3 mm in the park). Second, an overall increase in macroscopic porosity accompanied dolomitization, evident by the solution of fossils and skeletal grains now seen as hollow molds. ***Fossil molds***, especially small skeletal grains from crinoids (sea lilies), are especially common in the strata in the park. In addition, some of the larger non-descript hollow voids known as ***vugs*** (most greater than 1 or 2 inches in diameter) apparently formed coincident with dolomitization. However, many vugs probably are later solutional features created during more recent phases of weathering and cave development. Third, some fossils were replaced by ***silica*** (SiO_2) during the early phases of dolomitization. Silicified fossil corals and stromatoporoids are relatively common in strata assigned to the Hopkinton Formation in the park. Elsewhere in eastern Iowa, and buried beneath the park in underlying Silurian strata (about 100 ft below the main cave), more pervasive silicification resulted in the formation of chert nodules within the Silurian dolomite strata. Chert is essentially absent from the exposed succession of strata seen in the park, but laterally-equivalent strata to the west in Jones County are locally prominently cherty.

A long history of burial and erosion followed the deposition and dolomitization of the Silurian strata in eastern Iowa. However, this complex history is not portrayed at Maquoketa Caves, but is evident elsewhere in Iowa where younger strata are found. In general, long periods of deposition within shallow seas were succeeded by long episodes of erosion following the withdrawal of those seas from the continental interior. This pattern of deposition and erosion was repeated many times during the Paleozoic Era in Iowa. Ancient deposits from Cambrian and Ordovician seas occur beneath the park, as identified in water wells drilled in the area. The Silurian rocks at Maquoketa Caves were undoubtedly buried beneath Devonian, Mississippian, and Pennsylvanian aged strata at one time, but these younger strata were eroded away during the long period of post-Pennsylvanian erosion. Although not yet identified in the park, Pennsylvanian-aged shales and sandstones locally infill eroded channels and karst systems in the Silurian bedrock in nearby areas of Jackson County.

A more recent erosional history created the dramatic landscape that we see today at Maquoketa Caves, as discussed elsewhere in this guidebook. As with limestone, dolomite is susceptible to dissolution by weakly acidic rain and ground waters resulting in a degradational process known as ***karst***. Such karst processes dissolved a network of caves into the Silurian bedrock, probably coincident with the downcutting of the nearby Maquoketa River Valley during the Pleistocene (the last million years or so). As erosion and dissolution continued, portions of the main cave system progressively collapsed, creating the steep valley walls along Raccoon Creek as well as the sinkholes and natural bridge seen in the park. Smaller-scale dissolution of the dolomite bedrock has accompanied these changes, creating a variety of irregular pits, vugs, enlarged fractures, and mini-caves evident in the park.

The origin of large calcite-filled vugs and voids (up to 35 cm in diameter, with large crystals of ***calcite*** spar) observed in the lower strata along Raccoon Creek is not known with certainty. These calcite fills may have formed during early stages of phreatic cave development in the valley, but this is speculative. Calcite precipitation is also known to have accompanied Late Paleozoic mineralization events in the region (often associated with sulfide minerals). Iron oxide rims around some of the calcite void fills in the park suggest former association of pyrite with the calcite, now oxidized. Large deposits of oxidized iron sulfide minerals, associated with calcite, are hosted within the Silurian dolomite strata elsewhere in Jackson County.

The valley of Raccoon Creek in the park exposes Silurian bedrock strata in excess of 130 feet (40 m) thick. Geologists give names to the various intervals of contiguous and correlatable strata in a region, and the strata exposed at Maquoketa Caves span portions of two different formations: the upper part of the ***Hopkinton Formation*** (seen in the lower reaches of the valley walls downstream from Dancehall Cave) and the lower to middle parts of the overlying ***Scotch Grove Formation***. These upper Hopkinton strata belong to the ***Picture Rock Member***, and the Scotch Grove strata comprise the ***Welton Member***. These stratigraphic units are discussed more fully later.

THE FOSSILS

The Silurian dolomites seen at Maquoketa Caves State Park contain a variety of fossils, but careful looking is required for most visitors in order to begin to recognize the distinctive shapes of the fossil forms. Most fossils are seen as molds -- the original shell material has been dissolved during dolomitization leaving an external (and sometimes internal) mold. Some fossils preserve the original shell forms by dolomite crystal replacement. Dolomite replacement is most common for crinoid

columnals. Some fossils in the park's lower strata are silicified, especially certain corals and stromatoporoids.

The fossils seen at Maquoketa Caves are identified as the molds of shells and skeletons of creatures that inhabited the warm tropical Silurian seas. Although the species and families of animals that inhabited these seas are now long extinct, many of them have living counterparts in the modern oceans. Fossils identified in the rocks within the park include the following forms: crinoids (sea lilies), corals, sponges (stromatoporoids), bryozoans, brachiopods, snails (gastropods), clams (bivalves), nautiloids, and trilobites.

Crinoids are animals that superficially resemble plants, with a flower-like head on a long stem. Modern stemmed crinoids are known as sea lilies, but these creatures are actually animals belonging within the Phylum Echinodermata (which also includes starfish and sea urchins). The crinoid animal was protected in life by an array of calcite plates and ossicles – the rigid head was composed of a geometric pattern of plates, the arms formed by a series of small calcite ossicles, and the stems composed of a stack of circular poker-chip-like columnals. On the death of the animal, however, the integument that held these plates together decayed, and the calcite skeleton readily disarticulated into a mass of calcite plates and columnals. Therefore, most of the crinoid fossil material is now represented by small molds of plates and circular columnals, most less than 3 mm in diameter. These small molds form the dominant fossil seen throughout most of the thick pile of Scotch Grove Formation seen in the park. Densely packed accumulations of small crinoid plates and columnals are locally seen as thin coarsely-crystallized stringers (generally less than 2 inches thick). These stringers are common in Hopkinton strata in the park, and they are also seen in parts of the overlying Scotch Grove Formation (locally prominent). Some partially-articulated crinoid fossil material is occasionally identified in fossiliferous stringers in the Scotch Grove Formation in the park, including stem segments (up to several inches long) and articulated crinoid cups (heads). Identifiable crinoid cups are most common in and around Twin Arch Cave, where specimens of the common Silurian crinoids *Eucalyptocrinites* and *Marsupiocrinus* have been identified. Correlative strata in southern Dubuque County have yielded diverse crinoid faunas with over twenty species recognized. Similar diverse crinoid faunas undoubtedly occur in the park, but large volumes of rock need to be mechanically broken to recover these fossils (thereby precluding making similar crinoid collections within the park in order to preserve the natural beauty).

Fossil ***corals*** are common in strata of the Hopkinton Formation in the park, and these are among the easiest fossils to see because of their relatively large size and distinctive forms. The coral-rich strata of the Hopkinton Formation contain a recurring association of fossils that Witzke and Johnson (1999) termed the "tabulate coral-lamellar stromatoporoid community." The coral fossils belong to two different groups of extinct corals. The ***Tabulate Corals*** are colonial corals whose individual corallites (the cell in which an individual coral animal lived) are subdivided by flat partitions (called tabulae). Several different kinds of tabulate corals are seen in the park, including the distinctive "honeycomb coral" (*Favosites*), the "chain coral" (*Halysites*), and the "tube coral" (*Syringopora*). Most tabulate corals are about 2 to 4 inches (5-10 cm) in diameter, but specimens of *Favosites* and *Syringopora* up to 10 inches (25 cm) wide are noted in the park.

The ***Rugose Corals*** include both solitary and colonial forms characterized by corallites subdivided by both horizontal and vertical partitions; the vertical partitions typically display a radiating pattern within each corallite. Solitary rugose corals commonly show a cup- or horn-shaped form, and, as such, these are commonly known as cup corals and horn corals. Most horn corals are relatively small (zaphrentids typically ½ to 1 inch in diameter), but some larger forms are sometimes seen (cystiphyllids recognized in park; diameters to 2 inches, lengths to 7 inches; 5 x 18 cm). Colonial rugose corals are relatively rare but reach larger sizes (up to 6 inches, 15 cm). The commonest colonial rugosan is *Arachnophyllum* with large hexagonal corallites, and additional forms are seen locally (fasciolate morphologies).

Corals are much less common in the overlying strata of the Scotch Grove Formation, but a few small corals have been identified in the park. The middle and upper intervals of exposed strata in the park locally contain small specimens of favositid tabulate corals (ranging in size from ½ to 3inches; 1.5-8 cm), small *Halysites* (to 3 inches, 7 cm), and horn corals (cystiphyllids up to 1½ inch diameter; 4 cm). Upper beds have revealed distinctive small button-shaped cup corals (*Porpites*). The basal beds of the formation locally contain scattered small *Halysites* (< 2 inches; 5 cm) and cup corals.

Pancake-shaped fossils preserving a finely laminated skeleton are commonly associated with the coral faunas of the Hopkinton Formation. These fossils belong to a group of creatures known as ***stromatoporoids***. Stromatoporoids are extremely common fossils in Silurian and Devonian strata of Iowa, although the biological affinities of stromatoporoids is not known with certainty. They most likely are a group of sponges with rigid well-calcified skeletons. Stromatoporoids are seen in the park as flattened disc-shaped molds and silicified lamellar forms generally less than 6 inches (15 cm) in diameter. However, specimens up to 20 inches (50 cm) in diameter are recognized in Hopkinton strata in the park. Stromatoporoids are generally absent in overlying Scotch Grove strata in the park, but a single large mold (8 inches, 20 cm) was recognized south of Twin Arch.

Bryozoans are relatively small colonial animals whose fossils in the park include small stick- and fan-like forms (most ¼ to 1 inch; 0.5-2.5 cm). Molds of bryozoan fossils are usually difficult to discern because of their small and delicate forms, but two general types of bryozoans are seen in the crinoidal dolomites of the Scotch Grove Formation. Small flattened twig-like forms (cystodictyonids) and lacey fan-like forms (fenestellids) are recognized.

Shell molds of ***brachiopods*** are a distinctive fossil form seen in the park, although they are not particularly noteworthy in most strata. Brachiopods have two hinged shells (valves) that superficially resemble clam shells, but brachiopods are a distinct and separate group completely unrelated to clams (brachiopods have unequal valves). The most distinctive and largest brachiopods in the park are seen scattered along several horizons within the Hopkinton Formation, and these belong to a widespread Early Silurian species, *Pentamerus oblongus*. Molds of these brachiopods superficially resemble deer hooves, characterized by a cloven appearance in the beak area of one of the valves. *Pentamerus* is the largest brachiopod seen in the park, reaching lengths to 2½ inches (6 cm). They occur in small clumped groupings (especially in unit 3), and some specimens are preserved in "life position" (oriented with the beak down as in life). The specimens seen at Maquoketa Caves State Park are the highest known stratigraphic occurrences of the *Pentamerus* yet identified in the Iowa Silurian succession. Previously known only from the basal Picture Rock Member and lower strata within the Hopkinton Formation, *Pentamerus* occurs in middle and upper parts of the Picture Rock member in the park.

Additional brachiopod fossils are also identified in the park. Small ribbed shells (*Dolerorthis*) have been recognized in coral-rich Hopkinton strata. Overlying strata of the Scotch Grove Formation are known to contain diverse assemblages of brachiopods in eastern Iowa (Witzke and Johnson, 1999), but these are often difficult to discern or identify in the natural exposures of the park. Nevertheless, a number of brachiopods have been identified in Scotch Grove strata in the park, especially in the area of Wide Mouth and Twin Arch caves. Identified forms include *Atrypa*, *Hedeina*, gypidulids, orthids, *Leptaena*, *Ferganella*, and *Rhynchotreta*.

Distinctive mollusk fossils (Phylum Mollusca) recognized in Scotch Grove strata in the park include snails (***gastropods***), clams (***bivalves***), and ***nautiloids***, but none of these are particularly abundant. The few snail molds include scattered small low-spired forms (< 1 inch; 2.5 cm), and a single large planispiral *Tremanotus* (with a 2-inch, 5-cm aperture) was recognized near Twin Arch Cave. A single specimen of a fossil clam mold (*Plethomytilus*) was seen in the same area.

Among the largest and most distinctive fossils seen in the park are molds of ***nautiloid cephalopods*** (Fig. 2). These occur scattered throughout the Scotch Grove Formation, but they are most easily seen in the cliff face immediately south of Twin Arch Cave. Some of the nautiloids are found in localized

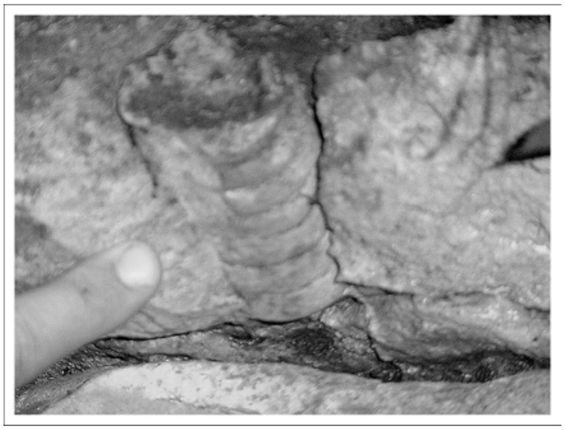


Figure 2. Nautiloid in the Scotch Grove Fm.

concentrations, with ten to twenty nautiloids visible within an area of only several square feet (1 x 0.4 m). Nautiloids are ancient relatives of the chambered nautilus, a modern shelled cephalopod (cephalopods also include unshelled squid and octopus). Nautiloid shells are subdivided into a series of chambers interconnected by a long tube (siphuncle). In life the chambers can alternatively be filled with gas or fluid to regulate buoyancy. The soft body occupied a living chamber nearer the aperture of the shell. In the modern nautilus, a tentacled head with eyes protrudes from the shell, and locomotion is achieved by water jetting (similar to squids). Most of the fossil nautiloids seen in the park were probably predators and scavengers when alive within the Silurian seas, plying the waters in search of food. Unlike the modern coiled nautilus, all nautiloids identified in the park possessed straight to slightly curved elongate shells. Many nautiloid molds resemble tapered tubes or cones subdivided internally by numerous partitions (sutures); the siphuncle is centrally located in most forms. Nautiloid molds with cross-sectional diameters of up to 3 ½ inches (9 cm) are recognized in the park; complete shells of this diameter likely reach lengths of 3 feet (1 m) or more. However, most specimens are considerably smaller, generally with diameters of ¾ to 2 inches (2-5 cm). Several different straight- and curve-shelled nautiloids have been identified in the rocks and cliff faces of Maquoketa Caves State Park including *Michelinoceras*, *Phragmoceras*, and *Kionoceras*.

Many additional fossils have been recognized in strata of the Hopkinton and Scotch Grove formations across eastern Iowa, and given a diligent search, many of these likely can also be recognized in the park. A variety of trilobites, an extinct grouped of multi-legged arthropods, are known in the region, but only a single possible trilobite fragment was seen by this author in the park (probably a smooth illaenid like *Bumastus*). The reader is referred to a summary of the fossil faunas in the Silurian of eastern Iowa by Witzke and Johnson (1999).

THE HOPKINTON FORMATION

Only the uppermost portion (about 25 ft thick) of the Hopkinton Formation is exposed in the park, extending from Dancehall Cave downstream along the lower valley walls of Raccoon Creek. The base of the formation lies about 100 feet lower, in the subsurface below. The formation has been subdivided into four members (Witzke, 1992), but only the uppermost member, the Picture Rock Member, is exposed at the park. Previous identification of strata of the underlying "Cyclocrinites beds" (Farmers Creek Member) in Dancehall Cave is probably incorrect (see Anderson, ed., 1978, p. 39).

The Hopkinton Formation is named after exposures farther up the Maquoketa River Valley near the town of Hopkinton in Jones County (Calvin, 1906). Bold cliffs of Hopkinton dolomite are dramatically exposed along segments of this valley in Jones and Jackson Counties. The type locality of the Picture Rock Member is found in the bluffs along the Maquoketa River at Picture Rock County Park (Johnson, 1983). Numerous cave systems are formed within Hopkinton strata in eastern Iowa, especially in the middle part of the formation. The formation averages about 130 feet (40 m) thick in east-central Iowa, and it is widely exposed in quarries and natural outcrops in the region.

Strata of the Picture Rock Member show irregular and discontinuous bedding breaks, and the member is commonly exposed as a thick-bedded to massive cliff-forming interval. It contains an abundant and conspicuous fauna of corals and stromatoporoids, silicified in part (the "Tabulate Coral-Lamellar Stromatoporoid Community" of Witzke and Johnson, 1999). Local accumulations of *Pentamerus* brachiopod shells have previously been noted only in the basal part of the member in eastern Iowa (Witzke, 1992). The recent identification of scattered *Pentamerus* molds at Maquoketa Caves State Park is the first record of *Pentamerus* in Iowa occurring at higher stratigraphic positions within the Picture Rock Member. Even though this author has been studying the Silurian stratigraphy of Iowa for over twenty-five years, the moral of this recent identification is that there still must be many stratigraphic and paleontologic discoveries remaining to be uncovered in the region, even in such well-visited areas as Maquoketa Caves.

THE SCOTCH GROVE FORMATION

The Picture Rock Member is sharply overlain by dolomite strata of the Scotch Grove Formation in eastern Iowa. Scotch Grove strata (Fig. 3) reach thicknesses to about 100 feet (30 m) in the bedrock exposure at Maquoketa Caves State Park, but the upper part of the formation is erosionally absent across the park. The Scotch Grove Formation, where capped by younger Silurian strata elsewhere in eastern Iowa, is known to reach thicknesses to 240 feet (73 m), and thicknesses to 300 feet (90 m) are likely within Jackson County (Witzke, 1992, p. 26). Therefore, only the lower half to one-third of the formation occurs within Maquoketa Caves State Park. The entire succession of Scotch Grove strata in the park is assigned to the Welton Member, which forms the dominant crinoid-moldic dolomite facies of formation in the eastern Silurian outcrop of eastern Iowa (Jackson, Clinton, Dubuque counties). Farther to the west, the formation is dominated by less fossiliferous very cherty strata (Buck Creek Quarry Member).

Figure 3. Scotch Grove Fm in a bluff exposure

Strata of the Scotch Grove Formation were variously confused with parts of the Hopkinton and/or Gower formations by previous geologists, and the formation wasn’t formally named until 1985 (Witzke, 1985, p. 26). Its name derives from Scotch Grove Township in Jones County. The Welton Member was named by Johnson (1983) for a thick interval of fossiliferous porous dolomite above the Picture Rock Member of the Hopkinton Formation. The typical locality is in the quarry south of Welton, Clinton County.

At many localities in eastern Iowa, a distinctive but generally thin interval of dense, sparsely fossiliferous dolomite (that is locally brachiopod-rich or mounded into reef-like accumulations) occupies a stratigraphic position at the base of the Scotch Grove Formation, and this interval has been named the Johns Creek Quarry Member (Johnson, 1983). This interval is typically gradational with overlying strata of the Welton Member. However, the basal Scotch Grove

Johns Creek interval locally is not identifiable in parts of Jackson County, including Maquoketa Caves, where fossiliferous Welton strata apparently extend to the base of the formation. Nevertheless, some dense sparsely fossiliferous dolomite is seen at the base of the formation in the park, probably a remnant of typical Johns Creek lithology. In addition, the irregular to mounded bedding which is locally developed in the lower to middle Welton interval in the park bears strong resemblance to the remarkable mounded facies of the Johns Creek Quarry Member seen at other localities in eastern Iowa (see Witzke, 1992). Therefore, it seems likely that the interval of the Johns Creek Quarry Member in places like Maquoketa Caves is merely replaced laterally by rocks in the basal Scotch Grove Formation that are indistinguishable from the Welton Member. The apparent absence of the Johns Creek facies probably is not due to any sort of erosional or structural complexity.

The lower portions of the Welton Member contain the most diverse fossil faunas known from the entire Silurian of eastern Iowa (Witzke and Johnson, 1999). These strata were deposited during a major deepening event that marked the maximum seaway flooding of North America during the Silurian (which occurred late in the Llandovery Stage). As the seaway deepened, the ancient environments of Welton deposition showed decreasing bottom current activity, and depths ultimately approached the maximum limits of storm current activity on the sea bottom. Lime mud and shells that accumulated in these deepening environments were occasionally disrupted by currents generated during large tropicial storms.

Several kinds of sedimentary features displayed in Welton strata at Maquoketa Caves provide evidence for episodic bottom current activity during deposition (best displayed in the areas of Widemouth and Twin Arch caves): 1) locally dipping and cross-stratified beds; 2) development of graded bedding; 3) preservation of articulated crinoids; and 4) coral-stromatoporoid growth forms. Although Welton strata are more-or-less horizontally bedded in most of the park, many exposures locally show low-angle dips (generally less than 10º). As discussed later, some of these dips may relate to the incipient development of carbonate mounding. However, certain low-angle dipping units internally show cross-stratified features including wedge-shaped bedforms. Best seen on the west side of the entrance to Wide Mouth Cave, beds up to 30 to 35 inches (75 to 90 cm) thick locally show cross-stratification composed internally of thin graded units. Dips are generally low (< 10º) but locally reach 15 to 20º. Wedge-shaped geometries within these cross-stratified units may be locally present. Graded bedding is well displayed in places, and is locally recognized in both horizontally-bedded strata as well as in low-angle cross-bedded units. Graded beds show a gradation in grain size from bottom to top, and in Welton strata grading is indicated by changes in the size and abundance of fossil grains, especially the crinoid debris. Individual graded units show the coarsest and most concentrated fossil grains at their base, and fossil size and abundance decrease upward. Most of the larger fossils identified in the Welton Member within the park are seen in the basal parts of these graded units, including articulated crinoid stems and cups and brachiopod shells. Graded units seen at Wide Mouth and Twin Arch caves vary between about 1 and 8 inches (2-20 cm) in thickness. Sediment grading provides good evidence for episodic bottom current activity during deposition, whereby the lime mud and grains were winnowed, transported, and re-deposited during a single event (probably a storm). The coarsest grains remained as a lag, or were the first to settle out from the suspended sediment load.

As discussed earlier, crinoids (as with most echinoderms) readily and rapidly disarticulate into individual calcite grains shortly after death. As such, the preservation of articulated crinoid cups and stem segments requires rapid burial. Occurrences of articulated crinoid material in the Welton Member in the park and elsewhere in eastern Iowa provide further evidence of burial events triggered by episodic bottom current activity. Further evidence of rapid burial events is provided by a single stromatoporoid specimen to the south of Twin Arch Cave; this specimen shows a bulbous skeleton in life position (20 x 6 cm) with a second growth phase (10 x 8 cm) that originates from the apex of the underlying colony and grows outward onto the sediment that buried most of the underlying skeleton. In other words, about 6 cm of mud quickly buried the stromatoporoid killing most of the colony. The highest portion of the colony, however, remained unburied and that small portion survived to begin a second growth phase. Similar coral and stromatoporoid growth forms were documented in the Scotch Grove Formation at Palisades-Kepler State Park by Philcox (1971), and these were interpreted to provide evidence of episodic sedimentation and burial events. A small coral colony near Twin Arch Cave is tipped on its side (90º from life position), also likely a result of episodic bottom current activity. Finally, the segregation and concentration of nautiloids seen in "pockets" near Twin Arch, as noted previously, likely involved transportation by bottom current.

Most bedrock strata in Iowa are, at least in a general sense, horizontally bedded. In reality, however, extremely low-angle regional structural tilting imparts almost imperceptible dips to these strata, which across most of the state commonly range between about 1º and 3º. Nevertheless, clearly perceptible higher-angle dips are locally observed, but these are so exceptional across Iowa that any stratal dip exceeding 10º is generally anomalous and requires explanation. Several areas within Maquoketa Caves State Park display broadly-rolling strata that locally display beds dipping at angles of 5 to 10º. Higher-angle dips sometimes indicate proximity to high-angle fault systems or flexures, but, in the Silurian strata of Iowa and other areas of the Midwest, additional causes of inclined bedding are also known.

As seen at Palisades-Kepler State Park and many other Midwestern localities, the Scotch Grove Formation and correlative strata to the east contain *in situ* mound-like accumulations of carbonate sediments that are commonly called "carbonate mounds" or "reefs." These mounded features grew upward in the seaway because of increased but localized accumulation and cementation of carbonate mud and skeletal material on the sea bottom, and the growth of these mounds was influenced, if not controlled, by biological processes in a very direct sense. As shallow-water loci in an otherwise deeper-water seaway, the mounded reef-like accumulations served as favorable sites for bottom-dwelling organisms in the shallower surface waters. The shallower environments across the mound crest received more sunlight and better water aeration enabling increasing numbers of organisms, both plant and animal, to flourish. Carbonate-precipitating organisms, both plant and animal, left behind growing masses of carbonate sediment which expanded with each generation of life and death. The carbonate mounds became self-perpetuating and ever-enlarging features during a considerable portion of upper Scotch Grove deposition, and coalesced complexes of mounds formed localized masses of carbonate sediment up to 1 or 2 miles in horizontal extent and up to 200 feet vertically (equivalent inter-mound strata are only about one-fifth as thick). These features formed elevated reef-like masses on the sea floor, and the carbonate strata that comprise them thereby display strata at a variety of dips, with the steepest angles (10 to 40º) usually flanking the margins of the mound.

Although not containing mounded features as large as those identified in the upper Scotch Grove Formation, the lower portions of the formation also are known to contain a number of carbonate mounds in eastern Iowa. These lower Scotch Grove mounds are generally assigned to the Johns Creek Quarry Member, but they merge upward and laterally with strata of the Welton Member. The largest of these lower mounds in nearby Jones County is known to reach widths of 500 feet (150 m), heights of 50 feet (15 m), and dips up to 30º (see Witzke, 1992). Even though Maquoketa Caves exposes correlative portions of the lower Scotch Grove Formation, mounds of such a scale are not seen in the park. Nevertheless, the anomalous bedding (5-10º) seen at this stratigraphic position in the park invites comparison with mounded features elsewhere in the lower Scotch Grove. Perhaps the dipping Scotch Grove strata in the park relate to early or incipient stages of carbonate mound growth in the region, and these strata might provide insights into the origin and development of these curious features.

Several observations at Maquoketa Caves State Park are consistent with interpreting localized developments of low-lying incipient carbonate mounds within the Scotch Grove Formation, especially in the areas of the Natural Bridge, Match Cave, Widemouth Cave, and Twin Arch Cave. Beginning underneath the Natural Bridge and continuing a short distance upstream, inclined (up to 10º) lower Scotch Grove strata are observed to dip southward, then abruptly reverse and dip northward. The resultant bedforms display a low-lying asymmetrical mound-like feature about 60 feet (18 m) across and about 6 feet (2 m) high. Westward dips to 10º are recognized near Match Cave. Gently rolling (locally dipping to 10º) strata are seen throughout the upper reaches of the Raccoon Creek Valley above the Natural Bridge, but discrete mound-like bedforms have proven difficult to identify. By contrast, Scotch Grove strata exposed downstream from Dancehall Cave do not seem to show similarly dipping features, and a horizontally-bedded aspect predominates there.

Large mounds in the Scotch Grove Formation, like those seen at Palisades-Kepler State Park, show certain sedimentary features that apparently are unique to carbonate mound facies in the region, and are not seen in the inter-mound regions. Such features include the presence of wedge-shaped graded beds, nautiloid "pockets," large bulbous stromatoporoids, and relict botryoidal submarine cements (see summaries in Witzke, 1992, 1999). Although not restricted to mounds, graded beds are also considerably more common in mound facies than in the inter-mound strata. Suffice it to say that all of these sedimentary features have been observed along the cliff faces in the area of Twin Arch and Wide Mouth caves at Maquoketa Caves State Park. These sedimentary features provide further evidence for the localized presence of small-scale carbonate mounds within the lower Scotch Grove Formation. These mound-like features are contained within strata of the Welton Member, probably occurring at a somewhat higher stratigraphic position than the prominent Johns Creek Quarry mounds of the basal Scotch Grove. It is proposed that carbonate mound growth likely diminished gradually upward during deposition of the lower Scotch Grove Formation (possibly related to relatively rapid sea-level rise; see Witzke, 1992). A later stage of more dramatic carbonate mound growth was to follow, coincident with deposition of upper Scotch Grove strata. Evidence of this later stage has been eroded from the area of Maquoketa Caves.

THE FIELD TRIP

The field trip will examine Silurian dolomite bedrock strata at a number of sites within Maquoketa Caves State Park (Figs. 4, 5). Trip participants are encouraged to get down and get close to the rock surfaces to observe the rock fabrics and fossil content of the bedrock in the park. However, ***collecting and hammering are not allowed in the park*** in order to help preserve all of its geologic features intact.

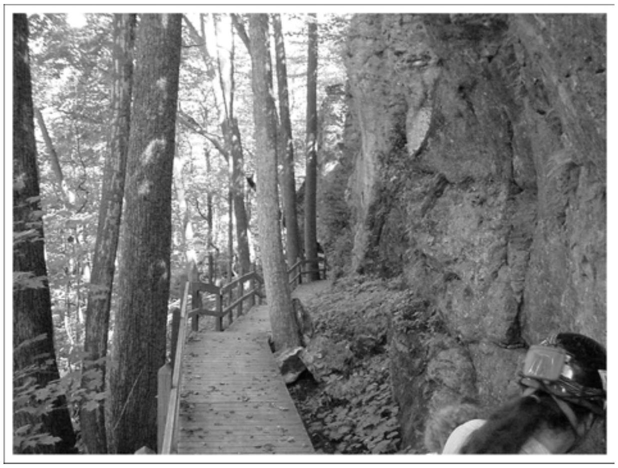


Figure 4. Trail upstream from Dance Hall Cave.

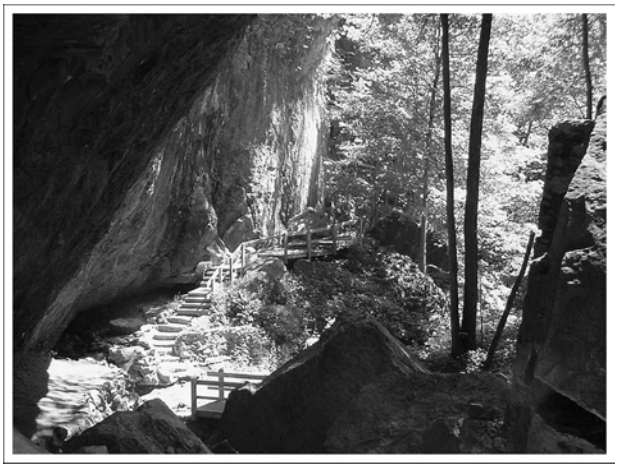


Figure 5. Trail downstream from Dance Hall Cave.

Various features of the dolomite bedrock can be examined as we walk through the park. However, the rock is difficult to clearly see in places, being obscured by more recent speleothem growth, solutional pitting, or vegetative coverings (especially mosses and liverworts). We will look for features of varying scale that reflect the solution of the dolomite both in the caves and along the valley walls of Raccoon Creek. The dissolution of the bedrock has created networks of open space within the rock, ranging from small vugs and pits up to large-scale caves and sinkholes.

Other features of the bedrock that we should look at include the style and thickness of bedding surfaces, and the crystalline fabrics of the dolomite (which range from microscopic extremely-fine crystalline to coarse crystalline rocks). Look for mineral fillings of coarsely crystalline calcite (spar) within certain vugs and void spaces. We will also look for fossils contained in the dolomite bedrock. Most fossils are seen as hollow molds (of crinoid debris, brachiopods, corals), but some fossils are replaced by silica or dolomite crystals.

The trip will look at strata of the Hopkinton Formation proceeding downstream from the lower entrance to Dancehall Cave. The best Hopkinton exposure is seen a short distance off trail past the stream crossing southwest of Shinbone Cave. A spectacularly exposed cliff face is easily accessible here, and numerous fossils can be identified. Beautiful molds and silicified skeletons of tabulate corals are conspicuous, and characteristic forms include *Favosites, Halysites, Syringopora, Arachnophyllum,* and others. A few horizons show large molds of pentamerid brachiopods, *Pentamerus oblongus*. A few *Pentamerus* shells are seen in life position. A supplemental trailside exposure allows easy access to the contact between the Hopkinton and Scotch Grove formations, where it is seen immediately below a prominent overhang.

We will look at the relatively monotonous section of Scotch Grove Formation that is exposed along the trail and stairway that leads past Balanced Rock (west of lower Dancehall Cave entrance – Fig. 6). Look closely for the common to abundant small void spaces (most less than 3 mm) in these rocks; most of these represent molds of small crinoid debris. Observe the change in bedding style within the succession, from more massive cliff-forming strata below, to a slightly more bedded style above.

Our field trip examination of Scotch Grove strata will continue on the upstream side of Dancehall Cave as we traverse the valley walls of the upper Raccoon Creek drainage. Beginning under the Natural Bridge, we will look at the seemingly anomalous dips of bedrock strata (up to about 10º). The anomalous bedding may reflect the presence of a small carbonate mound. A very instructive series of trailside exposures of the Scotch Grove Formation will be visited as we wind our way from Wide Mouth Cave, over to Twin Arch Cave, and down along the trail past Hernando's and Up-n-Down caves. At Wide Mouth, we will look at an area of bedrock exposure that seems to show low-angle cross-stratification with graded bedding internally. A stacked succession of graded beds containing coarse fossil material at their bases is especially well displayed in the area of Twin Arch Cave. Numerous fossils can be seen in this area, and a variety are particularly evident in the ceiling of the cave. Fossils seen here include small favositid corals, horn corals, gastropods, several types of brachiopods, bryozoans, articulated crinoid cups, crinoid stem segments, and nautiloids. Loose concentrations of nautiloids are observed southward, including very large straight-shelled forms up to 3½ inches wide (with probable lengths of up to several feet).

Figure 6. Balanced Rock

REFERENCES:

Anderson, R.R., ed., 1978, Geology of East-Central Iowa; 42nd Annual Tri-State Geological Field Conference: Iowa Geological Survey, 217 p.

Calvin, S., 1906, Notes on the geological section of Iowa: Journal of Geology, v. 14, p. 571-578.

Johnson, M.E., 1983, New member names for the Lower Silurian Hopkinton Dolomite of eastern Iowa: Proceedings of the Iowa Academy of Science, v. 90, p. 13-18.

Philcox, M.E., 1971, Growth forms and role of colonial coelenterates in reefs of the Gower Formation (Silurian), Iowa: Journal of Paleontology, v. 45, p. 338-346.

Witzke, B.J., 1985, Silurian System, *in* Bunker, B.J., Ludvigson, G.A., and Witzke, B.J., The Plum River Fault Zone and the structural and stratigraphic framework of eastern Iowa: Iowa Geological Survey, Technical Information Series, no. 13, p. 18-41.

Witzke, B.J., 1992, Silurian stratigraphy and carbonate mound facies of eastern Iowa: Iowa Dept. of Natural Resources, Geological Survey Bureau, Guidebook Series no. 11, p. 3-63.

Witzke, B.J., 1999, Bedrock Geology of Palisades-Kepler State Park: Geological Society of Iowa, Guidebook 68, p. 3-18.

Witzke, B.J., and Johnson, M.E., 1999, Silurian brachiopod and related benthic communities from carbonate platform and mound environments of Iowa and surrounding areas, *in* Boucot, A.J, and Lawson, J.D., eds., Paleocommunities – A Case Study from the Silurian and Lower Devonian: Cambridge University Press, p. 806-840.

SILURIAN STRATIGRAPHIC SUCCESSION IN MAQUOKETA CAVES STATE PARK, JACKSON CO., IOWA.

Unit Descriptions based on three measured sections
by Brian Witzke, Michael Bounk, and Bill Bunker
October 2-3, 2001

1) primary section begins along cutbank of Raccoon Creek (southwest of Shinbone Cave) and proceeds up the bluff to ridge top, SE NE SW NW sec. 6, T84N, R2E.

2) supplemental section, trailside exposure east of Shinbone Cave, NE NW SE NW sec. 6; and

3) exposures along trail and stairs past Balanced Rock onto upland ridge, west of Lower Dancehall Cave entrance, SE SE NE NW sec. 6.

abbreviations: xf, extremely fine; vf-f, very fine to fine; f-m, fine to medium; m-c, medium to coarse; measurements in meters (m), centimeters (cm), and feet (ft).

SILURIAN SYSTEM
SCOTCH GROVE FORMATION
WELTON MEMBER

Unit 11. Dolomite, dominantly vf-f crystalline, minor f-m crystalline in lower and middle parts; variably porous, scattered to common small crinoid debris molds; basal 1.2 m denser and less porous; scattered vugs throughout; small flat cup coral (*Porpites*) noted 2.3 m above base; interval represented by intermittently exposed ledges and benches on ridge tops above main cliff sections below, ledges forms irregular bedding breaks approximately 0.6-1.2 m thick; total thickness of unit at primary section, 5.0 m (16.4 ft); thickness at Balanced Rock section, 2.7 m (8.9 ft).

Unit 10. Dolomite, dominantly vf-f crystalline, vf-m crystalline 2.1-3.4 m above base; porous, scattered to abundant small crinoid debris molds through, fine to very coarse crinoid debris molds common to abundant 1.1-3.4 m above base; scattered to common vugs; interval is more bedded than below, with irregular bedding breaks every 30-100 cm, but upper part of unit is massive at Balanced Rock section; prominent bedding break occurs 3.4 m above base; fossil molds scattered to common, lower half contains coarse crinoid debris, atrypid brachiopods; upper half includes coarse crinoid debris, crinoid cup (*Eucalyptocrinites*), gastropod (2 cm diameter); small coral (*Halysites*, 7 cm diameter) noted 95 cm below top of unit; interval forms steep cliffs and benched slopes; small cave in lower part of unit above Balanced Rock; total thickness 5.0 m (16.4 ft).

Unit 9. Dolomite, dominantly vf-f crystalline, porous, scattered to common small crinoid debris molds and other fossils, scattered vugs, large vugs locally common in upper part; fossils in basal 1 m include indeterminate brachiopods, cystodictyonid bryozoan; fossils in upper 2.1 m include indeterminate brachiopods (possibly gypidulids), fenestellid bryozoans, small gastropods, nautiloid (*Kionoceras*); massive to thick bedded, some discontinuous bedding breaks; unit forms steep cliffs; upper 85 cm bed locally overhanging; Balanced Rock occurs in middle part of this unit; total thickness 5.2 m (17 ft).

Unit 8. Dolomite, dominantly vf-f crystalline, includes xf and m-c crystalline in lower part, stringers of very coarse crystalline dolomite in upper part (dolomitized crinoid debris); porous, scattered to common small crinoid debris molds; scattered to common vugs, large vugs locally prominent in middle to upper part, calcite-filled vugs locally in upper beds; fossiliferous, scattered indeterminate brachiopods, middle part with scattered to common rhynchonellid brachiopods (*Ferganella*), fossiliferous stringers scattered through unit include coarse crinoid debris and crinoid stems, scattered fenestellid and cystodictyonid bryozoans; massive to irregularly bedded, discontinuous bedding breaks, bedding break 1.3-1.5 m above base locally forms minor bench or break in slope; overhanging cliffs above upper and lower entrances to Dancehall Cave show change from massive cliff-forming interval below (unit 7) to irregularly-bedded aspect above beginning at or near base of unit 8; prominent bedding break at top; total thickness 4.8-5.1 m (15.7-16.7 ft).

Unit 7. Dolomite, f-m and m-c crystalline, more coarsely crystalline than overlying and underlying strata; porous, scattered to common small crinoid debris molds, coarse crinoid debris molds scattered throughout; scattered to common vugs (1-10 cm diameter); irregular faintly horizontally bedded aspect, discontinous bedding breaks locally observed (every 0.4-1.3 m) but unit primarily displayed as massive cliff-forming interval; total thickness 4.4 to 4.5 m (14.4-14.7 ft).

Unit 6. Dolomite, vf-f crystalline; porous, scattered to common small crinoid debris molds, scattered large vugs; unit displays faintly bedded aspect (discontinuous breaks approximately 70 cm); prominent bedding break at base of unit, discontinuous break at top; total thickness 2.8 m (9.2 ft).

Unit 5. Dolomite, vf-f and f-c crystalline, dense vf crystalline in basal part; porous, scattered to common crinoid debris molds, scattered to common vugs, locally prominent zone of small vugs (1-5 cm diameter) noted 0.9-1.1 m above base of unit; fossiliferous, crinoid debris molds and scattered stem segments, scattered indeterminate brachiopods, rare small corals (cup coral, *Halysites* < 5 cm diameter) noted in basal 80 cm; discontinuous bedding breaks especially 90 cm above base and upper 50 cm; unit marked by overhanging ledges above prominent recessive interval (unit 4); total thickness 2.3 m (7.5 ft).

HOPKINTON FORMATION
PICTURE ROCK MEMBER

Unit 4. Dolomite, mixture of vf-f, f-m and m-c crystalline, sugary-textured with intercrystalline porosity, coarse crystals are primarily dolomitized crinoid debris, m-c crystalline in stringers (1-4 cm thick); scattered vugs (some calcite-filled), scattered fossil-moldic porosity (corals, crinoid debris); fossiliferous, especially in middle part, some corals and stromatoporoids are partially silicified; fossils include cup corals (57, 100 cm below top), colonial rugose coral *Arachnophyllum* 8 cm diameter (50 cm below top), fasciolate rugose coral (102 cm below top), *Halysites* to 10 cm diameter (47, 89, 96, 112 cm below top), *Favosites* to 10 cm diameter (56, 119 cm below top), *Syringopora* (119 cm below top), laminar stromatoporoids (52, 84, 90, 100, 119 cm below top), rare small brachiopod *Dolerorthis* (56 cm below top), large *Pentamerus* brachiopod (4 cm) noted 118 cm below top; irregularly-bedded aspect, discontinous beds every 5 to 20 cm; unit forms persistent re-entrant with overhanging ledge above (unit 5); total thickness 1.6 to 1.7 m (5.3-5.5 ft). Description primarily based on section 2; difficult access at section 1.

Unit 3. Dolomite, f-m and m-c crystalline, sugary-textured, coarse crystals are primarily dolomitized crinoid debris, m-c crystalline in stringers, intercrystalline porosity; scattered to common vugs (some calcite filled in lower half of unit); scattered to common fossil-moldic porosity (includes corals, stromatoporoids, crinoid debris); fossiliferous throughout, prominent corals and stromatoporoids, some partially silicified; fossils include cup corals (up to 4 cm diameter, 75 cm above base), colonial rugose coral *Arachnophyllum* (15 cm diameter, 15 cm above base), *Halysites* (especially near base), scattered *Syringopora* (up to 25 cm diameter, 2.0 m above base), common *Favosites* (up to 20 cm diameter), common laminar stromatoporoids (up to 15 cm diameter); *Pentamerus* noted 1.43 m below top of unit; massive to irregularly-bedded cliff-forming unit, gradational above; total thickness 2.75 m (9 ft).

Unit 2. Dolomite, vf-m crystalline alternating with m-c crystalline lenses, intercrystalline porosity; scattered vugs, calcite-filled vugs (to 15 cm diameter) locally present; fossiliferous throughout, scattered to prominent corals and stromatoporoids, moldic to silicified; small cup corals (40 cm above base), *Halysites* (noted 33, 43 cm above base and top), *Favosites* 6-20 cm diameter (noted 37, 39, 40, 43, 48, 63, 67, 79 cm above base), *Syringopora* to 10 cm diameter (noted 35, 43, 45, 58 cm above base), laminar stromatoporoids to 10 cm diameter (noted 20-25, 78 cm above base); scattered to common *Pentamerus* brachiopod shell molds occuring as solitary shells or in small clusters (laterally discontinuous accumulations about 50-100 cm in diameter), *Pentamerus* shells noted at 5, 10 (some in life position), 16, 55, 62-64, 69, 78, 81-85 (commonly in life position, shells to 6 cm) cm above base of unit; unit forms minor re-entrant, irregular bedding breaks at base, 43cm, 58 cm above base, and top of unit; total thickness 85 cm (2.8 ft).

Unit 1. Dolomite, vf-m and m-c crystalline, coarsest crystalline dolomite in stringers 1-3 cm thick (mostly dolomitized crinoid debris), intercrystalline porosity, scattered vugs, calcite-filled vugs to 25 cm diameter best developed 25-50 cm below top of unit; scattered to common fossil-moldic porosity (small crinoid debris molds and corals); scattered to prominent corals and stromatoporoids, silicified in part; fossils include small cup corals (1.5 cm diameter), *Favosites* to 10 cm diameter (noted 16-20, 42, 53, 115 cm below top of unit), *Syringopora* to 15 cm diameter (noted 18-23 cm below top of unit), laminar stromatoporoids to 50 cm diameter (noted 8 and 58 cm below top of unit); upper 1.75 m of unit forms a single massive bed, prominent bedding break at top (forms re-entrant) and 1.75 m below top; maximum exposed thickness (above Raccoon Creek) 2.05 m (6.7 ft).

DEVELOPMENT AND EVOLUTION OF THE MAQUOKETA CAVERN SYSTEM

Michael J. Bounk
Iowa Department of Natural Resources
Geological Survey Bureau
Iowa City, Iowa

Dancehall Cave and some of the at least nine caves occuring in the walls of the ravines upstream and downstream of Dancehall (Figs. 1, 2, 3, 4, 5) are the remains of a once much larger cavern system. This was discussed by Hedges (1958), who stated that many of the smaller caves in the valley walls were once side passages of an enlarged Dancehall Cave, which was once a third longer than it is now. According to Greg McCarty (Iowa Grotto) one of these caves, Shinbone (figure on back cover) is partly mechanical.

Based upon the narrowness and angular nature of the valley downstream of Dancehall Cave, and the presence of caves along the valley walls, the cave at one time probably extended downstream to its mouth along the Maquoketa River, as discussed by Hedges (1967). It also extended upstream beyond the natural bridge to beyond the ravine where Wide Mouth Cave is located. Wye Cave was presumably a part of this system, although the relationship has not yet been proven. Hedges (1967) estimated 3 miles of main passage, and 5 to 15 miles of side passage, not all of which would have been enterable.

The total length of the valley is about 2830 m. Taking into account the frequent changes in direction of cave passages, 5660 m of main passage is estimated. I estimate that the entire cavern, with its side passages, as discussed here (Fig. 7) once had a total passage length of about 10k (6.2 miles).

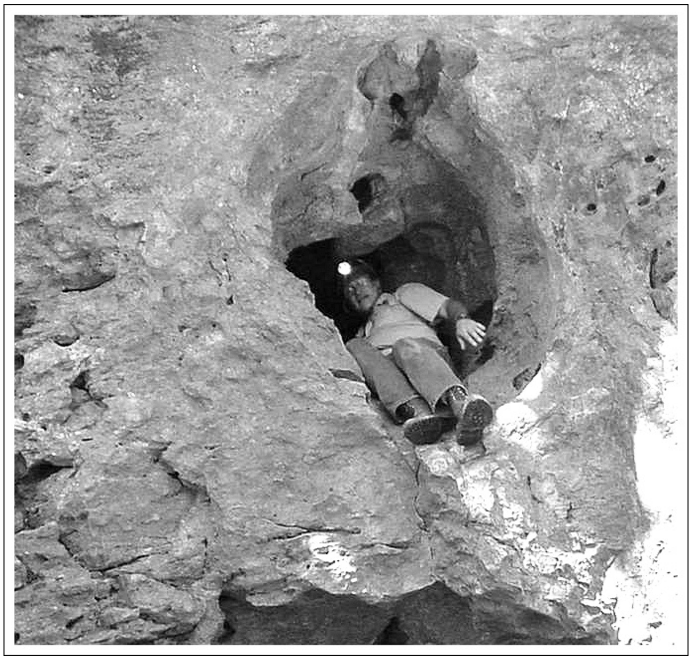


Figure 1. Author Michael Bounk exiting Barbell Cave.

Development of this cavern system began before the development of the present valley. According to Art Bettis (personal communication) this likely would have been some time after the last glaciation of this area, which was about 500,000 years ago. Development of the cave probably began at or just beneath the water table, as commonly occurs in solutional karst (Davis, 1960). Groundwater in the saturated zone flows from areas of higher to lower head, ultimately being discharged along streams that have cut into the water-bearing unit. In an isotropic rock, with high intergranular porosity, such as poorly cemented sandstone, flow will be directly towards the point of discharge. In carbonate rocks, limestone or dolomite, there is relatively little intercrystalline porosity and permeability. For this reason, the water tends to follow fractures in the rock. As it flows through the rock, carbonic acid in the water, from dissolved carbon dioxide, dissolves the calcium and magnesium carbonate, and carries it away in solution. This makes the opening a little larger, thus permitting more water to flow through, and thus dissolving more carbonate. This tends to occur primarily at or near the water table surface. This is due to the water at this level being more corrosive, due to mixing of waters with differing amounts of carbon dioxide (Picknett et al., 1976). The result of these factors is that the water follows and dissolves out those fractures, which best permit it

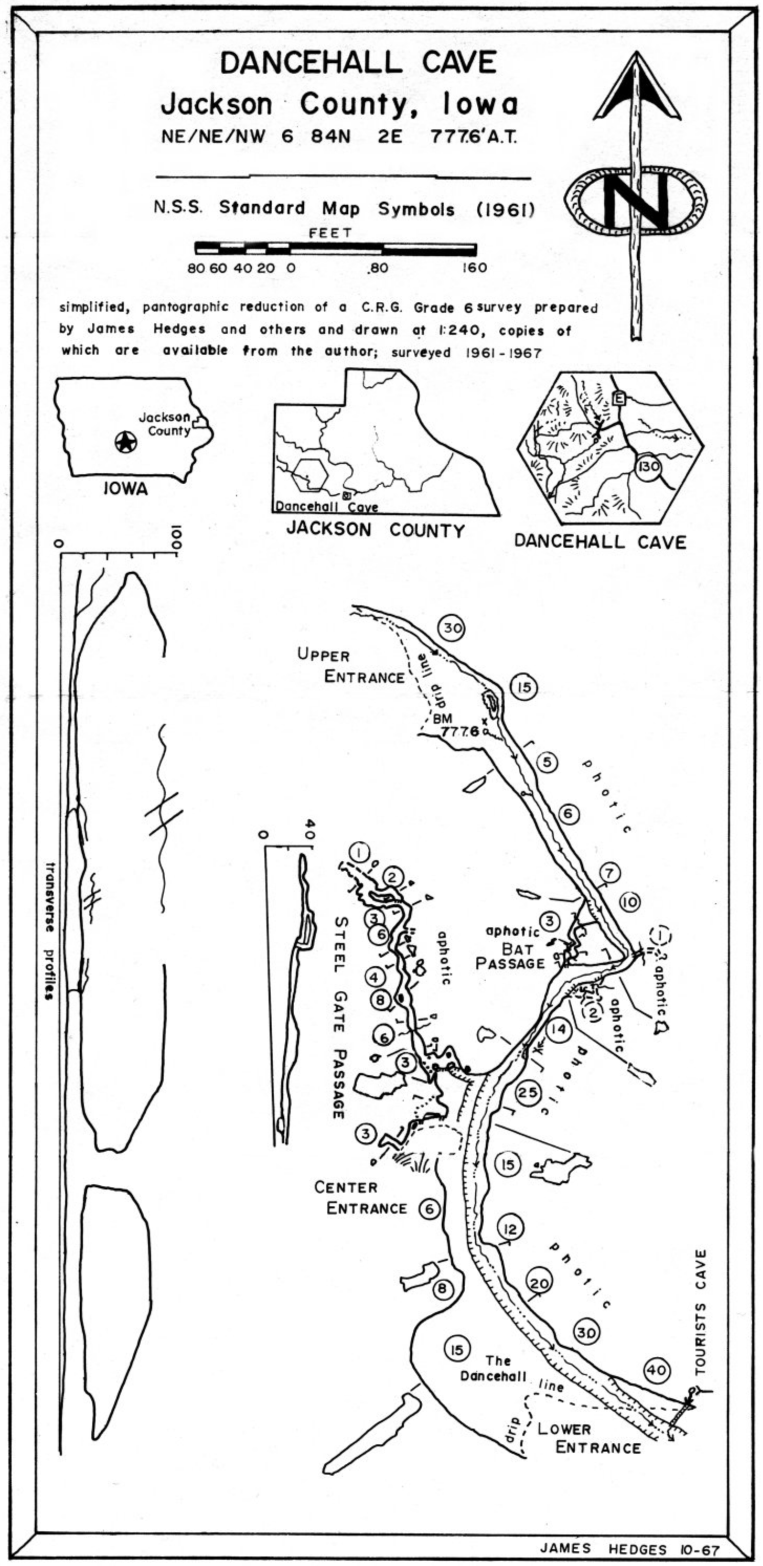


Figure 2. from Iowa Grotto, 1974.

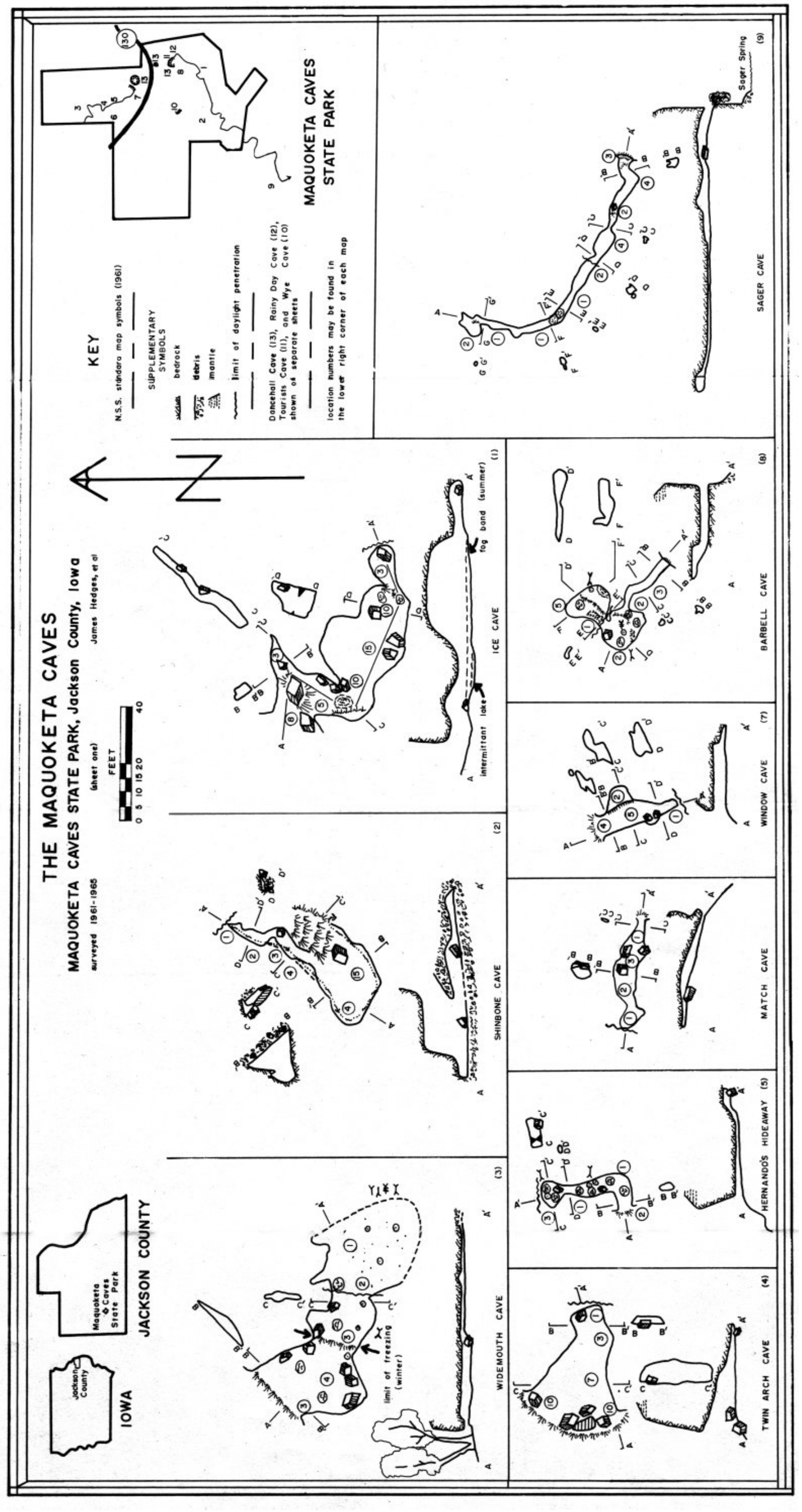


Figure 3. from Iowa Grotto, 1974.

to move from places of higher to lower head. This results in passages that formed a series of fracture aligned, branching, water-filled, near-horizontal elliptic tubes. These tubes drained the Silurian age carbonates in and around what is now Maquoketa Caves Park, carrying the flow to the Maquoketa River, then located at a higher elevation (i.e., valley less incised) than it is today. As the land surface was eroded downward, and the water table dropped, parts of these tubes were drained. Hallberg, et. al., (1984) date a major episode of down cutting in northeast Iowa to 160 thousand years ago. This is likely to be the time at which this drainage occurred here. When this occurred, erosion changed from around the entire circumference of the tube to the floor of the tube. This resulted in the floor of the tubes developing into a vadose trench. At this time, the cave was probably very similar to present day Coldwater Cave (Fig. 6) in appearance, and stage of development. As surface erosion continued, the roof of the cavern was breeched. This permitted the now unroofed passage walls to be eroded back into the narrow steep valley walls that we see today. This also permitted great amounts of rock and dirt to be carried into the valley and remaining passage, filling them to an unknown depth. As portions of the cave were unroofed and destroyed, adjacent segments of cavern were exposed to freezing conditions and thus frost wedging. This frost wedging has greatly enlarged the southern entrance of Dancehall Cave, and has probably been active to some extent everywhere in the main passage of Dancehall, destroying evidence of the early history of cave development. The present state of this process of cavern development and destruction resulted in the caves and valleys that we see today in the park, with two segments of main passage, a natural bridge, and a series of relatively small caves in the valley walls, which are the remains of side passages. Two known side passages of significant length that remain are the Steel Gate Passage, and Tourist's Delight Cave (Fig. 5). Tourist's Delight is normally unenterable due to a constricted entrance which is normally water-filled.

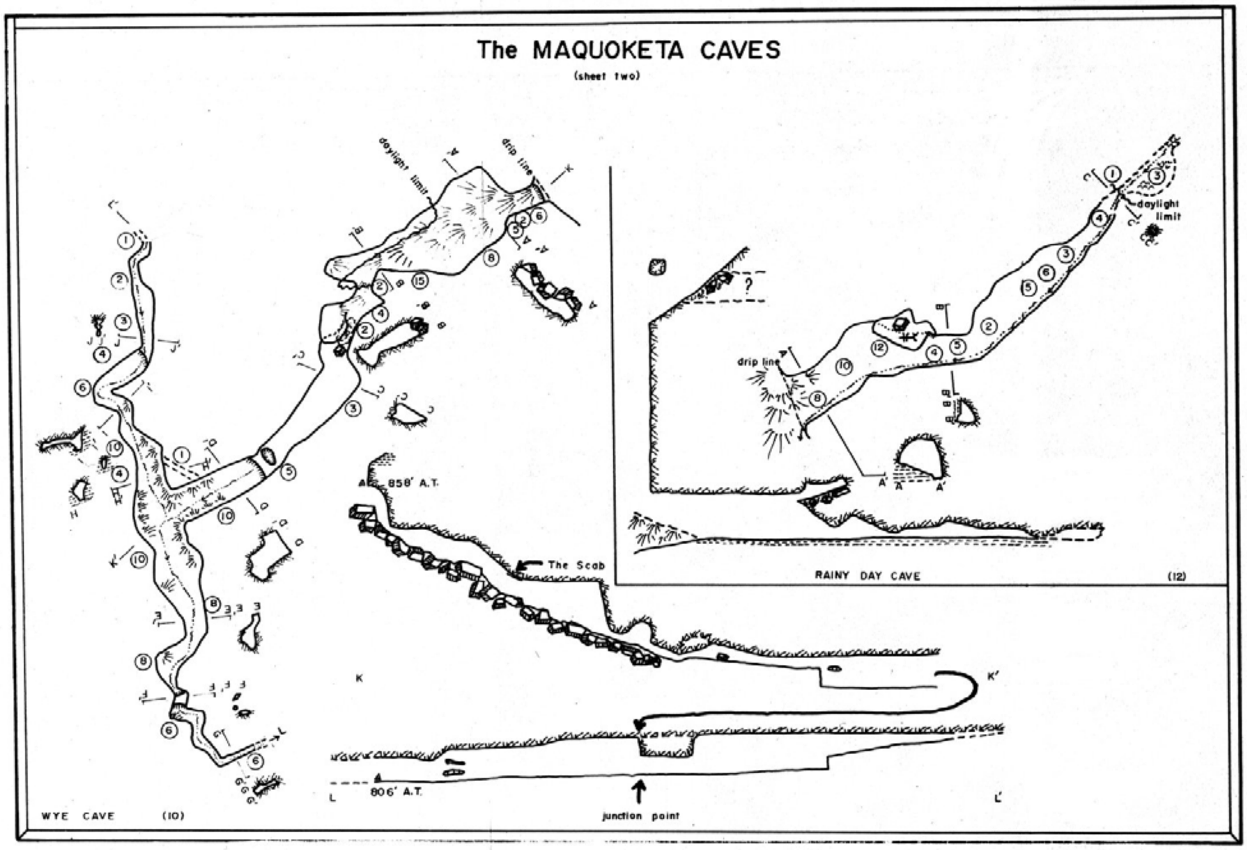


Figure 4. from Iowa Grotto, 1974

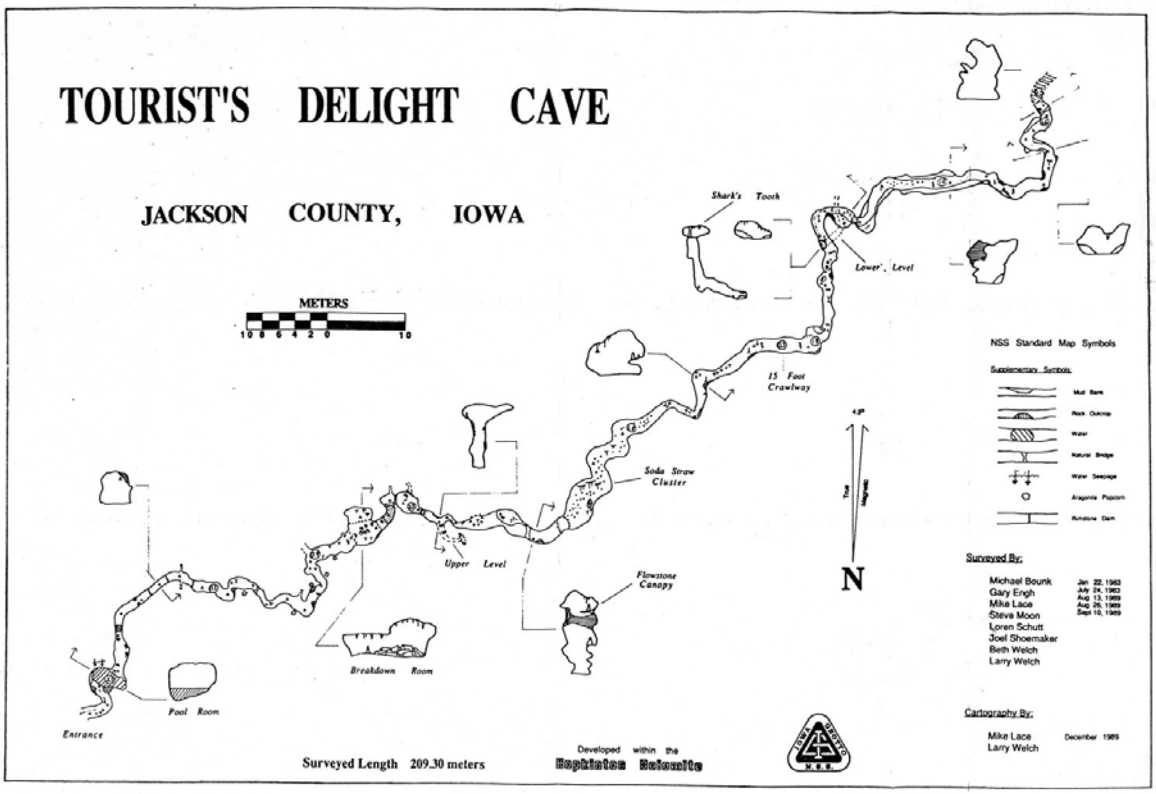
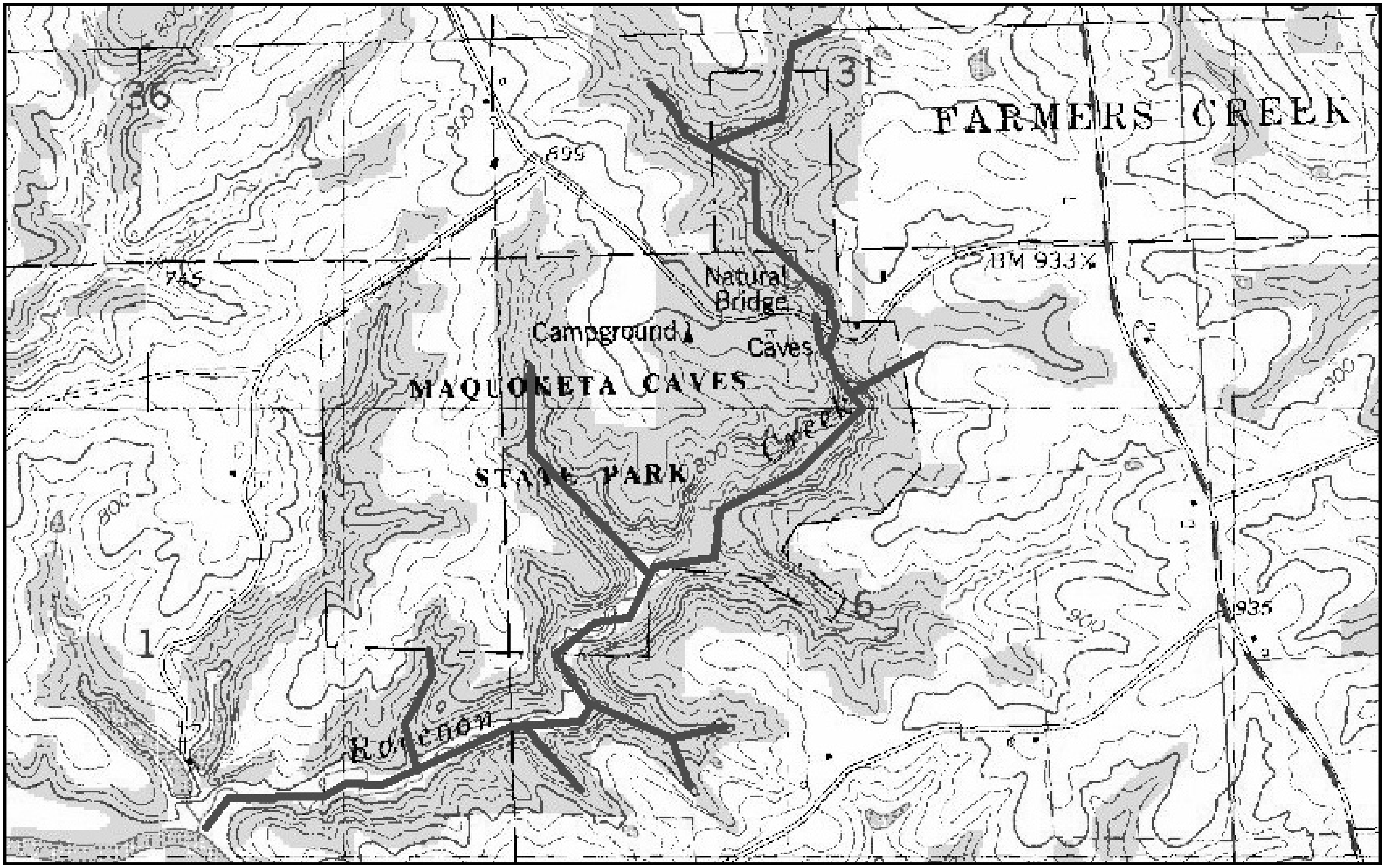


Figure 5. from Iowa Grotto, 1992.

Figure 6. Photograph of interior of Cold Water Cave.

Figure 7. Approximate location of former cave, now collapsed to form the valley of Raccoon Creek (indicated by dark line)



Development of the system continues at a lower unenterable level. In 1981, there was a major flood of the park. This flood ripped out much of the walkway in Dancehall Cave. After the flood, the stream in Dancehall disappeared into the floor upstream of the sinkhole entrance, and was pirated to Tourist's Delight Cave (Lambertz, 1984), indicating a probable passage between these two caves, below present floor level.

The processes that formed and are destroying this cavern system will continue, as the main passage of Dancehall Cave is further unroofed and as the lower level passage discussed above continues to develop.

REFERENCES

Bogli, A 1980, Karst Hydrology and Physical Speleology: Translation by J.C.Schmid, p. 202.

Davis, W. E. 1960. Origin of Caves in Folded Limestone: *in* Origin of limestone caves (G.W. Moore, ed.), Bull. Nat. Speleo. Soc. 22:5-18.

Hallberg, G. R., Bettis III, E. A. and Prior, J. C., 1984, Geologic Overview of the Paleozoic Plateau Region of Northeast Iowa: The Proceedings of the Iowa Academy of Science, Vol. 91, No. 1.

Hedges, J., 1958, Maquoketa Caves State Park, Jackson Co: Cave Survey Report No. 7, the Iowa Grotto, National Speological Society.

Hedges, J., 1967, Karst Catalogue: Unpublished paper, November 18, 1967.

Iowa Grotto, 1974, National Speleological Society 1974 Convention. Intercom, Vol. 10, Issue 1, p. 73, 75, 76. Iowa Grotto, National Speleological Society.

Iowa Grotto, 1992, The Iowa Cave Book, p101, Iowa Grotto, National Speleological Society.

Lambertz, John, 1984, Cave Reconstruction: *in*. Proceedings of the 1984 National Cave Management Symposium, *Missouri Speleology*, v. 25. Rolla, Missouri.

Picknett, R. G., L. G. Bray, and R. D. Stenner. 1976, The Science of Speleolology: Ford, and Cullingford (editors), p. 219-220.

VEGETATION OF MAQUOKETA CAVES STATE PARK

John Pearson, Plant Ecologist
Parks, Recreation & Preserves Division
Iowa Department of Natural Resources
Des Moines, IA 50319-0034

Although small in area, Maquoketa Caves State Park contains a diversity of vegetation that reflects the influence of geology and past land uses. Historical records from General Land Office (GLO) surveyors, aerial photographs of the park in 1936 and 1992, and studies of the vegetation by two investigators (Christiansen 1981, Swinconos 1997) provide an interesting opportunity to trace dramatic changes in the extent and species composition of forest vegetation in the park between the early 1800s and the present day. In addition, other habitats in the park support an array of plant species.

UPLAND FOREST

Forest at the time of pioneer settlement- circa 1837

Before examining the current vegetation within the park boundary, it is useful to consider the historic vegetation that was present over a broader area prior to the advent of widespread agriculture. Fortunately, a record of the historic vegetation of Jackson County is available from the plat maps of General Land Office (GLO) surveyors who surveyed the county between 1837 and 1839. Unfortunately, inconsistencies in map-making and descriptions of vegetation types among individual surveyors also create problems in using their records to reconstruct maps of the historic vegetation.

General instructions for mapping vegetation were provided to GLO surveyors during the 1832-1859 period when land in Iowa was first surveyed, but individual surveyors nonetheless used slightly different protocols to map the vegetation in townships for which they were responsible. This often resulted in the same vegetation type being labeled differently across township boundaries. Variations in mapping protocols among individual surveyors resulted when some surveyors meticulously drew boundaries between adjacent contrasting areas of prairie, forest, and wetland while others simply lumped them together within a single perimeter. Complicating the issue further is that some surveyors who lumped contrasting types described the individual components of a mapped complex in their journal notes while others neglected to do this.

For example, deputy surveyor Moses M. Strong surveyed Butler Township (T86N R1E, located in the northwest corner of Jackson County) in the year 1837 and mapped the majority of the vegetation in the township as a single polygon, describing it as a mixture of timber, scattering trees, and prairie openings. In contrast, deputy surveyor Charles Legate mapped adjacent Brandon Township (T85N R1E, on the south side of Butler Township) in the same year, but chose to describe the vegetation simply as “timber”. Thus, literal reconstruction of the two township maps results in a line separating “timber” from a an undifferentiated mixture of “timber, scattering trees, and prairie openings” at the township boundary. Surely the natural vegetation did not change abruptly at an imaginary legal line in pre-settlement times, but resolution of trans-township inconsistencies requires subjective interpretation.

Several investigators (Dick-Peddie 1955, Smith 1990, Anderson 1996) have attempted to reconstruct maps of the historic vegetation of Jackson County. Although all agree in general terms, there are also interesting differences in the county-wide maps that resulted from their research efforts, largely reflecting the degree to which they interpreted the original, sometimes ambiguous data left by the original surveyors. In the following paragraphs, these three reconstructions are briefly discussed in order of increasing degree of interpretation of the original data (which is inverse to their chronological order).

Anderson (1996) used a Geographic Information System (GIS) digitizer to trace the drawings of the GLO surveyors in an electronic format. He chose to adhere strictly to the original maps and notes left by the GLO surveyors, and to not draw inferences, even though this often resulted in “unnatural”, straight-

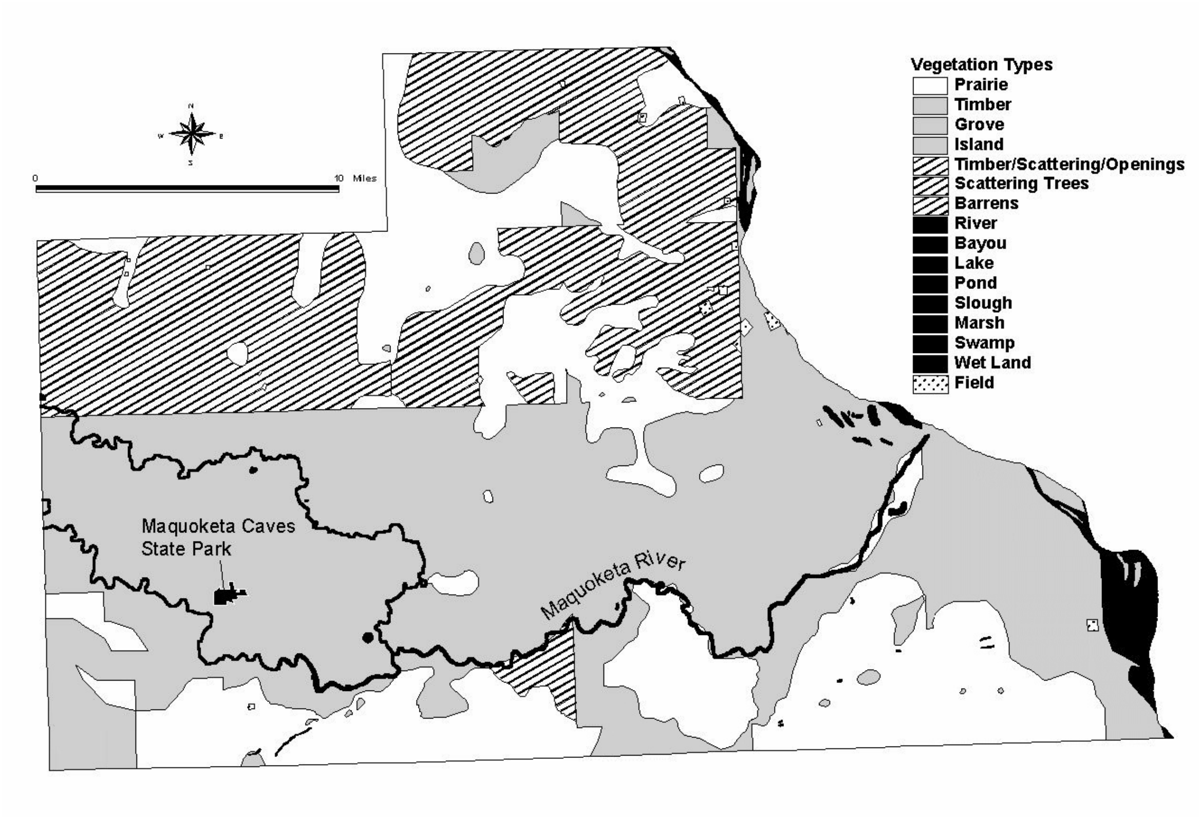


Figure 1. Historic vegetation of Jackson County from GLO plat maps, 1837-1839.

line boundaries at township lines (Fig. 1). His map portrays Jackson County as dominated by three main types of vegetation: 1) "timber", 2) "prairie", and 3) an undifferentiated mixture of "timber, scattering trees, and prairie openings". Some areas of "scattering trees" and "barrens" were also mapped separately in some townships. Very small cultivated fields, groves of trees, and wetlands were also depicted, but these did not occupy large areas of land. The area in and around Maquoketa Caves State Park was broadly mapped as "timber".

Smith (1990) used cartographers to trace the outlines of vegetation types by hand, but smoothed abrupt, unnatural lines into curving arcs representing presumed natural boundaries. Only two predominant vegetation types appeared on his map: 1) "forest" and "prairie". Small areas of other types were also noted. The area in and around Maquoketa Caves State Park was mapped as "forest".

Dick-Peddie (1955) drew the outlines of vegetation types and smoothed the boundaries in a manner similar to Smith (1990). Like Smith and Anderson, Dick-Peddie mapped large areas of "prairie". Unlike Smith and Anderson, however, Dick-Peddie differentiated forest cover based on presumed dominant tree species: "Oak-Maple-Linden" (in which the dominant tree species were red oak, sugar maple, and basswood) and "Oak-Hickory" (in which the dominant tree species were bur oak, white oak, black oak, and hickories). The majority of the forested land in the county was mapped as "Oak-Hickory", but a large area occupying the broad upland between the Maquoketa River and the North Fork of the Maquoketa River was mapped as "Oak-Maple-Linden". It is unclear how Dick-Peddie delineated these forest types within the county.

According to Dick-Peddie (1955), the species used most frequently by GLO surveyors as witness trees in Jackson County were white oak (37%), bur oak (18%), black oak (14%), sugar maple (5%), hickories (4%), basswood (4%), and red oak (3%). A refined, GIS-based summary of the witness tree data by Miller (1995) in areas mapped by the GLO surveyors as "timber" showed results very similar to those of Dick-Peddie for white oak, black oak, basswood, and red oak, and hickories, but with somewhat more sugar maple (9% instead of 5%) and less bur oak (7% instead of 18%). These data show that oaks, especially white oak, were very common in the county circa 1837.

Regardless of differing details in classification, all of the above researchers of GLO records agree that some type of forest predominated in the area of Maquoketa Caves State Park (Dick-Peddie 1955, Smith 1990, Anderson 1996). The modern soil survey for Jackson County (LaVan 1992) classifies soils in and around the park as Alfisols, supporting the idea that trees have occupied the area for a long time (on the order of hundreds of years, sufficient for the soil to develop horizons indicative of forest vegetation). However, Anderson (1996) shows that the GLO record from townships in the north part of Jackson County indicates the presence of interspersed prairie areas. The available evidence thus suggests that forest predominated in the area around the park, possibly interspersed with prairie openings.

Forest in 1936

Prior to state ownership, the land in the park was extensively used for agriculture, which employed practices that reduced the density of trees (grazing) or removed them entirely (clearing and cultivation of row crops or hay). Today, most of the park is forested, but areas in the far eastern and far western parts of the park are open, grassy areas representing the remnants of former cropfields, hayfields, and pastures. Much of the land that is presently forested in the park has recovered to this condition since the 1930s.

An aerial photograph of the park in 1936 (Fig. 2a) shows that much of the area was a mosaic of cropland ("A"), open grassy areas with scattered trees (probably pasture, "B"), and patchy woods interspersed with open and brushy areas (probably wooded pasture, "C"). Only two areas in the park- both associated with steep, bedrock-dominated topography- were forested in 1936 ("D"): the valley north of the road and the slopes west and south of what is now the campground.

Comparison of aerial photographs from 1936 and 1992 reveal many changes in vegetation and land use during the intervening 56 years (Fig. 2). During this period, the park boundaries expanded to include former cropfields and pastures with subsequent halting of cropping, grazing, and tree-cutting. In response, forest cover has greatly increased within the park. For example, in the far western part of the park, what was open, grassy pasture with scattered trees ("B") has become a sharply segregated mixture of densely forested slopes with a narrow band of open grassland on the top of the ridge.

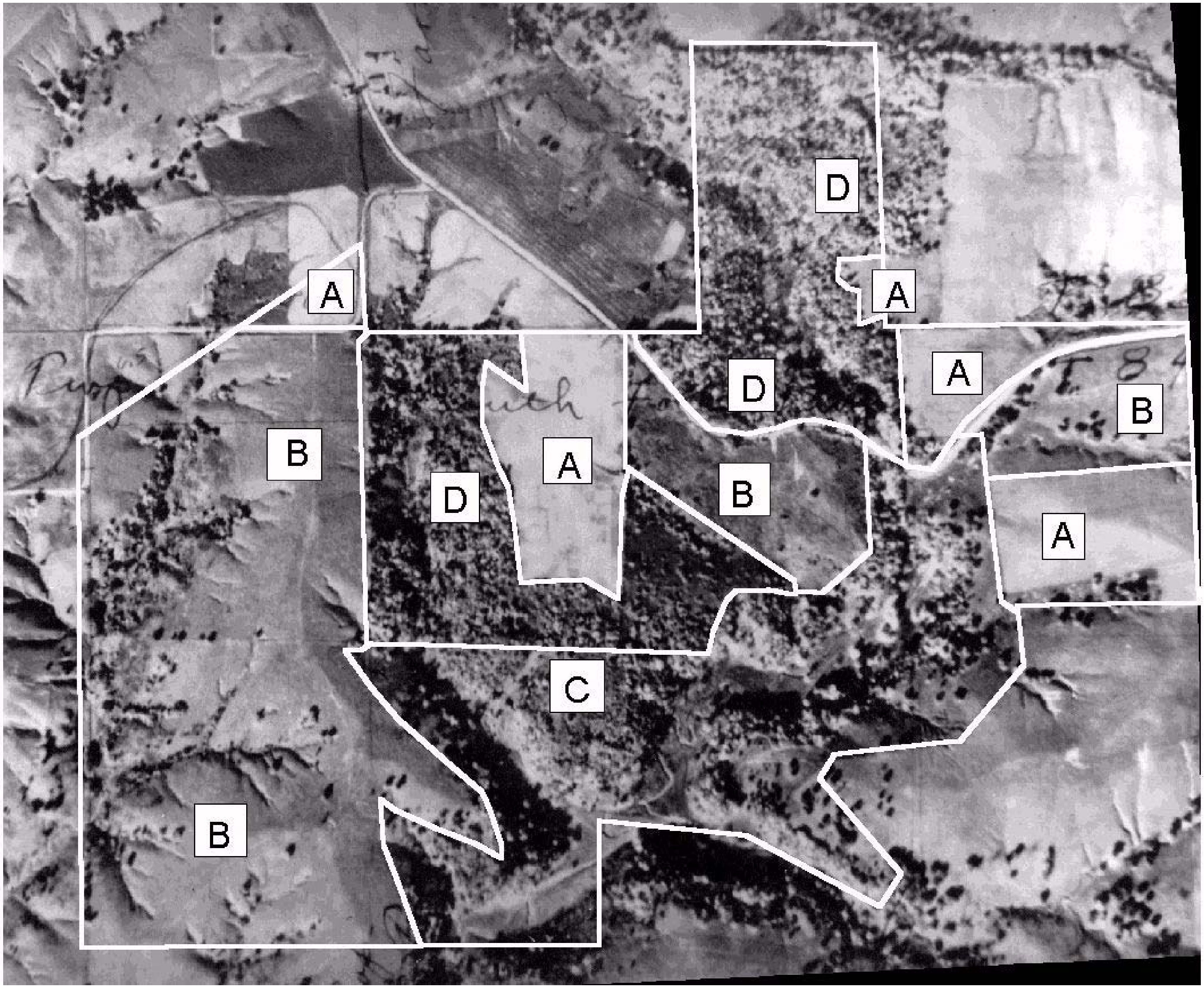
In addition to the areas where natural succession has converted open land to forest, some areas were converted to forest cover by planting. In particular, the 1936 cropfield in the center of the park was planted with pines about 1961 (when this tract was acquired by the park) and was then developed into the present-day campground in 1992. (Thus the pines surrounding the campsites are today about 40 years old.) Another, small pine plantation was established about 1940 where a former cropfield once extended into the park north of the present-day office buildings (these pines are thus about 60 years old).

Tree cover in areas that were partially forested in 1936 has become more dense and continuous since then. An area that was apparently wooded pasture in 1936 with a patchwork of scattered trees, groves of trees, and open grassland ("C") is now heavily and uniformly forested. Even within the areas that were already heavily forested in 1936 ("D"), trees have expanded to fill small gaps and openings. Forested tracts that were obviously different from each other in canopy cover in 1936 ("C" versus "D") are today indistinguishable from each other in this regard (Fig. 2b).

Forest in the recent past- 1979 to 1997

Although forest vegetation in the park has recovered from past clearing and grazing in terms of cover and canopy closure, differences in species composition still remain among tracts with different histories. Two investigators have described and mapped forest types in the park based on species composition in the recent past: Dr. Paul Christiansen of Cornell College in 1979 and 1980 (Christiansen 1981) and DNR district forester Steven Swinconos in 1997 (Swinconos 1997). They identified and mapped several forest communities in the park, including both mature, old-growth stands and immature, second-growth stands.

Figure 2a. Delineation of vegetation types in Maquoketa Caves State Park in 1936. Key: A, cropland; B, open pasture; C, partially forested pasture; D, mature forest.



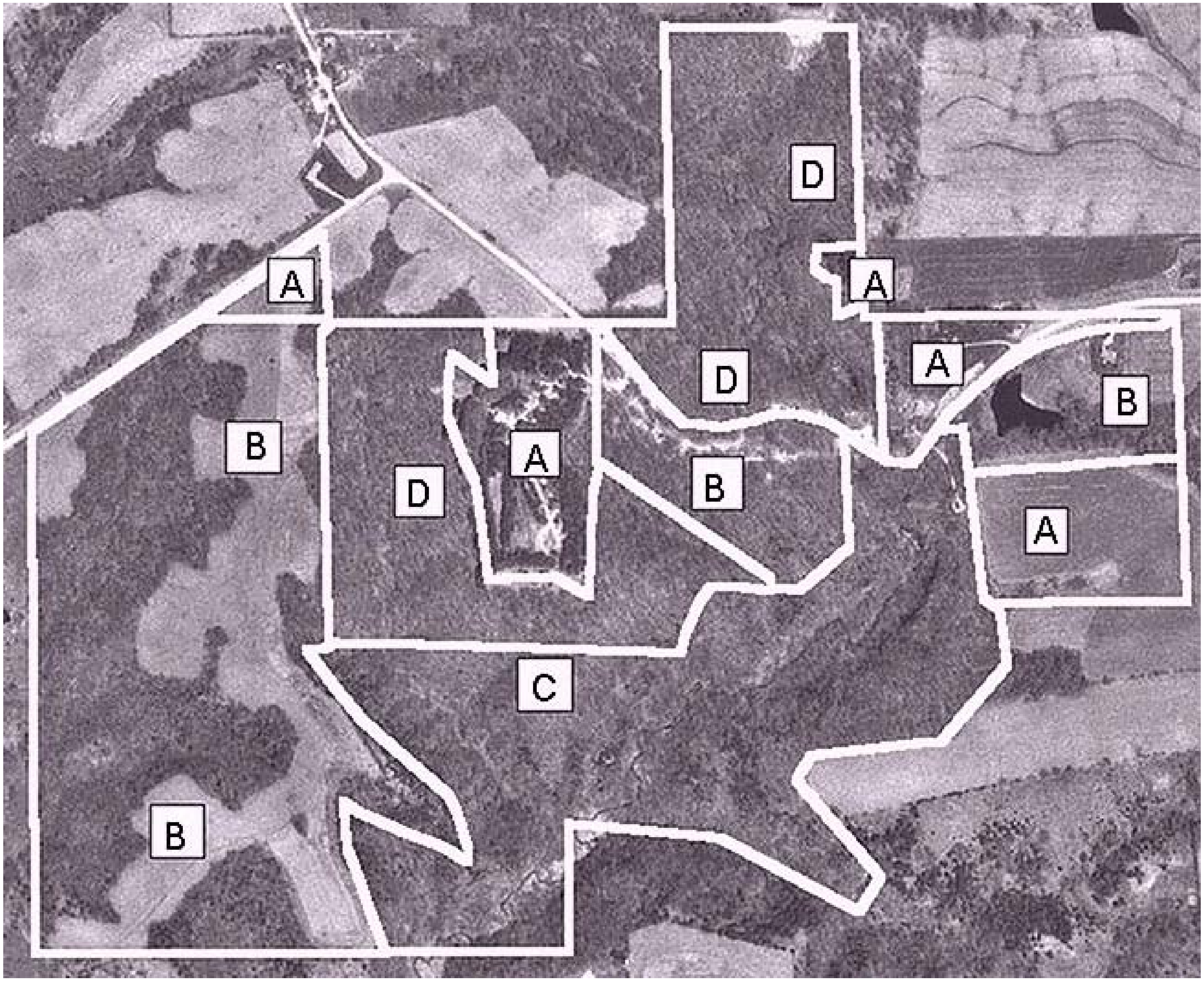


Figure 2b. Overlay of 1936 vegetation type boundaries on 1992 aerial photograph. Compare to Figure 2a. Letters refer to vegetation in 1936. Note expansion of modern forest into former pastures.

In the following section, their descriptions of modern forest tracts will be used within the historical framework of forest tracts identified in the 1936 aerial photograph (Fig. 2a).

Tracts heavily forested in 1936 ("D")

Two tracts of land in the park appeared to be heavily forested in 1936: the area north of the road and the area surrounding the campground on its west and south sides. Parcels within the northern tract were acquired by the park in 1921 and 1940; parcels within the southern tract were acquired in 1931 and 1961. Any tree cutting or grazing that may have occurred in these parcels prior to acquisition was discontinued after these dates. Internal gaps and openings in the forests within these tracts had filled with trees by 1992. Based on observations in 1979 and 1980, Christiansen classified portions of these areas as "mature forest". Based on observations in 1997, Swinconos described a portion of the northern tract as "residual old growth" with a stand age of 150 years, an average tree diameter of 18 inches, and a stand basal area of 110 square feet per acre. Both investigators identified the dominant canopy species in these sites as white oak (*Quercus alba*), red oak (*Quercus borealis*), and sugar maple (*Acer saccharum*).

Although the descriptions of canopy tree dominance in this type by Christiansen and Swinconos are similar, their delineation of the boundaries of the "mature forest" and "residual old growth" differ from each other and from the extent of the forested areas evident on the 1936 aerial photograph. Christiansen demarcated a subset of the 1936 forested area as mature forest (west of the campground in the southern tract and west of Raccoon Creek in the northern tract) and classified the remainder as "immature forest". Swinconos mapped only the stand west of Raccoon Creek in the northern tract as residual old growth and classified the remainder as "second growth". Disparity among demarcations is due to the heterogeneity of forest vegetation, differing methodology among mappers, and the difficulty of determining the boundaries of large areas by ground surveys of small plots and narrow transects.

Both investigators identified the major understory species as sugar maple (*Acer saccharum*), basswood (*Tilia americana*), elm (*Ulmus* spp.), and ironwood (*Ostrya virginiana*). The most abundant herbaceous species in the mature forest community were identified by Christiansen as wood nettle (*Laportea canadensis*), Virginia creeper (*Parthenocissus virginiana*), waterleaf (*Hydrophyllum appendiculatum*), black snakeroot (*Sanicula* spp.), and honewort (*Cryptotaenia canadensis*). He listed a total of over 100 plant species as occurring in the mature forest community.

Tracts partially forested in 1936 ("C")

The valley of Raccoon Creek south of the park road was partially forested in 1936, with groves of trees interspersed with brushy areas and open, grassy areas (Fig. 2a). Parcels within this tract were acquired by the park in 1931 and 1976. By 1992, this area had become covered with forest. On Christiansen's (1981) map, upland vegetation in this tract was classified as "immature forest", developed on land that was pastured and where only brush and herbaceous vegetation was present circa 1930. He noted that canopy closure in 1980 varied from 30% to 100%, explaining that a complete canopy was present where young trees were present at the time of abandonment while an incomplete canopy was present in areas which had been previously cleared of trees. Similarly, Swinconos (1997) classified upland forests in this area as "second growth" regenerating from pasture. He estimated the stand age as 50 years, the average tree diameter as 12 inches, and the stand basal area as 120 square feet per acre.

Both Christiansen and Swinconos identified ash (*Fraxinus* spp.), elm (*Ulmus* spp.), walnut (*Juglans nigra*), and sugar maple (*Acer saccharum*) as the common canopy tree species in this community. Both investigators identified the common understory tree species as sugar maple, basswood, elm, and ironwood (these four species were also identified as the common understory trees in the mature, old-growth forest). Christiansen also identified gooseberry (*Ribes*) and hazelnut (*Corylus americana*) as abundant shrubs and Virginia creeper (*Parthenocissus virginiana*), sedges (*Carex* spp.), hog peanut (*Amphicarpaea bracteata*), black snakeroot (*Sanicula* spp.), bedstraw (*Galium* spp.), and lopseed (*Phyrma leptostachya*) as important species in the herbaceous layer. He listed a total of over 150 plant species as occurring in the immature forest community.

Tracts that were open pasture in 1936 ("B")

Three areas in the park were open, grassy pasture with scattered trees in 1936 (Fig. 2a): a small tract in the center of the park in and south of the present picnic area (acquired by the park in 1931), a large tract in the western end (acquired in 1976), and a small tract near the northeastern corner (acquired in 1997). By 1992, forest occupied a significant portion of each tract. The three tracts will be discussed starting with the oldest acquisition (1931) and progressing to the newest acquisition (1997).

1931 acquisition

This tract in the center of the park was open pasture with a few scattered trees in 1936. By 1992, trees densely covered all of the site except where mowing currently maintains a semi-open strip of scattered trees over the picnic area lawn. Christiansen (1981) mapped this area as part of a much larger area of "immature forest". Likewise, Swinconos (1997) mapped it as part of a larger area of "second-growth" forest. In fact, both investigators mapped it as part of the tract that was partially forested in 1936.

As summarized earlier, both authors identified ash (*Fraxinus* spp.), elm (*Ulmus* spp,), walnut (*Juglans nigra*), and sugar maple (*Acer saccharum*) as the common canopy tree species in this community with sugar maple, basswood, elm, and ironwood as common understory species.

1976 acquisition

This large tract in the far western end of the park was mostly open pasture in 1936, but contained scattered trees and brushy areas in a rocky ravine draining to the southwest. By 1992, trees had increased dramatically in area and density, converting the entire ravine and much of the loess-capped slopes above it into forest; about 50% of the overall tract is now wooded (Fig. 2b).

Observing the ravine in 1979 and 1980 (only 3-4 years after acquisition of the tract and the presumed cessation of grazing), Christiansen classified the vegetation there as an "old field". He described the old field at that time as "vegetation in transition from herb dominated to woody domination", noting that development of woody vegetation was more advanced in the rough ground along draws and creek banks than in the rest of the tract. He identified eastern red cedar (*Juniperus virginiana*), elm (*Ulmus* spp.), ash (*Fraxinus* spp.), and white oak (*Quercus alba*) as the most prominent tree species in the woody portions of the old field along with lesser amounts of walnut (*Juglans nigra*), hackberry (*Celtis occidentalis*), red oak (*Quercus borealis*), and basswood (*Tilia americana*). He also noted raspberry (*Rubus* spp.) and numerous seedlings of ash (*Fraxinus* spp.), chinquapin oak (*Quercus muhlenbergii*), and black cherry (*Prunus americana*) invading the open portions of the old field, which was otherwise dominated by Kentucky bluegrass (*Poa pratensis*), Canada goldenrod (*Solidago canadensis*), and sedges (*Carex* spp.). Christiansen identified about 90 plant species in the old field community.

In 1997, Swinconos described the forest vegetation in the ravine as "regrowth from an open pasture". He estimated the stand age as 30 years, the average diameter as 8 inches, and the stand basal area as 100 square feet per acre. The principal tree species in the canopy layer were elm (*Ulmus* spp.), bigtooth aspen *(Populus grandidentata*), black cherry (*Prunus americana*), ash (*Fraxinus* spp.), bitternut hickory (*Carya cordiformis*), and hackberry (*Celtis occidentalis*). A woody understory dominated by ironwood (*Ostrya virginiana*), elm, ironwood, gooseberry (*Ribes* spp.), raspberry (*Rubus* spp.), and prickly ash (*Zanthoxylem americanum*) had developed under the taller canopy.

Although the observations of Christiansen and Swinconos were 17 years apart, both mentioned elm and ash as principal canopy species. Christiansen described white oak as a "prominent" species regenerating in the old field in 1980, but Swinconos mentioned only "a few" white oaks in the young forest that he saw in 1997. Both mentioned red oak as a minor component of the vegetation that they observed.

1997 acquisition

This recent acquisition (associated with purchase of the Sager's Museum property in the northeast corner of the park) was an entirely open pasture in 1936. By 1992, a strip flanking a small drainageway had become forested (comprising about 30% of the overall tract) while the adjacent upland was still a mowed, grassy area. Swinconos (1997) determined that the forested swale was strongly dominated by small black locust (*Robinia pseudoacacia*) trees intermixed with boxelder (*Acer negundo*), elm (*Ulmus* spp.), and cottonwood (*Populus deltoides*). He estimated the average tree diameter as 6 inches and the stand basal area as 100 square feet per acre. The age of the stand is unknown, but dense trees are visible in the 1992 aerial photograph, indicating only that they are over 10 years old today. Woody plants in the understory included boxelder, mulberry (*Morus* sp.), and elderberry (*Sambucus canadensis*). Swinconos observed that young black locust sprouts were rapidly advancing into the adjacent open field.

Comparison of formerly grazed forest to old-growth forest

The presence of both mature, old-growth forest and immature, second-growth forest presents an opportunity to compare their dominant species and infer the effects of post-settlement land use on forest composition. The old-growth stands were either never cut or else were cut immediately after initial pioneer settlement in the mid-1800's and then allowed to develop into a mature condition by 1936. It is unclear if the old-growth stands were grazed, but they developed on land that had not been previously grazed by domestic cattle. In contrast, the remaining forests in the park are known to have developed later on land that had been grazed. Grazing on these areas was sufficiently heavy in intensity and long in duration to reduce tree density to only scattered individuals or patches (where they had not been entirely removed) by 1936.

Presumably, had they been spared the effects of prolonged grazing, the forests regrowing on pastures would today have resembled the mature, old-growth remnants. However, this is not the case. Data collected by Christiansen (1981) and Swinconos (1997) reveal that the mature, old-growth stands are today dominated by white oak, red oak, and sugar maple. In contrast, the dominant tree species in the three younger, grazing-influenced stands in the parks are:

black locust, elm, and boxelder in stand released from mowing at least 10 years ago,

elm and ash in a stand released from grazing 25 years ago,

elm, ash, walnut, and sugar maple in stands released from grazing 70 years ago.

Compared to the composition of the mature, old-growth forests, the immature, second-growth stands lack the dominance of white oak and red oak. The second-growth stands also display a unique and consistent importance of elm trees. Ash and walnut are also found prominently in the older former pastures but not so in the mature, old-growth forest.

The lack of white oak and red oak indicates that these species have failed to redevelop on land that was used extensively as pasture in the 1900s; the reasons for their failure to thrive in the modern, post-grazing forest are not entirely clear, but may be related to the interplay of fire suppression, deep shade, competition with other trees, deer browsing, and other factors. In contrast, elm, ash, and walnut have colonized the old pastures and are today more abundant than is typically found in old, undisturbed forests; these three species are common, long-lived invaders of old pastures throughout the state. Sugar maple is abundant in the 70-year old forests that developed in an open pasture and in a partially forested pasture; it is a highly shade tolerant species that thrives in the deeply shaded conditions typical of forests which have been protected from cutting and grazing for many decades.

OTHER VEGETATION TYPES

Although upland forests discussed in the preceding sections cover most of the area in the park, the scenic canyon along Raccoon Creek is the area most often seen by park visitors. Moreover, it contains plant communities on cliffs and floodplains that do not occur elsewhere in the park.

Bottomland Forest- Narrow alluvial deposits in the floodplain of the Raccoon Creek valley are occupied by bottomland forest vegetation. The dominant trees are walnut (*Juglans nigra*), elm (*Ulmus* spp.), ash (*Fraxinus* spp.), hackberry (*Celtis occidentalis*), boxelder (*Acer negundo*), and cottonwood (*Populus deltoides*) (Christiansen 1981, Swinconos 1997). These bottomland species are also prevalent in the immature, second-growth forests that developed on former pastures and may have rapidly invaded the uplands from the bottomlands following abandonment of the pastures. Common herbaceous plants are wood nettle (*Laportea canadensis*), pale touch-me-not (*Impatiens pallida*), honewort (*Cryptotaenia canadensis*), black snakeroot (*Sanicula* spp.), cleavers (*Galium aparine*), hog peanut (*Amphicarpaea bracteata*), and thin-leaved coneflower (*Rudbeckia triloba*). At total of 85 plant species have been identified in the bottomland forest community (Christiansen 1981).

Cliffs- The steep and sometimes vertical bluffs of the canyon walls contain a complex of plant communities associated with rock outcrops and thin soils over bedrock. Christiansen (1981) identified three specific communities, whose descriptions are quoted below:

> *Rock-covering community*- "Carpets of moss on rocks and boulders furnish the substrate for a vascular plant community dominated by clearweed (*Pilea pumila*), bladder fern (*Cystopteris bulbifera*), wood nettle (*Laportea canadensis*), pale touch-me-not (*Impatiens pallida*), walking fern (*Asplenium rhizophyllum*), Virginia creeper (*Parthenocissus virginiana*), wild ginger (*Asarum canadense*), hepatica (*Hepatica acutiloba*), and zig-zag goldenrod (*Solidago flexicaulis*). On the ledges of the rock walls, colombine (*Aquilegia canadensis*) and harebell (*Campanula rotundifolia*) are common. A [rare] species, Sullivantia (*Sullivantia sullivantia*), is found in this habitat. Monkshood (*Aconitum novaboracense*), a [federally threatened] species is known from this habitat on a rock wall ledge. Canada yew (*Taxus canadensis*) grows only at the lip of the gorge and on the upper rocky ledges." Christiansen (1981) identified a total of 50 plant species occurring in this community.
>
> *Prairie openings or "glades"*- "Several openings too small to map contain prairie vegetation. These openings are on shallow soil, often on the ends of ridges which slope toward the south or southwest. Quite a large number of species are present with grasses such as big bluestem (*Andropogon gerardii*) and sideoats grama (*Bouteloua curtipendula*), composites such as asters and goldenrods, and numerous other species." Nearly 50 plant species were identified by Christiansen (1981) as occurring in this community.
>
> *Juniper stands*- "Near the lip of the gorge on shallow soils, a community dominated by eastern red cedar (*Juniperus virginiana*) occasionally develops. Cedar furnishes most of the cover. Characteristic species include false Solomon's seal (*Smilicina stellata*), northern bedstraw (*Galium boreale*), and sedge (*Carex eburnea*). This community should not be confused with eastern red cedar acting as a successional species invading grassy areas. On these rocky soils, it appears that cedar dominates because of its drought resistance and the associated species can tolerate the complex of conditions including soils and those imposed by the cedar overstory." Only about 15 plant species were identified by Christiansen (1981) as occurring in this community.

LITERATURE CITED

Anderson, Paul. 1996. GIS research to digitize maps of the Iowa 1832-1859 vegetation from General Land Office township plat maps. Final report (phase four of four) to the Iowa Department of Natural Resources, Des Moines, Iowa.

Christiansen, Paul. 1981. Flora and vegetation, *in* Hinman, E. and P. Christiansen, Natural resource study of Maquoketa Caves State Park, Jackson County, Iowa. Report to Iowa Conservation Commission. 67 pp.

LaVan, Mark. 1992. Soil survey of Jackson County, Iowa. USDA Soil Conservation Service, Washington, D.C. 279 pp. + 96 maps.

Miller, Michael. 1995. Analysis of historic vegetation patterns in Iowa using Government Land Office surveys and a Geographic Information System. Masters thesis, Iowa State University, Ames, Iowa. 135 pp.

Swinconos, Steven. 1997. Forest stand mapping of Maquoketa Caves State Park. Unpublished notes.

HISTORY OF MAQUOKETA (MAQUAWEUTAW *) CAVES STATE PARK

Wayne Buchholtz

Park Superintendent, Unit 9
State Parks/Recreation Areas/Preserves Division
Iowa Department of Natural Resources.

> *"The great Niagara Falls, the Mammoth Cave of Kentucky, the wonderful Yosemite Valley and the Grand Canyons of the Rockies are ever unfolding their hidden treasures of beauty and grandeur. But, in the middle west, near the center of the Mississippi River Valley in a quiet little country place almost unnoticed by the casual passer-by is a small wonderland known as Burt's Caves later as the Morehead Caves . . . Burt's Cave or Caves as they would be more commonly named, are located nine miles northwest of Maquoketa in one of the wildest and most romantic spots in the State Of Iowa."*
>
> (from *The History of Jackson County*)

> *"Passing over on the side of the mountain, we come again to the entrance having once passed through the hill. At the right of the entrance is another aperture, probably one hundred and fifty feet wide, one thousand feet long, with the lowest arch high enough to walk under conveniently, and without stooping. This cavern is hardly less interesting to the spectator than the tunnel through which we have just passed. In one part of it is a beautiful, flat prominence known as the ballroom, where the light, fantastic toe is merrily tripped, at times, hour after hour. Here we gathered specimens, which we cannot describe save to say they are beautiful and we prose them. Passing through this cavern, we some seventy-five feet into a ravine where the banks on either side are solid rock, and, extending up several hundred feet, make as grand scenery as the eye desires to behold. Then we reach the entrance to still another cave. We entered this but a few hundred feet. Beyond us we should judge from the sound, a young Niagara. Here there have been less explorations made than anywhere else about the mountain. But, viewing the entrance from without, and taking a hasty survey of the height and breadth of this elevation, we predict that here will be found the greatest wonders of all this mountainous region."*
>
> (quote from Judge Thayer published in the *Clinton Age*)

These two quotations from explorers of the Maquoketa Caves area over 100 years ago still describe reactions of today's park visitors. Not quite a mountain or Niagara Falls, Maquoketa Caves is a natural landform unique to Iowa. The first visitors to view the natural wonders of the area that is now known as Maquoketa Caves State Park were prehistoric native North Americans, a thousand years ago or more. By the 1800s, recognizable American Indian tribes such as the Sac and Fox were using the caves for shelter and ceremonies. Frank E. Ellis (1933), an early park custodian, wrote

> *The great underground passages were thousands of years ago the homes of prehistoric people. This fact has been proven by the many discoveries of stone, flint, bone and horn artifacts that have been washed out from time to time by flood waters. These caves are wonderful rooms and passage-ways which made warm shelter in winter and cool havens in summer for these ancient folk who loved them for the homely protection they offered them.*

For more information on the prehistoric residents of the area, see the article by Joe Artz on page 51 of this guidebook.

The first historic rediscovery of the caves came in 1834 when two “mountain men” moved through the area with their families. The story of this discovery by Joshua Bear and David Scott is recounted in their own words in the *History of Jackson County*, and reproduced by Henry (1993). While on an early evening hunting trip, the men were following a herd of deer down the valley of Raccoon Creek when the deer led them down a steep-walled canyon. Reaching the end of the canyon they discovered that the deer had disappeared into a cavern. Since darkness was falling and the deer had no route to escape except past them, the men decided to build a camp fire in the mouth of the cave to prevent the deer’s escape, then taking them in the morning light. Upon waking the next morning the two discovered the deer had escaped though a second cave outlet. The men had rediscovered what is now Dancehall Cave.

Since then many visitors and explorers have followed. As early as 1844 a minister, the Reverend William Salter, was exploring the caves and describing what he discovered. By 1860 the area, then known as Burt’s Caves, had become a popular area for picnics, exploring, and dances. Tour groups would come in buggies, and in 1868 a dance floor was built north of the Natural Bridge (near Dancehall Cave) in a scenic valley. Between 1870 and 1890 a pavilion was constructed, as well as a concession and other buildings.

A Chronology of Maquoketa Caves State Park

from Henry (1993, p13)

Prehistory	unknown indigent people use the caves; artifacts from everyday life are later found in the caves
Up to 1831	Sac, Fox, Sioux, and Winnebago Indians in the area, perhaps using Dancehall Cave for Councils
1832	the “Black Hawk Purchase”; Native Americans forced to move on
1837	Joshua Bear and David Scott rediscover Dancehall Cave while hunting
1844	Reverend William Salter explores the caves
1860s	the caves and surrounding region becomes a popular recreation spot; a dance pavilion is built
1919	Iowa State Board of Conservation recommends the property above the caves be purchased for a proposed state park
1921	first land secured from private ownership; name changes from ‘Bart’s” or “Morehead’s” Caves to Maquoketa Caves
1931	additional land purchased
1933	official dedication of park
1930s	CCC camps work on park improvements
1940s	WPA continues projects in park
1960s – 1970s	Park doubles in size
1981	Much flood damage to Dancehall Cave
1982-1983	Repairs carried out by residents of the Iowa Men’s Reformatory in Anamosa
1991	Maquoketa Caves State Park nominated and accepted for inclusion in the National Register of Historic Places

In 1919, Maquoketa residents and organizations began a concerted effort to make the Burt’s Caves area a state park. In 1919 the Iowa State Board of Conservation recommended the purchase of the land that included Burt’s Cave, in response to suggestions from the Fine Arts Club of Maquoketa that the area be made into a state park. In 1921, the Maquoketa Chapter of the Iowa Federation of Women’s Club secured an option on 16.95 acres of the land, including the natural bridge and most of the caves (Scheffler, 1992). At about this time the name “Maquoketa Caves” began to be applied to the area. Although it was not yet officially a state park, the area’s geologic wonders began to attract many visitors. As the number of visitors increased the need for appropriate management of the area became apparent, and in 1928 Frank E. Ellis was appointed honorary custodian. He was greeted with a donation of $2000, raised by the Isaac Walton League for improvement of the facilities (Henry, 1993). In 1931 an additional

67.67 acres of land were acquired, increasing the park size to 111 acres. On Friday, October 13, 1933 Maquoketa Caves State Park was formally dedicated. The dedication was a gala event, witnessed by about 2,000 spectators with the usual contingency of dignitaries. Thomas Henry (1993, p. 10-11) described the dedication ceremony.

> *Just try to imagine the excitement! The obligatory brass band kicked things off (the Maquoketa Boy Scouts Band), along with a drill by American Legion Drum and Bugle Corps. This was followed by an invocation given by the Reverend G.F. Barsalou. And then the big event, the presentation of Maquoketa Caves State Park to the State of Iowa from Mrs. Henry Frankel who was "chairman" (according to the program notes from that day) of the Iowa State Board of Conservation. The acceptance and dedication was made by the Honorable Clyde L. Herring, Governor of Iowa in 1933. And of course, the singing of some patriotic songs topped off the event.*

The dedication of Maquoketa Caves State Park during the Great Depression afforded the opportunity for many early improvements of facilities and infrastructure. Between 1934 and 1937 the Civilian Conservation Corps (CCC) worked on numerous trails, erosion control, construction of picnic shelters, and other improvement projects. They also cleared cave passages and created a new creek channel through Dancehall Cave where they installed the first electrical lighting. From 1938 to 1941 the Works Progress Act (WPA) continued improvements after the CCC's moved out. The park saw picnic and parking facilities added and expanded. The enclosed stone shelter and concession lodge (Fig. 2) was constructed and a picnic area built near Dancehall Cave. Additional trails were added to give the park visitor further areas to explore. The stone entrance portals (Fig. 1) and retaining wall with fire places (picnic circle) were added at the this time to create a park that brought 1000's of visitors to the park each year. The park continued seeing improvements with additional picnic shelters, sidewalks, steps and handrails added. Eventually camping would become a main attraction to the park. Additional land purchases in the 1960s and 1970s expanded the park to its current size of 272 acres.

Figure 1. Stone portal at park entrance

But, many of the early facilities were damaged repeatedly by human and natural activity. The park's main attraction, Dancehall Cave suffered serious flood damage in 1939 and again in 1981. On both occasions, repairs were made, with the assistance of labor provided by the Iowa Men's Reformatory at Anamosa. The damage from the 1981 flood was so substantial that the cave was closed to the public for over a year, with clean up, reinstallation of the electric lighting, and building new walkways and retaining walls not completed until 1993. The increase in park visitation through the years has also taken its toll on the facilities constructed in the 1930's and 1940's. Trails and other facilities have been repeatedly closed for minor repairs or improvements.

In 1993, the Iowa Department of Natural Resources began a major master planning study to redevelop the park and add modern facilities. The lodge concession

Popular caves and formations not listed or mentioned in the park brochure

- Shinbone Cave
- Hernando's Hideaway Cave
- Wide Mouth Cave
- Steel Gate Passage in Upper Dancehall
- Bat Passage in Upper Dancehall
- Wye Cave
- Match Cave
- Up and Down Cave
- Barbell Cave
- Fat Man's Misery (a mechanical cave)
- Tall Man's Misery (a mechanical cave)

was converted to a shelter and restroom combination. A new modern restroom was constructed in the main picnic area replacing the former pit vault latrine constructed in the 1950's. Two shelter houses were remolded making one handicapped accessible along with other buildings. The camp area was converted from a primitive camp area to a modern camp area with showers, restrooms, running water and electrical hookups. There are 28 back-in sites, 14 with electricity and 6 walk-in sites available throughout the year. Modern potable water and wastewater facilities were added to the park to increase capacity and efficiency to State Code standards. The park office and service building was constructed near the former park ranger's residence. Additional property was also added at the entrance of the park, including the former Sager's Museum, which was converted into the park's interpretive center.

Figure 2. Park concession building as it appeared in the late 1960s.

During the 1993-2000 redevelopment period, crews worked on repairing, replacing and improving the maize of foot trails throughout the park. Some trails were reopened after having being closed for many years because of their poor condition. Boardwalks replaced the deteriorating old fire escapes and rock steps where trails went up the bluffs. Railroad tie steps replaced wash outs and eliminated erosion.

HIGHLIGHTS OF CAVES AND FEATURES EXPLORED AFTER THE AREA BECAME KNOWN AS MAQUOKETA CAVES.

The Palisades: "*Approaching the south entrance or opening we look out again into the brightness of day, and behold one of the most beautiful scenic panoramas we have ever gazed upon. Our eyes become tired from the magnificent beauty of it all and we can scarcely lead ourselves to believe that we are in Iowa, far separated from the mountains and gorges of mountainous regions."*

A Bottomless Pond: *"Right near the Big Spring is a pond of water which is some 30 - 40 feet in circumference. In passing one gives it only a casual glance, but no one has yet been able to ascertain its depth. A large rock tossed into its center gives only the deep bass boom of deep water. For years tourists have been tossing large stones into this pond without lessening its depth whatever."*

The Grotto: (Upper Dancehall) *"Long before we reach the bottom we stop to look across the intervening space. High up above our heads tower the great solid rock dome of The Grotto. We gaze with awe and feel we are standing before a grandeur majestic sublime beyond the power of words or pen."*

The Natural Bridge: *The Natural Bridge, in all its realistic and imposing grandeur, spanning the gorge through which a fairy mountain brook wend its way out into the Grotto and thence into the subterranean depths below.... Right near the Natural Bridge has been erected a large pavilion for dancing - a building 50-100 feet with an excellent hard wood floor. Around this building are clustered other smaller ones used as lunch stands and booths; a large elevated platform for speakers or programs, and many seats, making this an ideal place for picnics, celebrations, meetings, etc.*

In 2000 additional improvements were planned and in 2001 a new Organized Youth Camp Area was added across from the park office. A new check in station was completed in 2001 to accommodate campers seeking information. A major clean up was initiated and efforts are underway to improve the natural resources throughout the park. A tall grass prairie is planned to be planted near the wastewater facility. Vistas and lookouts will be cleared to bring back the view found when the Civilian Conservation Corp first constructed the shelters at key areas and bring the park facilities into the 21st century.

Maquoketa Caves has had various names over the years. The Fox and Sac tribes gave the area the name of **Horse Thief Cave**. Later the name **Burt's Caves** and **Morehead Caves** would become common. These names were taken from J.B. "Burt" Morehead explorer and owner of part of the caves. The name Maquoketa Caves is derived from the Mesquakie words of "Maqua" meaning medicine and "keto" meaning place. A second meaning from the Fox Indians uses "Mako" meaning bear and "keta" meaning river - so named because of the many bear along the Maquoketa River.

CAVES KNOWN FROM THE MOREHEAD DAYS

From souvenir brochure "Morehead Caves (Formally Burt's Caves)

- ***The Devil's Cavern*** (Middle Dancehall)
- ***The Pulpit*** (found in Middle Dancehall Entrance)
- ***The Big Tunnel*** (cave between Middle and Lower Dancehall entrances)
- ***The unexplored Cave*** (unknown location within the Big Tunnel)
- ***The Dancehall*** (Just before you leave the lower entrance)
- ***The Palisades*** (the south valley with high rock walls)
- ***Balanced Rock*** (same location and name today, only accessible)
- ***The Big Spring*** (Tourist Delight, now closed to the public to preserve formations)
- ***The Bottomless Pond*** (eroded away, thought to be just below Tourist Delight)
- ***Bear Cave*** (Rainy Day Cave)
- ***Ice Cave*** (same name today)
- ***Lookout Point*** (still there, but covered with vegetation)
- ***The Tombs*** (Found throughout the south valley and visible when vegetation dies off)
- ***The Grotto*** (Upper Dancehall entrance)
- ***The Natural Bridge*** (same name and location, there are three other smaller natural bridges)
- ***Spirit Valley*** (north valley leading up stream)
- ***Cathedral Rock*** (Twin Arches)

Many of the caves have been given new names over the years. All the known caves have been explored over the years by 1000's of visitors. In 2000 a new cave was discovered following the formation of a sink hole. The cave was explored by park staff and professional cavers and was given the name ***"Millennium Cave".*** As new caves have been discovered so has the park changed in many ways. Maquoketa Caves State Park is a major attraction in Eastern Iowa. Whether Maquoketa means 'medicine place' or 'bear river' the park provides a sense of closeness to nature through its flora and fauna and extraordinary beauty. Its past has been long, from the formation of the caves beginning millions of years ago and continuing today to its recent history of discovery, exploration and utilization during the last century. Maquoketa Caves continues to be the Niagara, Yosemite, Mammoth Cave and Grand Canyon of the Iowa landscape.

Enjoy Maquoketa Caves State Park!

REFERENCES

Ellis, Frank E., 1933, Official program for the Dedication of Maquoketa Caves, Jackson County, October 13, 1933.

Henry, Thomas, 1993, A Guide to Maquoketa Caves State Park; published by Iowa Department of Natural Resources, Des Moines, Iowa, 71 p.

History of Jackson County 1879, Western Historical Company 2. Quote from the Clinton Age paper by Judge Thayer of Maquoketa Iowa

Scheffler, Jim, 1992, Have You Heard . . .?: *Iowa Conservationist*, May 1992, p17.

Souvenir brochure "Morehead Caves (Formally Burt's Caves)

WILDLIFE IN THE AREA OF MAQUOKETA CAVES STATE PARK

Raymond Anderson
Iowa Department of Natural Resources
Geological Survey Bureau

Maquoketa Caves State Park is considered by some people to be one of the best sites for bird and animal watching in Iowa. The lush forests, limestone bluffs, and cool streams in the park, in conjunction with nearby farm fields and prairie regions, provide a variety of habitats and food sources that support a wide diversity of animals. One of the best descriptions of the animals in the park is found in Thomas Henry's *A Guide to Maquoketa Caves State Park*, and this narrative draws much of its information from his publication.

Birds of Maquoketa Caves State Park

Many of the birds commonly observed in much of Iowa are also seen at Maquoketa Caves State Park. One-such frequently observed bird is the house (or English) sparrow (*Passer domesticus*), which perches and nests in some of the larger caves. This bird is not truly a sparrow, but a weaver finch, introduced into America from Europe in the 1860s. Other common birds include black capped chickadees, white breasted nuthatches (*Sitta carolinensis*), downy woodpeckers (*Picoides pubescens*), and catbirds (*Dumetella carolinensis*). The chickadee's "*dee-dee-dee*" song may be heard during the fall field trip, but their more melodic "*pee-pee*" call is most frequently heard in the spring and summer. The song of the charcoal gray, white, and black nuthatch is weak and hard to hear. But, these nimble birds are easy to spot as they scamper up and down trees, often walking upside down along branches in search of an insect dinner. Another bird that might be observed walking up the trunk of a tree is the downy woodpecker, a small woodpecker with striking black and white markings. Male downy's display a brilliant red spot on the back of their heads. The songs of the stately black and gray catbirds (sounding much like mockingbird) are as varied as they are beautiful, frequently continuing for long periods of time without repeating phrases. One commonly heard sound is a cat-like "*meow*" that gave the bird its name.

Figure 1. White Breasted Nuthatch

Figure 2. Catbird

Figure 3. Tree Swallow

A variety of brightly colored birds are common in the park in the summer, including the indigo bunting (*Passerina cyanea*), a small brilliantly blue bird, perhaps one of the brightest colored birds that frequents Iowa, and ruby throated hummingbirds who display the full range of their aerial skills as they drink nectar from the park's many wild flowers. Bright red northern cardinals (*Cardinalis cardinalis*) live in the park as do orange-breasted American robins (*Turdus migratorius*) and the Iowa state bird, the

American goldfinch (*Carduelis tristis*). Many of the cardinals, robins, and gold finches winter over in the Maquoketa Caves State Park area. The goldfinches shed their brilliant yellow color in the fall, in favor of drab olive and white plumage for the winter. The American crow (*Corvus brachyrhynchos*), and the blue jay (*Cyanocitta cristata*) are also frequently observed birds in the park.

House wrens (*Troglodytes aedon*), tiny brown birds with distinctive cocked up tail, also make Maquoketa Caves State Park their seasonal home. Their loud, bubbling song is usually heard well in advance of an actual sighting. Barn swallows (*Hirundo rustica*) with their orange throat and breast and Tree swallows (*Tachycineta bicolor*) with a white breast and greenish back are two of several varieties of swallows that can be seen in the park

Many other birds can also be observed by the fortunate park visitor (see checklist at end of this article). These include the northern oriole (*Icterus galbula*), once referred to as the Baltimore oriole, and the eastern wood peewee (*Contopus virens*), an attractive flycatcher. Peewee have been reported near Barbell Cave in the summer, where their airborne antics in the pursuit of insects can be hilarious.

Mammals of Maquoketa Caves State Park

A variety of mammals make Maquoketa Caves State Park and the surrounding area their home. These includes large mammals, smaller mammals, and rodents. The only large mammal known in the park is the white tailed deer. It was the lure of a deer hunt that led the first non-Indian humans down the valley of Raccoon Creek to the area that would become the State Park. Joshua Bear and David Scott were described by Henry (1993) as "mountain men" living off the fat of the land with their families in 1837. One evening they pursued a herd of deer down a steep ravine with no other apparent route of escape for their prey. Upon reaching the termination of the valley they discovered that the deer had taken refuge in a cave, and since night had fallen, they decided to make a campfire at the mouth of the cave to trap the deer then capture them at first light. Later that evening their dogs treed a large animal thought originally to be a raccoon, but upon confrontation proved to be a panther (probably a mountain lion), which they killed. Panthers are not no longer known to inhabit eastern Iowa. When morning arrived, the men discovered that their deer had escaped out the back entrance of the cave, now known as Dancehall Cave.

Figure 4. Woodchuck

The next largest mammal found in the park is the woodchuck, also known as a groundhog but more accurately called a marmot. These animals, the size of a small dog with elegant brown fur, live year around in the park, hibernating in winter. The animals look friendly and cuddly, but like all wild animals can inflict serious injuries with their sharp teeth and claws. Red squirrels are common throughout the Park, which provides an abundance of trees and food for the animals. However the gray and black colored squirrels that are seen in other areas of Iowa are only rarely observed within the boundaries of the Park. Chipmunks are another animal that is abundant in Maquoketa Caves State Park. These active and extremely handsome animals burrow under brush, building dens in which they store large volumes of food for use in times of need. Chipmunks are frequent foragers in campgrounds and picnic areas where human food scraps are prized additions to their natural diet. Several varieties of mice also live in the Park. Field mice are perhaps the most common inhabitants of the park. These sleek little animals with the large black eyes are a favorite food for owls and hawks in the park. One of the more unusual mice in the park is the "jumping" mouse, a beautiful olive-colored animal with a darker stripe running down its back that leaps into the air like a kangaroo and are members of the family Dipodidae (which includes gerbils). Also called the kangaroo mouse, the jumping mouse has long hind legs and tail that enable it to leap distances up to 12 feet. Jumping mice have gray to brown fur and are white underneath. They can scurry as well as leap and are good swimmers. Solitary, nocturnal animals, they are found in marshes and on stream banks in coniferous and deciduous forests of both coasts of North America and also in fields and pastures. Two genera, *Zapus* and *Napaeozapus*, are North American, ranging from the Arctic Circle South to New Mexico and Tennessee; a related genus, with one species, *Eozapus setchuanus*, the Szechuan jumping mouse, is native to China. Jumping mice feed on a diet of grass seeds, fruit, and insect larvae. They gain weight in autumn and hibernate in fur-lined burrows during winter. Litters, containing from three to six young, are born in late spring. Jumping mice are classified in the phylum Chordata, subphylum Vertebrata, class Mammalia, order Rodentia, family Zapodidae (Columbia Electronic Encyclopedia, 2000). Henry (1993) reported an October 1992 observation of one of these mice as it "boinged" across a path near Ice Cave.

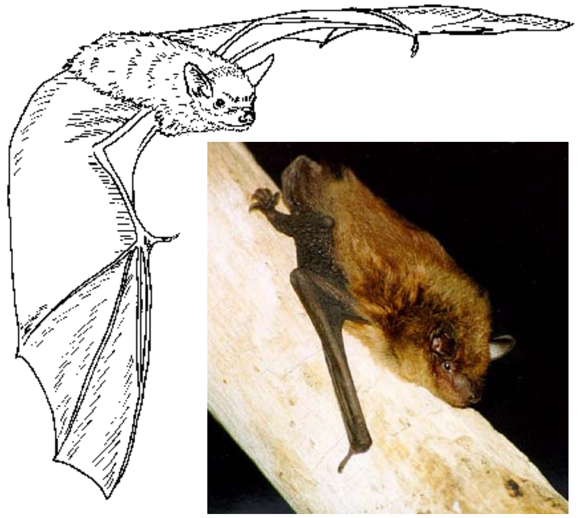


Figure 3. Sketch and photograph of the big brown bat.

A large number of bats also make Maquoketa Caves State Park their home. No list of the species that have been observed at the Park was available for this guidebook, but some of the species are described in a DNR pamphlet called the *Guide to the Bats of Iowa* (Laubach and others, 1994). This pamphlet mentions the presence of hibernating clusters of hundreds of Big Brown Bats (*Epteicus fuscus*) at Maquoketa Caves. Big brown bats covered with brown fur and are about 3.5-5 inches long with a wingspan of 13-14 inches. In the summer they emerge shortly after dusk to search for food, primarily beetles and moths but also flying ants, mosquitoes, mayflies, grasshoppers and crickets. They also feed on agricultural pests such as cucumber beetles (whose larvae are corn rootworms), June beetles, green and brown stink bugs, and leafhoppers (Laubach and others, 1994). The big brown bat is perhaps the only species of bat in Iowa that appears not to be threatened with extinction. Other bats that may inhabit the caves in the park include red bats (*Lasiurus borealis*), hoary bats (*Lasiurus cinereus*), Eastern Pipistrelle (*Pipistrellus subflavus*), northern myotis (*Myotis septentrionalis*), Indiana myotis or Indiana bat (*Myotis sodalis*), and the little brown bat or little brown myotis (*Myotis lucifugus*). Henry (1993) reports as many as 3,000 bats swarming from a single cave passage at nightfall. These bats do not harm people, in fact they may eat as many as 1,000 mosquitoes an hour, and a Texas study reported that a single large colony of bats may eat more than 250,000 pounds of insects every night.

REFERENCES

Henry, Thomas, 1993, *A Guide to Maquoketa Caves State Park*. Iowa Department of Natural Resources, Des Moines, Iowa, 71 p.

Laubach, Christyna M., Bowles, John, and Laubach, René, 1994, *A Guide to the Bats of Iowa*. Nongame Technical Series No. 2, Iowa Department of Natural Resources, Des Moines, Iowa, 32 p.

The Columbia Electronic Encyclopedia, Sixth Edition Copyright © 2000, Columbia University Press. http://www.encyclopedia.com/articlesnew/24740.html 9 October, 2001

MAQUOKETA CAVES STATE PARK ANIMAL CHECK LIST (FROM HENRY, 1993)

Birds

☐ Wild Turkey
☐ Ring Necked Pheasant
☐ Bobwhite Quail
☐ Mallard
☐ Wood Duck
☐ Canada Goose
☐ Hooded merganser
☐ Ruddy Duck
☐ Pied Billed Grebe
☐ American Egret
☐ Green Heron
☐ Great Blue Heron
☐ Black Crowned night Heron
☐ American Bittern
☐ Killdeer
☐ Starling
☐ Screech Owl
☐ Sparrow Hawk
☐ Great Horned Owl
☐ Barred Owl
☐ Morning Dove
☐ Blue Jay
☐ Cliff Swallow
☐ Bank Swallow
☐ Barn Swallow
☐ Tree Swallow
☐ Purple Martin
☐ American Crow
☐ Black Capped Chickadee
☐ Tufted Titmouse
☐ Evening Grosbeak
☐ House Wren
☐ Catbird
☐ Brown Thrasher
☐ American Robin
☐ Eastern Bluebird
☐ Turkey Vulture
☐ Whip-poor-will
☐ Nighthawk
☐ Red Tailed Hawk
☐ Sharp Shinned Hawk
☐ Marsh Hawk
☐ Yellow Billed Cuckoo
☐ Belted Kingfisher
☐ Common Flicker
☐ Northern Oriole
☐ Scarlet Tanager
☐ White Breasted Nuthatch
☐ Rose Breasted Grosbeak
☐ Cedar Waxwing
☐ Indigo Bunting
☐ Wood Thrush
☐ Rails
☐ American Woodcock
☐ Red Bellied Woodpecker
☐ Red headed Woodpecker
☐ Downy Woodpecker
☐ Hairy Woodpecker
☐ Pileated Woodpecker
☐ Yellow Bellied Sapsucker
☐ Red Winged Blackbird
☐ Yellow Headed Blackbird
☐ Cowbird
☐ Bronze Grackle
☐ Bald Eagle
☐ Osprey
☐ Ruffed Grouse
☐ Brown Creeper

☐ Chimney Swift
☐ American Goldfinch
☐ Chipping Sparrow
☐ House Sparrow
☐ Slate Colored Junco
☐ Bobolink
☐ Meadowlark
☐ Horned Lark
☐ Rufus Sided Towhee
☐ Warblers (many kinds)
☐ Cardinal
☐ Ruby Throated Hummingbird
☐ Flycatchers (several kinds)
☐ Vireos (several kinds)
☐ Eastern Wood Peewee
☐ Eastern Kingbird
☐ Eastern Phoebe

Mammals

☐ White Tailed Deer
☐ Fox and Gray Squirrel
☐ Raccoon
☐ Opossum
☐ Cottontail Rabbit
☐ Long Tail Weasel
☐ Mink
☐ Muskrat
☐ Striped Skunk
☐ Spotted Skunk
☐ Badger
☐ Flying Squirrel
☐ Beaver
☐ Meadow Vole
☐ Red and Gray Fox
☐ Coyote
☐ Woodchuck
☐ Pocket Gopher
☐ Thirteen lined Gopher
☐ Norway Rat
☐ Eastern Chipmunk
☐ Little Brown Bat
☐ White Footed Mouse
☐ Deer Mouse
☐ House Mouse
☐ Eastern Mole
☐ Short Tail Shrew

Snakes

☐ Eastern Garter Snake
☐ Northern Water Snake
☐ Bull Snake
☐ Black Rat Snake
☐ Timber Rattlesnake
☐ Massasauga Rattlesnake
☐ Fox Snake
☐ Prairie Ringneck Snake

Amphibians

☐ Eastern Gray Tree Frog
☐ Green Frog
☐ Leopard Frog
☐ American Toad
☐ Eastern Tiger Salamander
☐ Five Lined Skink
☐ Bullfrog
☐ Western Painted Turtle
☐ Snapping Turtle

THE ARCHAEOLOGY OF MAQUOKETA CAVES STATE PARK

Joe Alan Artz
Office of the State Archaeologist
University of Iowa

Since Euro-Americans first became aware of the caves in 1834, thousands of people have visited the area now known as Maquoketa Caves State Park. Few archaeological investigations, however, have been conducted. As a consequence, one of Iowa's most visited parks is also one of its least known, archaeologically.

The Office of the State Archaeologist has records of 14 archaeological sites within the park boundaries. The entire park has not been completely surveyed for sites, and none of the known sites has been extensively excavated. Unlike much of Iowa, where loamy soils yield easily to the shovel and screen, and artifacts can often be found by simply strolling across a plowed field, Maquoketa Caves State Park is not particularly friendly to archaeologists. Woodland vegetation and leaf litter obscures the ground surface, and the valley floors are mantled by sediments deposited in the past 150 years, burying remains from earlier times. In and around the caves themselves, thick deposits of rock fall and talus frustrate excavation. However, a few archaeologists have braved these frustrations, and in so doing have provided us with tantalizing glimpses of not only what the park contains, but also, and perhaps more importantly, what it may contain, in the way of archaeological resources.

PREVIOUS INVESTIGATIONS

The first persons to dedicate themselves to studying the prehistoric past in the Maquoketa vicinity were Frank Ellis (1880-1941), a Maquoketa insurance agent, and Paul Sagers (1909-1982), who was born in Iron Hill north of Maquoketa. Each man in his lifetime amassed an impressive collection of prehistoric artifacts from western Jackson County. In 1925, their work came to the attention of Charles R. Keyes, a professor at Cornell College in Mount Vernon, Iowa. As director of the Iowa Archaeological Survey, Keyes corresponded extensively with both men, and made several visits to sites they had discovered. He encouraged them to label and keep records of their finds (Cordell et al. 1991).

Ellis' collection of at least 16,000 Native American artifacts was unfortunately auctioned shortly after his death, and its whereabouts is unknown (Cordell et al. 1991). After his death, Sagers' collection was purchased by the State of Iowa. It is presently housed in a small limestone museum that Sagers himself built, located near the entrance to Maquoketa Caves State Park. The collection has been extensively studied by archaeologists, including Wilfred D. Logan, whose pivotal study of the Woodland cultural sequence in eastern Iowa was based on ceramics excavated by Sager from the Mouse Hollow and Levsen rockshelters, located near Maquoketa Caves State Park (Logan 1976).

Sagers collected materials from several sites in Maquoketa State Park, but an intensive archaeological survey was not conducted until 1980. That survey, funded by the Iowa State Conservation Commission and the Division of Historic Preservation in the State Historic Department, investigated about 100 of the park's 268 acres. Thirteen sites were recorded and limited test excavations were conducted at several of these (Roetzel et al. 1980). The 1980 survey also included an inventory of standing structures in the park, as well as a preliminary geomorphological study.

Since 1980, few archaeological surveys have been conducted within the park. One additional archaeological site, a trash dump possibly related to WPA or CCC construction projects in the 1930s, was recorded in the course of one of these surveys (Thompson 1993).

THE SITES OF MAQUOKETA CAVES STATE PARK

The known prehistoric sites at Maquoketa Caves State Park are distributed in more-or-less equal proportions among cave, valley bottom, and upland settings. A brief summary of findings in each setting follows.

The Caves

The 1980 survey investigated all the park's caves but found prehistoric cultural materials in only three: Dancehall, Rainy Day, and Ice. Initial testing at Dancehall (13JK52) and Rainy Day (13JK55) caves was disappointing, yielding relatively few artifacts. These materials were not deeply buried, and were mixed with glass and plastic from the historic period. Rainy Day Cave was tested to a depth of at least 50 cm. A test unit at Dancehall Cave (Fig. 1) reached a depth of 172 cm before encountering rockfall, but nearly all prehistoric artifacts were found in the upper 30 cm. The sediments exposed in the test unit profile were described as "highly laminated" flood deposits. Ninety-one small-diameter hand augers provided the basis for an isopach thickness map of the surface deposit of fine-grained sediments that underlies the floor of the cave (Fig. 1). The augers were excavated until rock was encountered, and the depth to the rock was recorded. As shown by contour lines in Figure 1, rockfall is relatively near the surface in the southeast half of the cave, but dips sharply to the northwest. Three areas of thinner sediments in three areas along the northwest wall of the cave may mark massive breakdown deposits. As shown in Figure 1, the test unit was placed in that part of the site where the fine-grained surface layer is thickest. Roetzel et al. (1980) suggest that this broad, low lying area is a former stream channel of Raccoon Creek, which presently flows along the southeast side of the cave.

Initial testing in Ice Cave (13JK56) indicated a richer archaeological record than encountered in the other two caves, and thus this cave was investigated more intensively. A test unit was placed just outside the mouth of the cave, several were placed in the center of the cave's main room, and one was excavated in the smaller room at the back of the cave (Fig. 2). These excavations yielded nearly 900 artifacts, most of which were animal bones and mussel shells. Pottery sherds (n=160) and a small side notched arrow point indicated a Late Woodland occupation that occurred sometime between AD 300 and 1000. An end scraper, a utilized flake, three bone awls, and 22 waste flakes were also recovered. The extensive faunal assemblage included bones of bats, rodents, and other mammals, but unfortunately neither the bones nor the mussel shell have been analyzed to determine the taxa present. A few charred nuts and seeds were also recovered. All the ceramic artifacts were found either in the large "main room" of the cave, or outside the cave. A small, shallow, basin-shaped fire pit was discovered in the main room. The top of this pit was buried only 5 cm beneath the cave floor. The smaller chamber in the back of the cave yielded primarily animal bone. Roetzel et al. (1980) suggest that the cave's entrance and main room were used as living areas, and the back chamber was used primarily for refuse disposal.

The artifact assemblages excavated from these three caves seem meager in comparison to collections from caves located nearby but outside the state park. For example, Sagers' excavations at the Levsen Rockshelter, on the Maquoketa River northwest of the state park, yielded nearly 5,000 potsherds, 1,400 stone artifacts, and 1,600 faunal specimens, dating from Late Woodland through Middle Archaic time (Cordell et al. 1991), a time span of up to 6,500 years. Sagers, however, worked at Levsen on-and-off for 10 years, removing and screening soil from the entire 133 m^2 area of the shelter. In contrast, the excavations at Dancehall, Rainy Day, and Ice Caves in the state park, had a combined area of only about 8 m^2. Differences between these assemblages in terms of the number and variety of artifacts probably reflects, at least in part, the effort expended in excavation.

The 1980 excavations were also relatively shallow. The maximum depth penetrated by any of the test units was 172 cm in Dancehall cave. Excavations halted upon encountering the uppermost layers of roof fall. The thickness of these roof fall deposits, and what may underlie them, is not known.

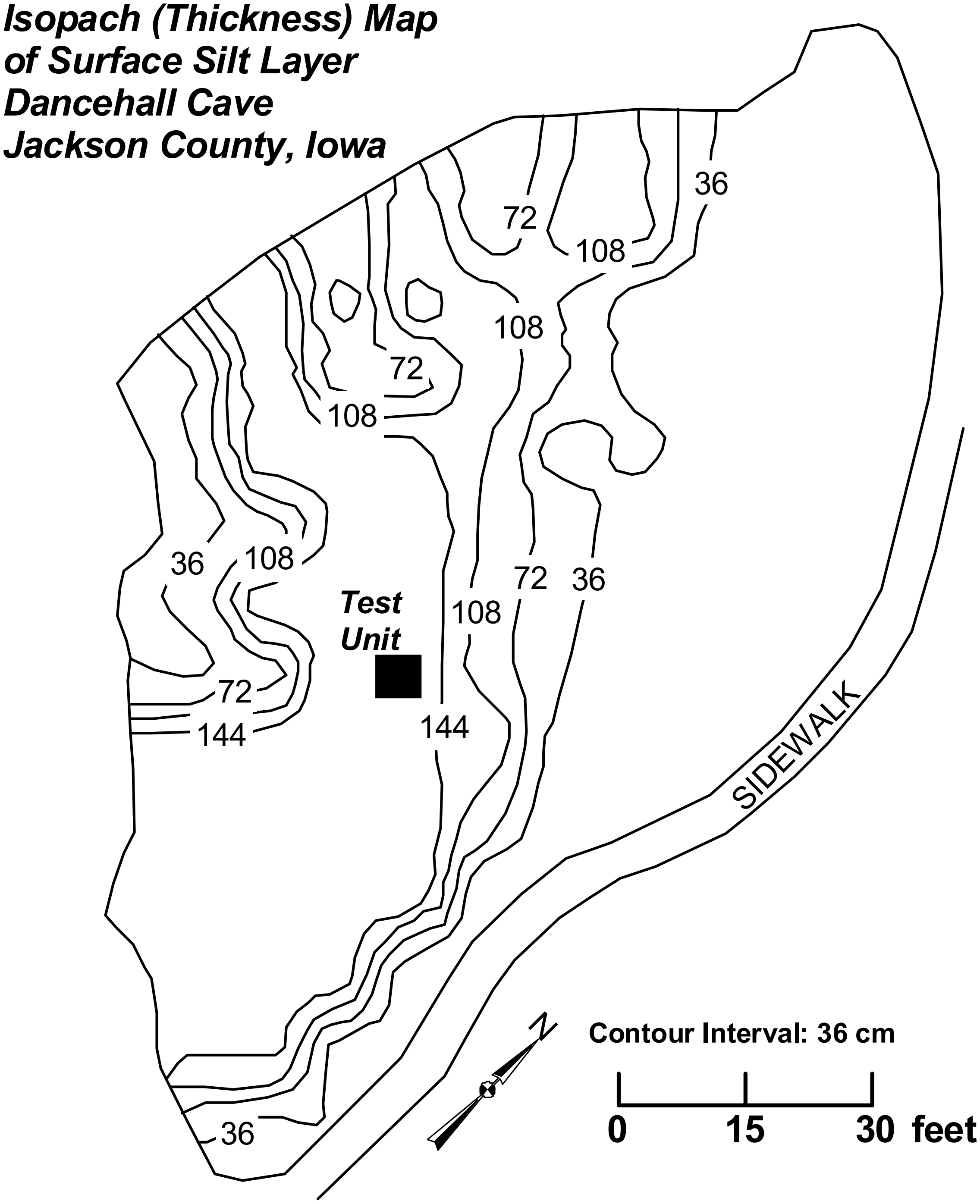


Figure 1. Isopach thickness map of surface layer of fine-grained sediments in Dancehall Cave, Maquoketa Cave State Park. Contours show depth in centimeters to rock layer(s) impenetrable by hand augers. Redrawn from Roetzel et al. (1980: figures 33 and 34).

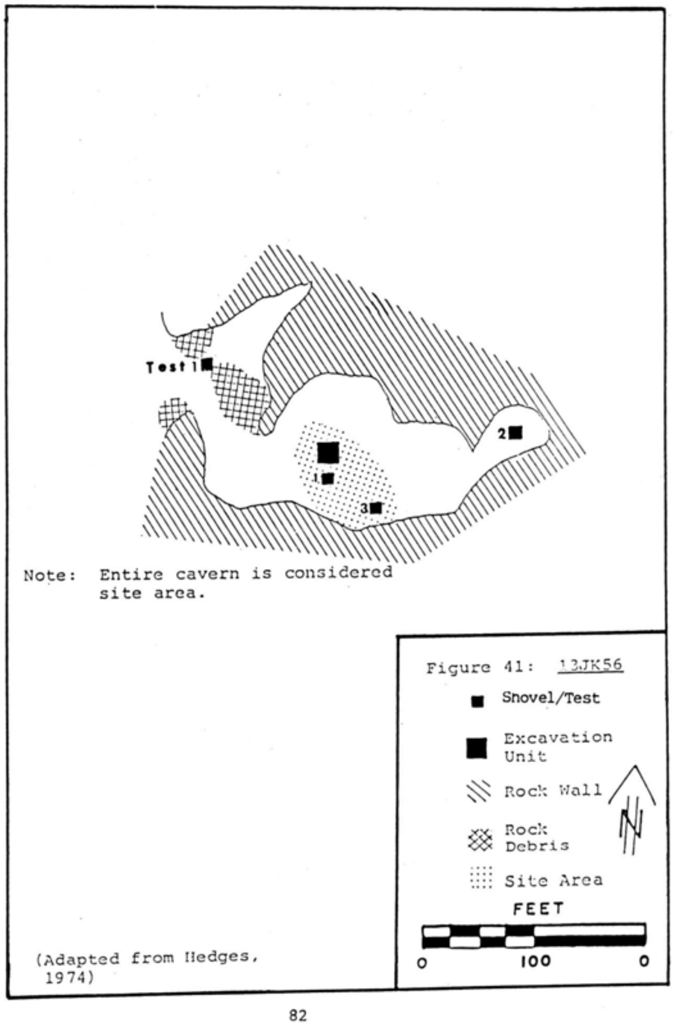


Figure 2. Plan of exacavations, Ice Cave, Maquoketa Caves State Park, Iowa. From Roetzel et al. (1980: Figure 41).

The Valleys

Geomorphological investigations conducted as part of the 1980 survey indicate that the valley floor is mantled by stratified, historic-age alluvium that buries a dark-colored, organic rich A horizon formed in Holocene alluvium. The alluvium is silty in the upper part, grading with depth to sandy loam and sand. Soil profile development in the alluvium (Roetzel et al. 1980) suggests the presence of Late Holocene as well as Early-Middle Holocene sediment packages.

The 1980 survey discovered artifact concentrations at six locations along Raccoon Creek. Three of these "sites," however, consisted of artifacts found on gravel bars and cutbank slump deposits in the stream channel. These artifacts, which were most likely eroded from their original contexts and redeposited by fluvial processes, are tantalizing evidence that a rich archaeological record is deeply buried in the park's valleys.

The only intact buried site encountered in 1980, 13JK57, yielded 13 flakes and one chipped stone biface from a single hand auger test. The artifacts were found at a depth of 90-150 cm in the A horizon of a buried soil, beneath 90 cm of historic alluvium.

Two other valley bottom sites were recorded on the basis of artifacts found on the surface and in shallow shovel tests at locations immediately north of the Natural Bridge (13JK48), and immediately south of the Dancehall (13JK53). The latter of these was first found by Paul Sagers. Both sites are located near and amongst boulder-sized talus detached from nearby rock faces. Like the cave sites, the possibility exists that additional, older prehistoric materials are buried in these talus settings.

The Uplands

The 1980 survey recorded four archaeological sites on upland ridgetops of Maquoketa State Park. One of these, 13JK51, extends for about 150 m along a NW-SE oriented ridge top in the southern part of the park. Of the 73 shovel and auger tests excavated at the site, 23 yielded artifacts. The total number of artifacts recovered from these excavations, however, was only 35 flakes, one of which showed evidence of use as a cutting or scraping tool. These were all found within 40 cm of the ground surface, and most of these (85%) were in the upper 20 cm of the soil.

The other three upland sites recorded by the survey are smaller in extent, ranging in size from 10 to 70 m in their largest dimension. One site yielded a chert scraper. The others yielded flaking debris. In contrast to the valley-bottom and cave sites, none of the upland sites yielded pottery, bone, or shell (Roetzel et al. 1980).

DISCUSSION

The 1980 archaeological survey was successful in documenting the presence of prehistoric archaeological sites in all major landform settings at the park. The sites recorded by the survey indicate relatively brief, perhaps seasonal occupations by prehistoric hunter-gatherers. The pattern appears to be one in which habitations occurred in the valley bottoms, including the caves, while the uplands were used primarily for less intensive activities, perhaps involving resource procurement.

Relatively few sites were found and, with the exception of Ice Cave, these yielded relatively few artifacts. The 1980 survey, however, was by no means intensive or exhaustive. Only about 20% of the park's uplands were surveyed. Except in about 10 acres of cropland, where the ground surface was exposed for direct examination, searching for sites required either shovel testing or raking aside leaf litter from small square plots in an attempt to find artifacts. Given the low artifact density encountered on the four upland sites, other similar sites may have gone undetected by the survey methods used.

A similar conclusion applies to the valley bottoms. The 1980 survey was conducted a few years prior to the adoption by Iowa's archaeological community, of guidelines requiring extensive subsurface testing in areas of thick alluvium. Consequently, although the survey made an effort to probe for buried sites, the extent of that probing would be considered inadequate by present standards. It is likely that other prehistoric sites lie buried in the park's valley alluvium.

The results of testing in the park's caves was undoubtedly disappointing to the 1980 surveyors. None of the sites yielded evidence of the kind of deeply stratified "layer cakes" of multiple prehistoric occupations that one might anticipate in such a setting. Perhaps the largest and wettest caves, located along the foot of the bluffs, are periodically flushed of sediment by the subterranean streams that flow through them. Alternatively, as is often the case in cave and rockshelter sites, the older, deeper occupational records in the cave may be buried beneath layers of rock fall.

REFERENCES CITED

Cordell, John, William Green, and Derrick Marcucci, 1991, The Paul Sagers Archaeological Collection: *Journal of the Iowa Archaeological Society* 38:5-10.

Logan, Wilfred D., 1976, *Woodland Complexes in Northeastern Iowa*: Publications in Archaeology 15. U. S. Department of Interior, National Park Service, Washington, D.C.

Roetzel, Kathleen A., Richard A. Strachan, Robert Douglas, Michael Eigen, and Patricia Emerson, 1980, *An Archaeological and Architectural Historical Survey of Maquoketa Caves State Park, Jackson County, Iowa*. Impact Services, Mankato, Minnesota. Copy on file, Office of the State Archaeologist, University of Iowa, Iowa City.

Thompson, Joe B., 1993, *A Phase I Cultural Resource Survey for Proposed Construction Activities at Maquoketa Caves State Park, Jackson County, Iowa*: BCA 269. Bear Creek Archaeology, Cresco, Iowa.

THE HURSTVILLE LIME KILNS

Raymond R. Anderson
Iowa Department of Natural Resources
Geological Survey Bureau
Iowa City, Iowa

INTRODUCTION

The Hurstville Lime Kilns, located near the intersection of old U.S. 61 north of Maquoketa, were previously visited by a GSI field trip in November 21, 1992 (see GSI Guidebook 56). The site features restored pot kilns, used in the late 1800s to help make the Maquoketa's lime industry famous throughout the Midwest. The four large stone kilns, designed to produce burnt lime, were built against the face of a high bluff in 1875 by Alfred Hurst (Fig. 1).

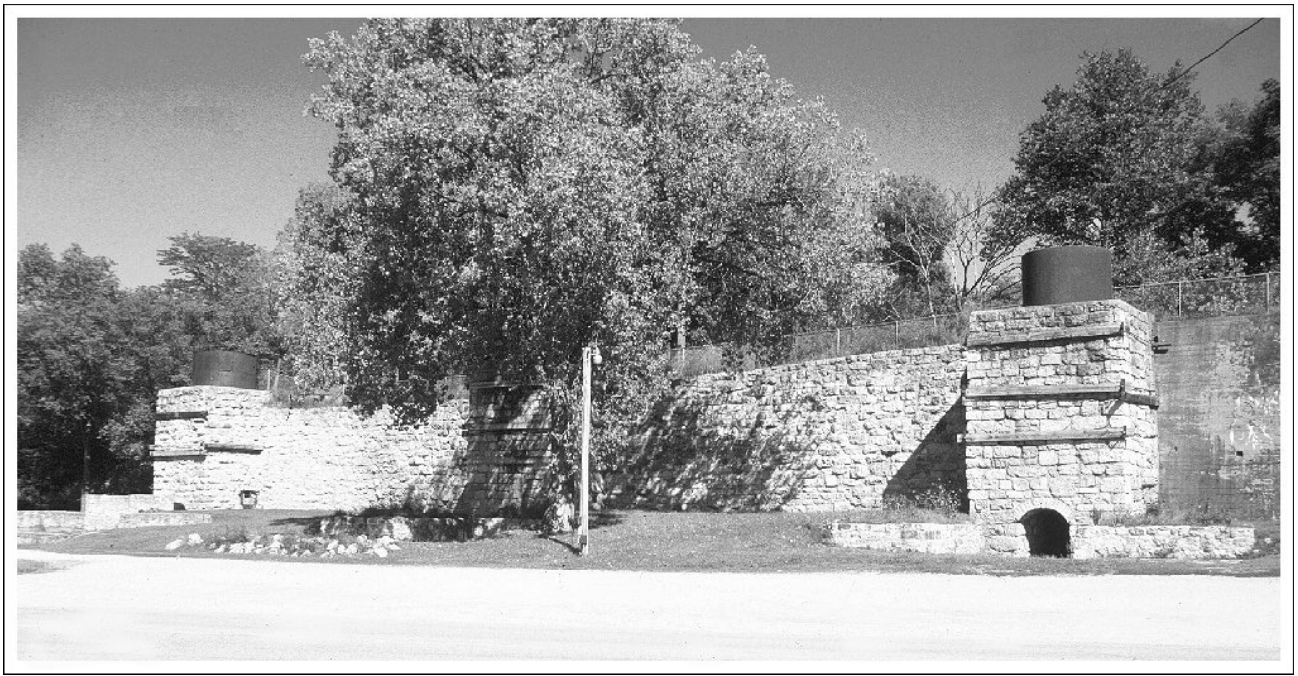


Figure 1. Photograph of the northern two historic lime kilns at Hurstville.

Lime is one of man's oldest and most vital chemicals. The ancient Romans used lime in building and road construction, uses which continue to the present day. From earliest times, lime has been made by heating limestone (calcium carbonate) to high temperatures. This process, known as calcining, results in quicklime, or calcium oxide. The limestone brick used at the Hurstville kilns was quarried nearby and fed into the kilns to be "cooked" down into lime. The Lime, frequently referred to as burnt lime, is calcium oxide (CaO), made by burning limestone ($CaCO_3$) at a temperature of 1100-1200 ^{o}C to drive carbon dioxide (CO_2) from the limestone. The formula for this reaction is:

$$CaCO_3 + \text{heat} \rightarrow CaO + CO_2$$

$$\text{limestone} + \text{heat} \rightarrow \text{burnt lime} + \text{carbon dioxide}$$

LIME PRODUCTION AT HURSTVILLE

In 1875 Alfred Hurst designed and constructed four kilns and opened a quarry to support them just north of Maquoketa, and under the name A. Hurst and Company, he and his brother William began the production of burnt lime. The A. Hurst and Company plant at Hurstville was equipped with 4 continuous

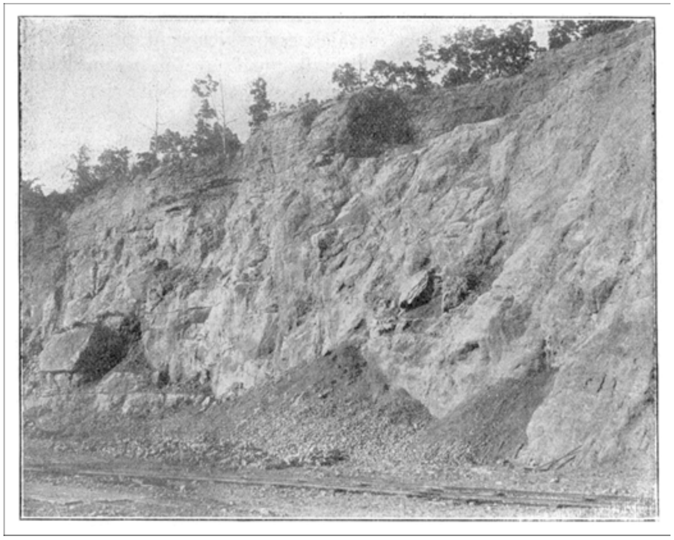


Figure 2: Hurstville Quarry provided stone that was fired in the lime kilns.

draw kilns, each 35 feet high and 6 x 8 feet in cross section (Fig. 4). Each kiln could produce about 125 barrels of lime daily (Savage, 1906). The "limestone" that was used to produce lime at Hurstville was actually dolostone ($CaMg(CO_3)_2$) from the Silurian Hopkinton Formation, Farmers Creek and Marcus members, produced from quarries directly behind the kilns (Fig. 2) and quarries on the east side of the North Fork of the Maquoketa River. The rock was quarried from a zone about sixty feet thick, including the *Pentamerus* beds and the overlying "cyclocrinites beds" containing such characteristic fossils as *Cyclocrinites dactylioides* and *Caryocrinites ornatu*s. The limestone was crushed to size on the quarry floor, loaded into narrow-gage hopper cars, and pulled by horses and donkeys up a low grade ramp to the kilns. When the cars were emptied, the brakes were released, and the cars coasted back to the quarry. Some of the stone was also dumped into a structure called the crushing building (Fig. 3) where it was stored and loaded in wagons for use as road stone.

The kilns were fired with wood collected from a 30-mile radius around the kilns. At its peak, the kilns burned about 100 cords of wood every day. One cord of soft wood could burn about 28 barrels of lime; one cord of hard wood could produce about 33 barrels. The company also owned a large tract of timber near Green Island, Iowa, which furnished wood for the lime burning operations.

The kilns were fired from the openings in their sides. When the firing operation was completed and the lime had cooled, it was shoveled from the openings in the front of the kilns into sheds that were constructed on the flat stone floors in front of the kilns. In these sheds the lime was crushed and loaded into barrels for shipment. Up to 60 people were employed at the kilns, engaged in quarrying and transporting the dolostone, cutting wood for the fires, and tending the kilns.

In 1889 the A. Hurst and Company purchased a second lime plant from the Maquoketa Lime Company at Pin Hook, one mile west of Maquoketa. That plant included three kilns, designed much like the Hurstville kilns with a similar capacity (Savage, 1906). The two Hurst lime plants and 3 other lime plants in Jackson County burned more than ¾ of the lime produced in Iowa around the turn of the century, with a total value of $69,550 in 1904 (Savage, 1906, p. 644). The lime, used primarily for plaster and mortar, was shipped via the Chicago, Milwaukee and Saint Paul railroad to various points in Iowa and adjacent states. Lime production by the A. Hurst Company at Hurstville peaked in 1914, then declined until 1920 when the company closed, driven out of business by the increased utilization of Portland cement in Iowa.

In the 1870's the A. Hurst Company

Figure 3. The "crushing house" actually served to store crushed limestone for use as road stone.

constructed a small company town called Hurstville for the Luxemburg immigrants that worked in the quarries and kilns. The town consisted of the Hurst Mansion, 23 workers' residences, livestock buildings, a post office, a general store, and a barrel shop. The town also served as a railhead for the shipping of cattle from area farms. By all reports, the town and its citizens were well cared for and there is no record of any strike. The unincorporated town of Hurstville still appears on Iowa Highway maps.

USE OF LIME TODAY

Lime is still an important chemical with many applications in today's society. The National Lime Association describes a wide range of industries and a myriad of uses for lime. It is used in paper, steel, sugar, plastics, paint, and many other applications. The largest single use of lime is in steel manufacturing, where it serves as a flux for removing impurities (silica, phosphorus and sulfur) in refining steel. Without this high-quality lime, U.S. steel production would be crippled. Lime is also essential to producing other metals, such as copper, aluminum, magnesium, uranium, gold, and silver.

The second leading use of lime is for environmental applications, involving air, drinking water, wastewater, and solid wastes. Lime is especially vital to municipalities in meeting their environmental and public health responsibilities at a reasonable cost. First, lime is widely used for potable water softening and to remove impurities (such as lead) from drinking water. Second, it is a highly cost-effective method to treat sewage sludge. Third, stack gases from municipal incinerators are treated with lime to remove sulfur dioxide, hydrogen chloride and other contaminants. Industrial, utility and mining operations rely on lime to comply with a host of environmental regulations. Lime is used to treat industrial and mining wastewater, in which it adjusts the pH of acidic waste, removes phosphorus and nitrogen, and promotes clarification. A growing use of lime is in the treatment of stack gases from industrial facilities, power plants, medical waste incinerators and hazardous waste incinerators. Lime absorbs and neutralizes sulfur oxides from these gases, helping to prevent acid rain, and also reduces emissions of hazardous air pollutants, including mercury.

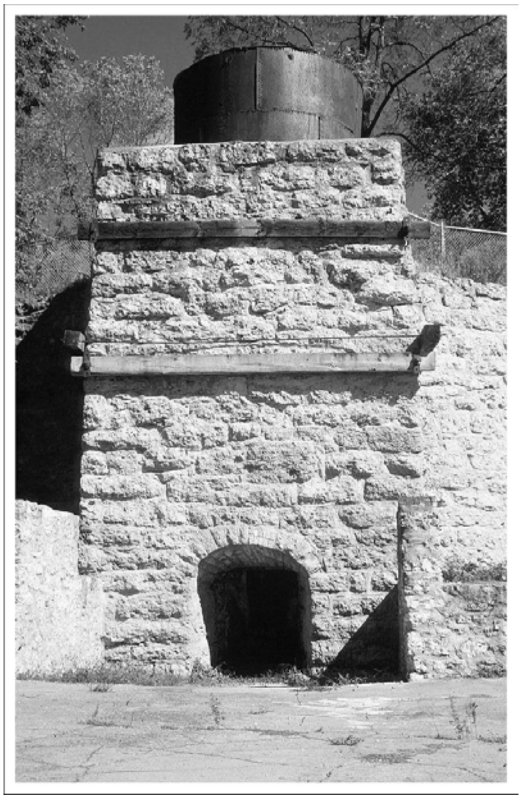


Figure 4. Photo of one of the Hurstville kilns

In construction, lime's traditional use is in mortar and plaster, because of its superior plasticity, workability and other qualities. Lime's dominant construction use today is in soil stabilization for roads, airfields, building foundations and earthen dams, where it upgrades low quality soils into usable base and sub base materials. It is also used as an additive in asphalt, in which it improves the cohesion of the asphalt, reduces "stripping "and retards the aging process. Dolomitic lime is also used in the production of masonry mortar and stucco, and high calcium lime is used in the production of aerated autoclaved concrete.

In addition to the uses described above, lime is essential to many other industries. For example, the chemical industry uses lime to manufacture sodium alkalies, calcium carbide, calcium hypochlorite, citric acid, petrochemicals, phenolates, stearates, naphthenates, nitrates, caseinates, calcium phosphates, propylene glycol, glycerin, and many others. These chemicals, in turn, go into virtually every product made in America. An important and growing use for lime is in the production of precipitated calcium carbonate (PCC), which is used in the production of paper, paint, ink, plastic, and rubber. The paper industry uses lime as a causticizing agent and for bleaching and, increasingly, for producing PCC for use in the paper manufacturing process. Other key uses of lime include refractories, sugar refining, agricultural liming, glass making, and leather tanning.

Today the Linwood Mining and Materials Corporation in Davenport is the only producer of lime in Iowa.

REFERENCES

Ludvigson, G.A., Bettis, E.A. III, and Hudak, C.M., 1992, Quaternary Drainage Evolution of the Maquoketa River Valley: Geological Society of Iowa Guidebook 56, 45p.

National Lime Association Web Page, http://www.lime.org, 22 October, 2001.

Savage, T.E., 1906, Geology of Jackson County: Iowa Geological Survey Annual Report V. XVI, p. 563-648.

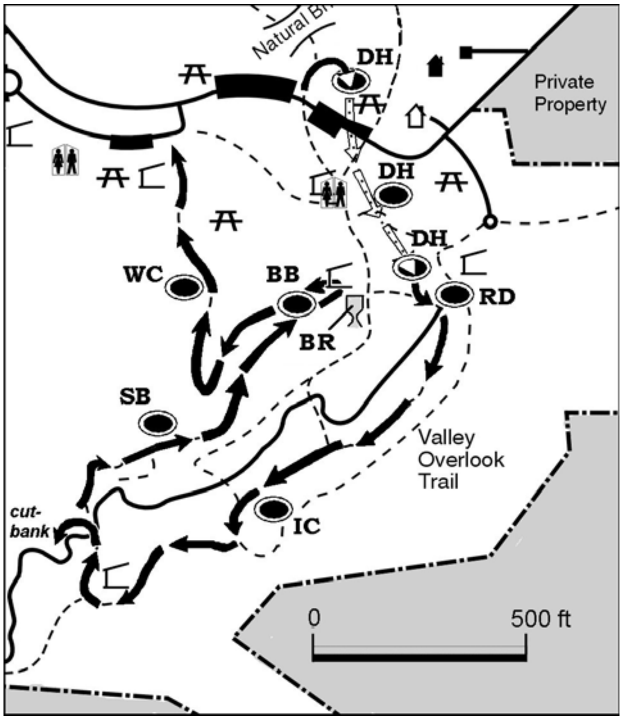
FIELD TRIP STOPS

For the Geological Society of Iowa's Fall 2001 field trip, ***The Natural History of Maquoketa Caves State Park***, we will have only three official trip stops. Stop 1 will be the central area of the Park, along Raccoon Creek where most of the caves are developed. The morning portion of the trip will include a loop down the southern trails, returning to the Park Picnic area for lunch. After lunch, we will take a loop up the northern trails ending back in the parking area. Stop 2 will require a drive to the western, upland area of the Park and a drive down a lane to view the prairie plots and an experimental planting area and a stop for a brief discussion of the features of this area. For the final field trip stop of the day, Stop 3, trip participants will drive to the Hurstville Kilns, just off Hwy 61 north of Maquoketa

STOP 1: MORNING – SOUTHERN LOOP

Morning activities at Stop 1 will begin in the parking area just across the road from the rest room facility near Dancehall Cave. After gathering everyone in the parking area, Ray Anderson (Geological Survey Bureau) will **welcome the trip participants** and **introduce the trip leaders**. **Stephanie Tassier-Surine** (Geological Survey Bureau) will then lead a brief **discussion of the Quaternary geology** of the Park area, **Mike Bounk** (Geological Survey Bureau) will describe the **geologic processes that led to the formation of the Park's caves and the steep-walled valley of Raccoon Creek,** and **Brian Witzke** will provide a brief **overview of the rock geology** of the Park.

The group will then proceed down the north trail (Fig. 1) to Dancehall Cave.



KEY TO LOCATIONS

DH – Dancehall Cave
RD – Rainy Day Cave
IC – Ice Cave
SB – Shinbone Cave
BR – Balanced Rock
BB – Barbell Cave
WC – Wye Cave

Figure 1. Map morning trip route, location of caves, and other features.

At the entrance to Dancehall Cave **Park Superintendent Wayne Buchholtz** will lead a brief discussion on the **discovery of the cave** and **history of this area**, followed by question and answer period. Then we will proceed into Dancehall Cave (see photo in introduction to field trip). **Please stay on the paved trail (Fig. 2) and stay together as a group**, in order to facilitate discussion of cave features. **Note** that many bats hibernate during winter in alcoves within the cave system. During hibernation, bats are sensitive to disturbance because they lose body heat when roused. Excessive disturbance may cause death by freezing before warm weather returns in the spring. For this reason, the paved trail through the interior part of Dancehall Cave is closed to human visitors in winter so as to protect hibernating bats.

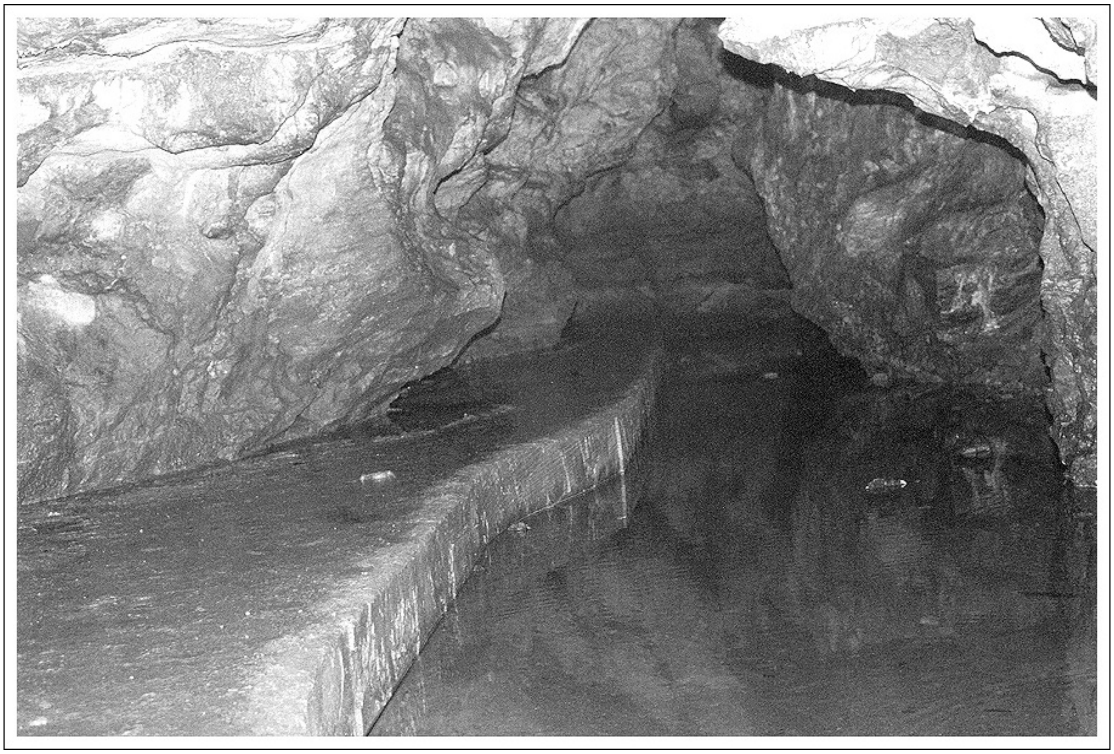


Figure 2. Paved trail through Dancehall Cave.

Figure 3. Stairway leading to the surface at Dancehall Middle Entrance.

About half way through the cave we encounter the Middle Entrance of Dancehall Cave and the wooden stairway leading to the surface (Fig. 3). Take a few minutes to examine the rock formations in this area, and note the entrance to Steel Gate Passage, several feet above ground level to the right. The group will stop in the large room at the south end of the cave for a discussion of the **archaeology of Maquoketa Caves State Park** by **Joe Artz** (Office of the State Archaeologist).

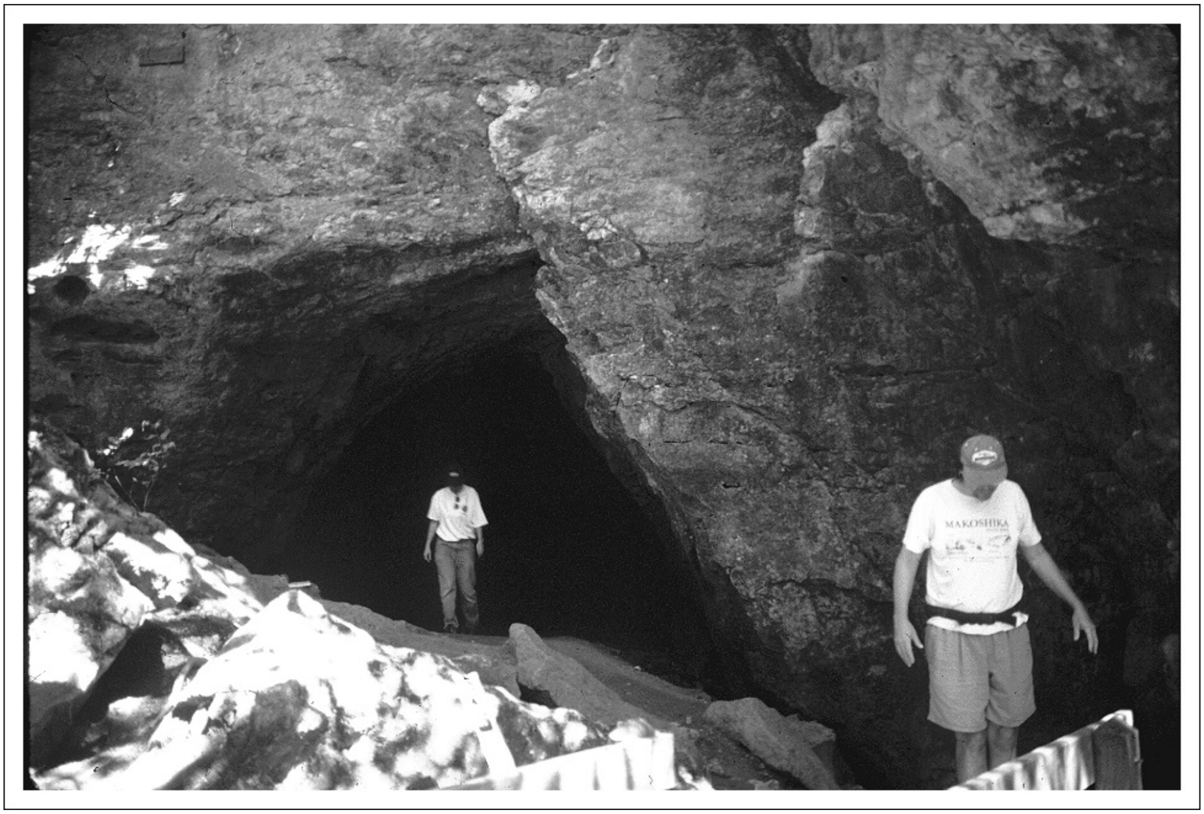


Figure 4. Trip leaders Stephanie Tassier-Surine and Brian Witzke at Rainy Day Cave.

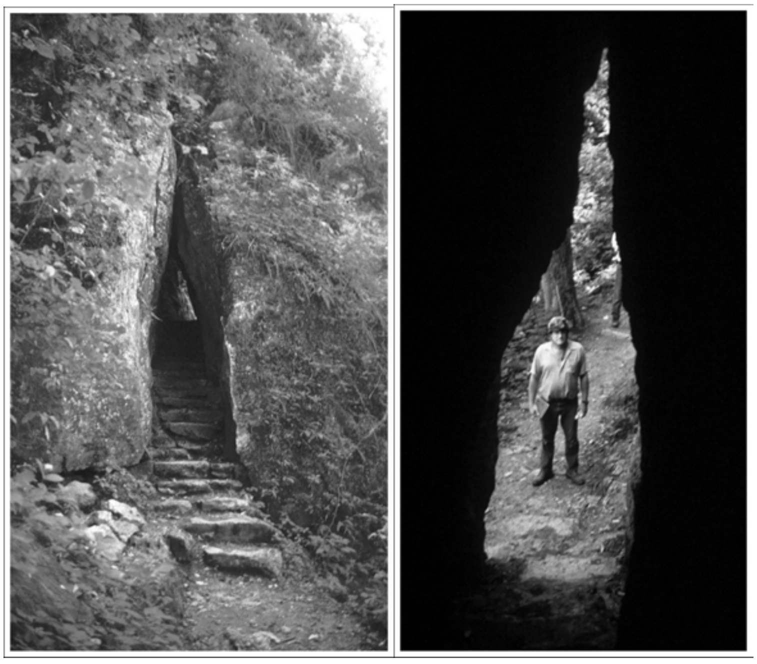


Figure 5. Fat Man's Misery Cave. The photo on the left shows the northern entrance to the cave; the photo on the right is trip leader Michael Bounk as viewed looking out from the cave.

On exiting Dancehall Cave, we proceed south, following the east trail along the rock cliff (see photo, Fig. 5, p. 16) past **Rainy Day Cave**. Rainy Day Cave (Fig. 4) has two rooms, the first a large oval shaped cavern, the second farther down the stream.

In this area **John Pearson** (DNR) will discuss **the vegetation along the canyon walls**. Herbaceous vegetation on rocks and cedar trees clinging to sheer walls are visible throughout much of the canyon. Many ferns, including walking fern and bulblet bladder fern, are abundant in many locations on cliffs. Rare plants such as sullivantia and northern monkshood grow on inaccessible walls and ledges. In some places, especially along the rim of the canyon, stunted cedar trees form small groves. Although no specific studies have been done in this park, cedar trees of this nature elsewhere in northeast Iowa can be several hundred years old.

Down the trail we will come to **Fat Man's Misery**, (Fig. 5) a mechanical cave, formed by collapse of a large ledge of rock that slid into the valley.

Continuing down the trail, we pass a junction with a trail, which has a series of steps, that leads to Raccoon Creek. Further south we encounter **Ice Cave**, marked by two large boulders. Ice cave also has two rooms, the first is the largest. Ice cave received its name because it feels cooler than the other caves at Maquoketa Caves State Park.

Figure 6. Balanced Rock. Ca. 1930.

Just beyond Ice Cave, we pass another trail leading down to Raccoon Creek, but continue on the south trail for a few hundred feet further until we reach a third trail leading down to the creek. Follow this third trail down to the creek, cross Raccoon Creek, then Brian Witzke will lead the group south along the creek to a cut-bank exposure of the Hopkinton Formation, the lowermost section of geologic strata exposed in the area. Brian will discuss the strata exposed at this location and trip participants will get a chance to examine the rocks close up.

Departing the cut-back exposure we follow the trail north along the west bank of Raccoon Creek. A hundred feet or so up the trail is a steep side trail branching to the left (west) and leads to **Shinbone Cave**. The opening to shinbone cave is small and obscured by some boulders and rubble. Shinbone is a dry cave, but it has a rough passage which may cause sore knees and bruised shinbones.

As the trail continues north it begins to move up the valley wall, eventually to a shelter. The shelter overlooks **Balanced Rock** (Fig. 6), which is reached from a lower trail. If time allows we will take a side trip to see Balanced Rock.

The Shelter, first constructed by the CCC in the 1930s, was refurbished in more recent times. The sheer cliff off the east end of the shelter area is one of the more precipitous in the park, so **BE CAREFUL!** While the trip participants are at the Shelter, **Wayne Buchholtz** (DNR Park Superintendent) will describe the work of the **CCC and the WPA** in the early days of Maquoketa Caves State Park. Then **John Pearson** (DNR Parks and Preserves) will **describe the flora** of the **glade just beyond the shelter**. This small prairie opening occurs on very thin soil overlying bedrock. Several plant species typical of prairies can be found here, including big bluestem, sideoats grama, leadplant, golden alexanders, and round-headed bush clover. Within the park, there are five small areas like this, which are the only places that prairie plants can be found.

After the flora discussion, trip participants will move up the trail past the glade and into the upland forest area and then into the picnic area on the east end of the campground. This is area presents another plant ecosystem that will be described by **John Pearson**. The picnic area is located in land that was entirely open pasture in 1936, but is now heavily forested except where mowed as a lawn. Large elms, ashes, walnuts, and sugar maples in the heavily wooded portion of the original pasture represent trees that invaded the open pasture after grazing stopped in the 1930s.

This marks the end of the morning portion of field trip **Stop 1**. After a break for lunch we regroup, in the parking area where we met earlier in the morning for the afternoon part of **Stop 1**, the Northern Loop.

STOP 1: AFTERNOON – NORTHERN LOOP

We begin the afternoon portion of Stop 1 in the parking area across from the restroom near Dancehall Cave (see Fig. 7). Following a few comments by trip leaders and a short question and answer period, we proceed north, down the same trail that we used this morning. At the base of the hill, at the fork in the road, we take the left fork and head toward the **Natural Bridge** (Fig. 9).

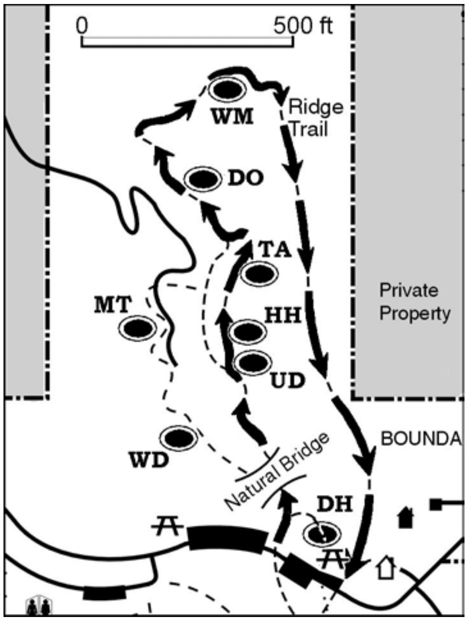
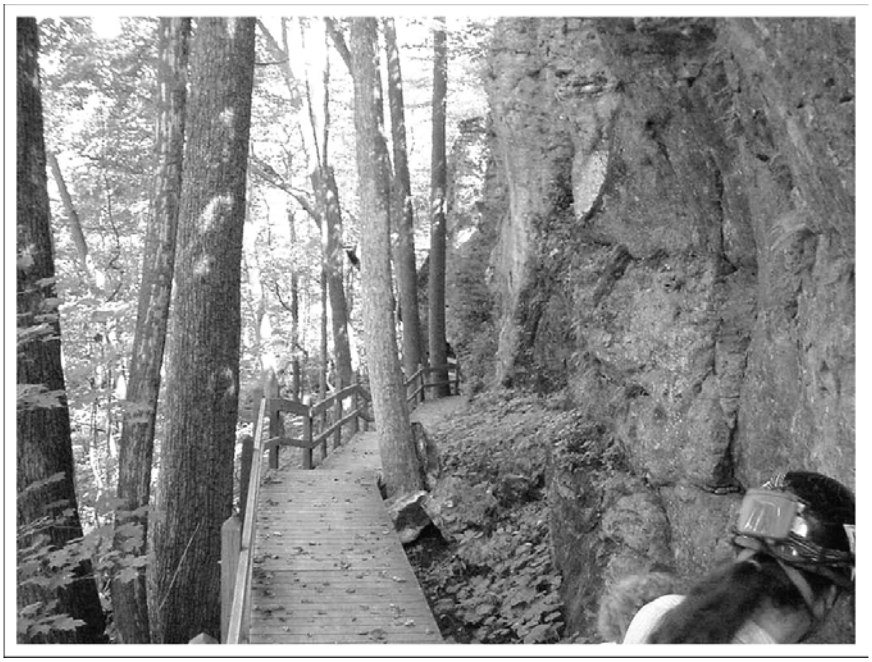


Figure 7. Map of afternoon trip route, location of caves, and other features.

KEY TO LOCATIONS

DH – Dancehall Cave
WD – Window Cave
UD – Up-n-Down Cave
HH – Hernando's Hideaway Cave
MT – Match Rock
TA – Twin Arch Cave
DO – Dug Out Cave
WM – Wide Mouth Cave

Figure 8. View of North Trail Loop at face of cliff.



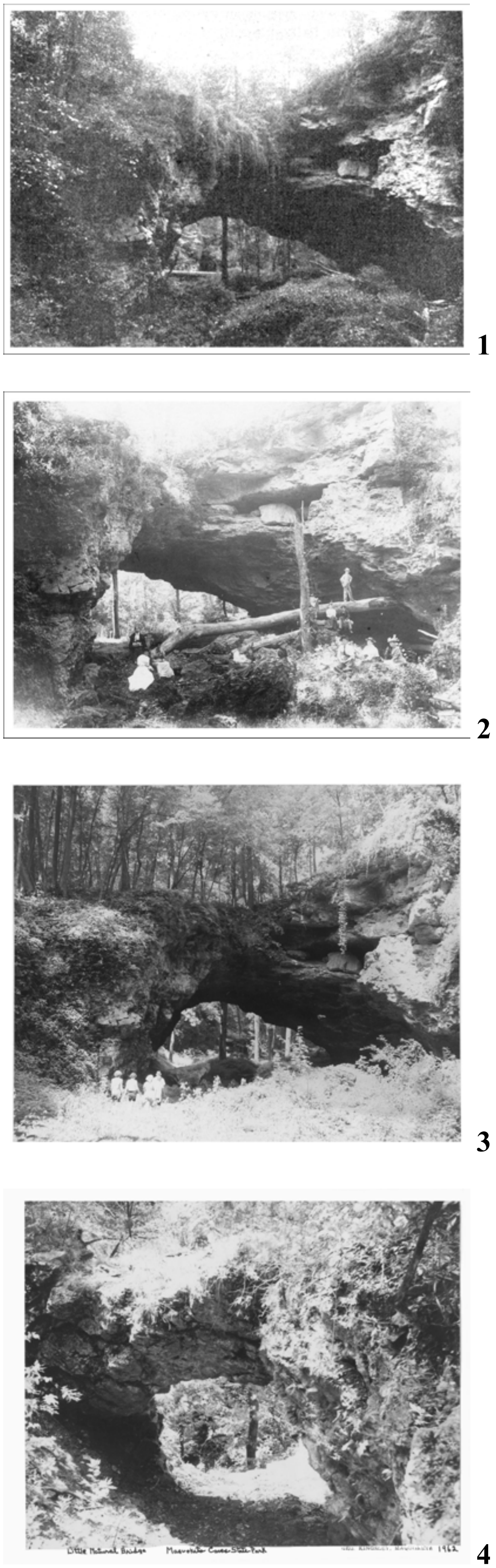


Figure 9. Four views of the Natural Bridge.
1. As seen in 1906.
2. As viewed ca. 1930.
3. Unknown date (note trees on bridge)
4. As viewed 1962.
(see front cover for modern view)

A modern photo of Natural Bridge appears on the cover of this guidebook. The bridge is actually a remnant of the original cave system in the area, most of which collapsed to form the valley of Raccoon Creek. For a discussion of this process see the article by Michael Bounk, beginning on page 23 of this guidebook.

Continuing under the Natural Bridge the trail forks again, we follow the right (east) fork along the bluff. About 100 feet up the trail we encounter a third fork in the trail, and again we bear right, along the cliff face. Shortly after this third fork the trail approaches **Up-n-Down Cave**. Not far up the trail is a second cave, **Hernando's Hideaway**. Hernando's Hideaway has a much smaller entrance than most of the other caves in the park. Exploring this cave requires a great deal of slithering and belly crawling.

Further up the trail lies **Twin Arch Cave**. Twin Arch Cave (Fig. 10) is not much more than a dry, open room, however the room has an attractive domed roof and is about 20 feet across. The roof of the cave displays an abundance of fossils, which will be discussed by **Brian Witzke**.

Passing Twin Arch Cave, the trail loops around and joins the lower trail. Bear right and continue to follow the trail upstream. The next cave we pass is **Dug Out Cave**. Farther along the trail we reach the northern most caves that we will visit on this field trip, **Wide-Mouth Cave**. Wide Mouth Cave (Figs. 11a, b) is a large, dry shelter and is accessed by climbing a series of steps above the main trail. The cave was reportedly filled with pure white speleothems before it was raided by souvenir hunters (Henry, 1993, p. 37).

As we return to the main trail we will continue in an easterly direction up and out of the valley to the Ridge Trail. On the way up the hill note the rock exposures along the trail. At the top of the hill we will follow the trail, steeply down into another drainage. Note that there are no rock exposures along this stretch of the trail. Why not? We are seeing the surface expression of a bedrock valley

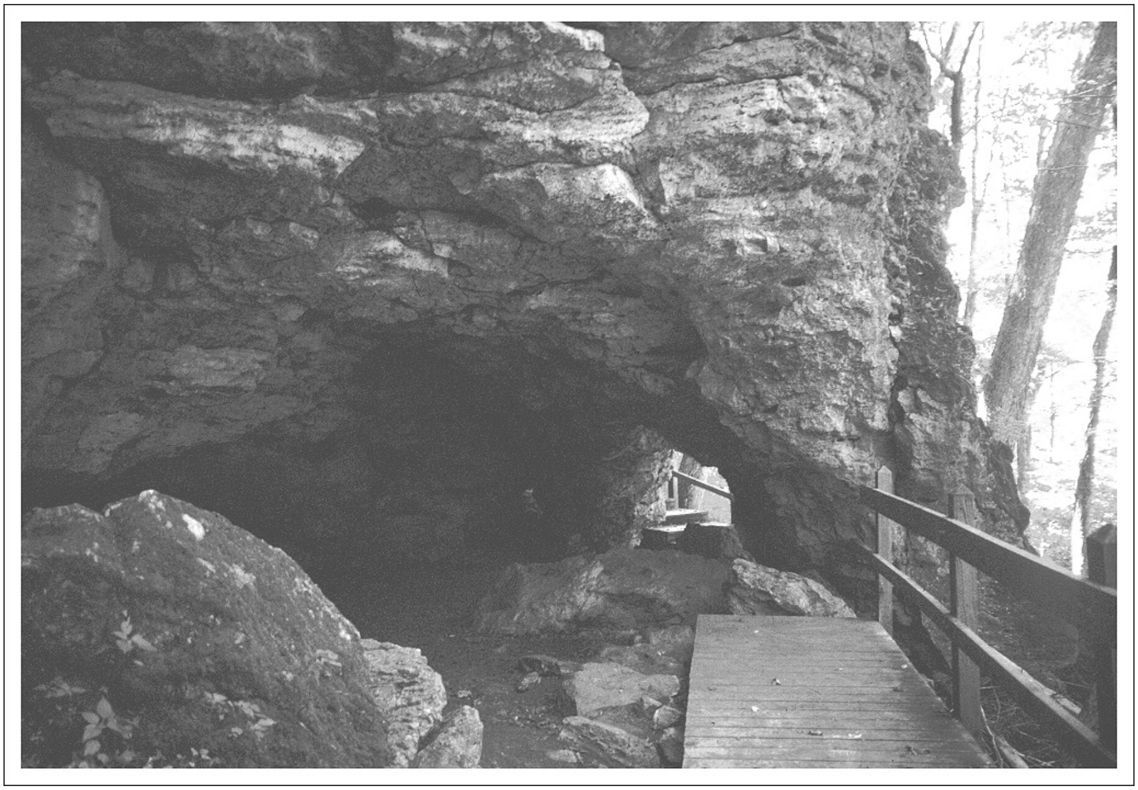


Figure 10. Twin Arch Cave.

that was subsequently filled in, then reoccupied by the creek. We will continue along the trail to another fork, and we will bear left, cross the creek, and move up out of the drainage to the upland trail. **John Pearson** will comment on the forest community as we hike along the Ridge Trail. **Highwalls are very near the trail at some locations, so walk with care.**

Figure 11a. Stairs leading up to Wide Mouth Cave. Cave is high on bluff on right.

Figure 11b. Wide Mouth Cave and trip leader Brian Witzke.

Continuing south on the Ridge Trail we ultimately reach the parking area near Dancehall Cave. This marks the end of **Stop 1** of the field trip. Trip participants will return to their vehicles and follow **John Pearson** (DNR) who will lead the group northwest out of the Park towards **Stop 2**.

STOP 2: WESTERN PARK UPLAND AREAS

About ¼ mile beyond the park border turn left on the road that accesses the western portion of Maquoketa Caves State Park (Fig. 12). Cross the parking area, pass through the gate, and drive south down the one-car lane. Along the route we will pass two areas where the Department of Natural Resources has been establishing prairies and an experimental oak seedling area.

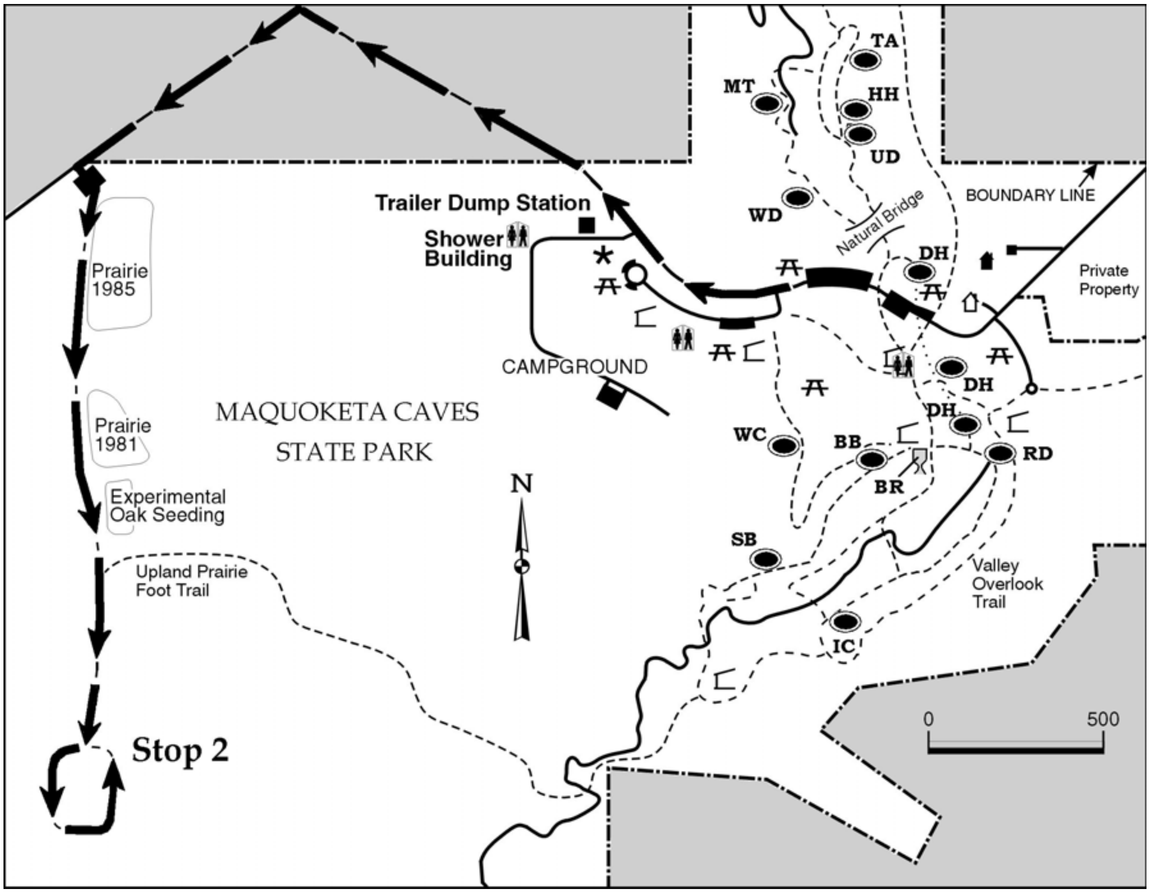


Figure 12. Map of Maquoketa Cave State Park and trip route to Stop 2.

This area was open pasture with only scattered trees in 1936, but dense forest now occupies about half of the land. This rapid expansion of trees did not start until grazing was suspended about 1976 when this parcel was added to the state park. The principal canopy trees in the young (25 year old) forest today are elm, bigtooth aspen, black cherry, ash, bitternut hickory, and hackberry. Compare the aerial photographs from 1936 and 1992 provided in Figure 2 of John Pearson's article, pages 34 and 35 of this guidebook.

John may stop at one or more of these areas if time allows. We will continue south to the circle turn around at the end of the lane where we will stop for a **discussion of the upland flora** led by **John Pearson** (DNR). For additional information on the flora of Maquoketa Caves State Park, see John's discussion beginning on page 31 of this guidebook.

Following the discussion, trip participants will return to their vehicles and proceed north up the lane then turn right and return back toward the central area of the park. **Ray Anderson** (Geological Survey Bureau) will lead the trip participants to **Stop 3**, the **Hurstville Kilns**.

STOP 3: HURSTVILLE LIME KILNS

The third and final stop of the day will be at the Hurstville Lime Kilns, located along Highway 61 about 2 miles north of Maquoketa. The trip participants will follow Ray Anderson (GSB) in a led vehicle out of Maquoketa Caves State Park to the intersection with Highway 428 (see Fig. 13). At the intersection turn right on Hwy 428 and proceed southeast towards Muscatine. At the intersection of Hwy 428 and Hwy 61, turn left (north) and drive for about 1½ miles to the Hurstville Kilns (Fig. 14). For information on the Hurstville Kilns see the article by Ray Anderson, beginning on page 57 of this guidebook.

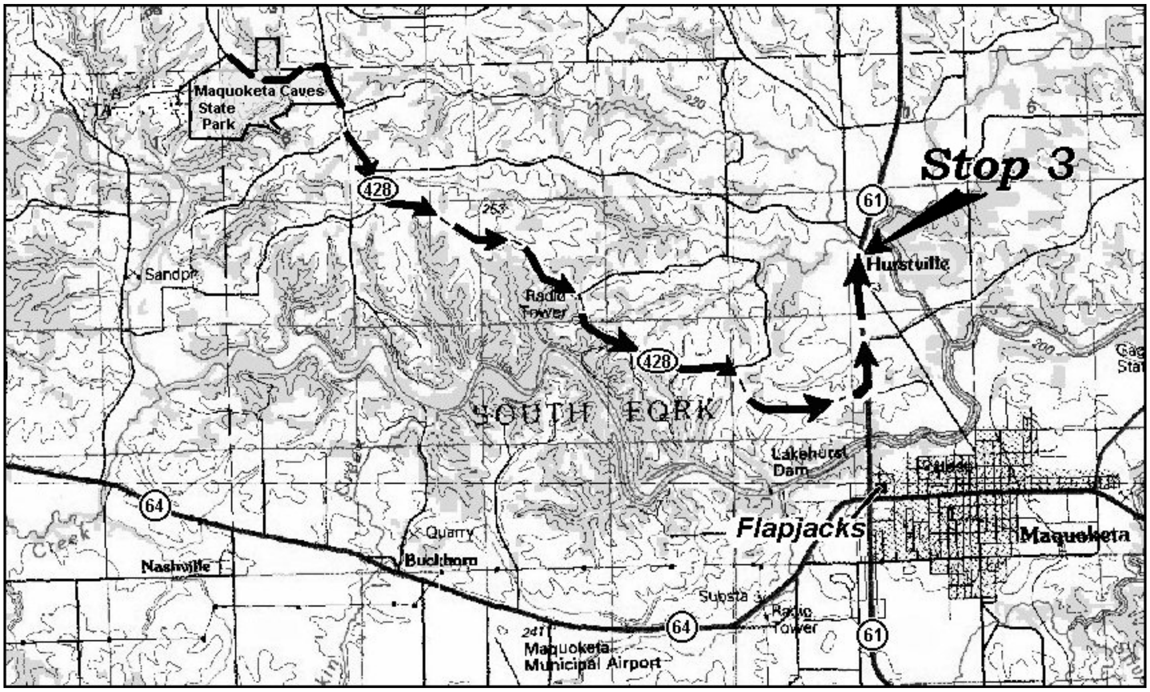


Figure 13. Map of route from field trip Stop 2 to trip Stop 3

This is the last stop of the day. The Geological Society of Iowa wishes to thank the trip leaders for their efforts in the preparation of this fieldtrip and guidebook and to thank trip participants for attending.

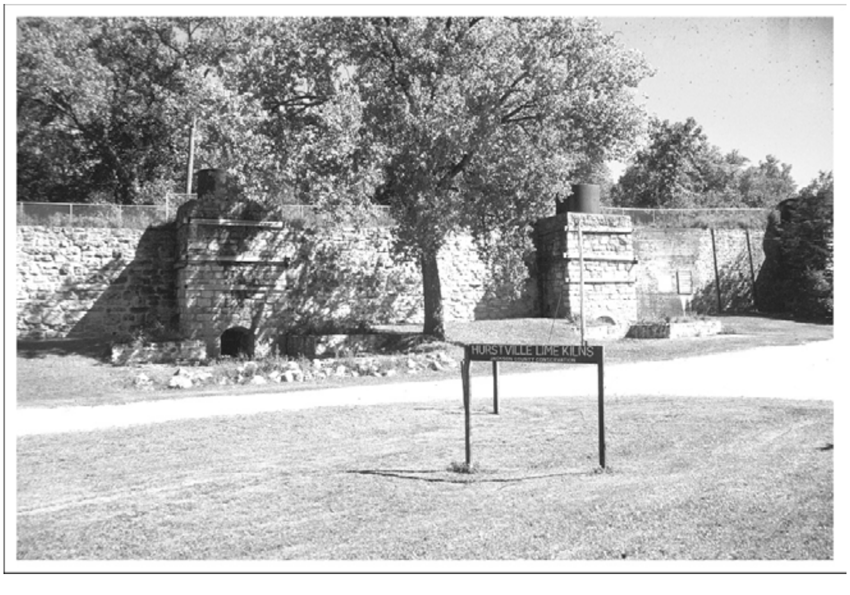
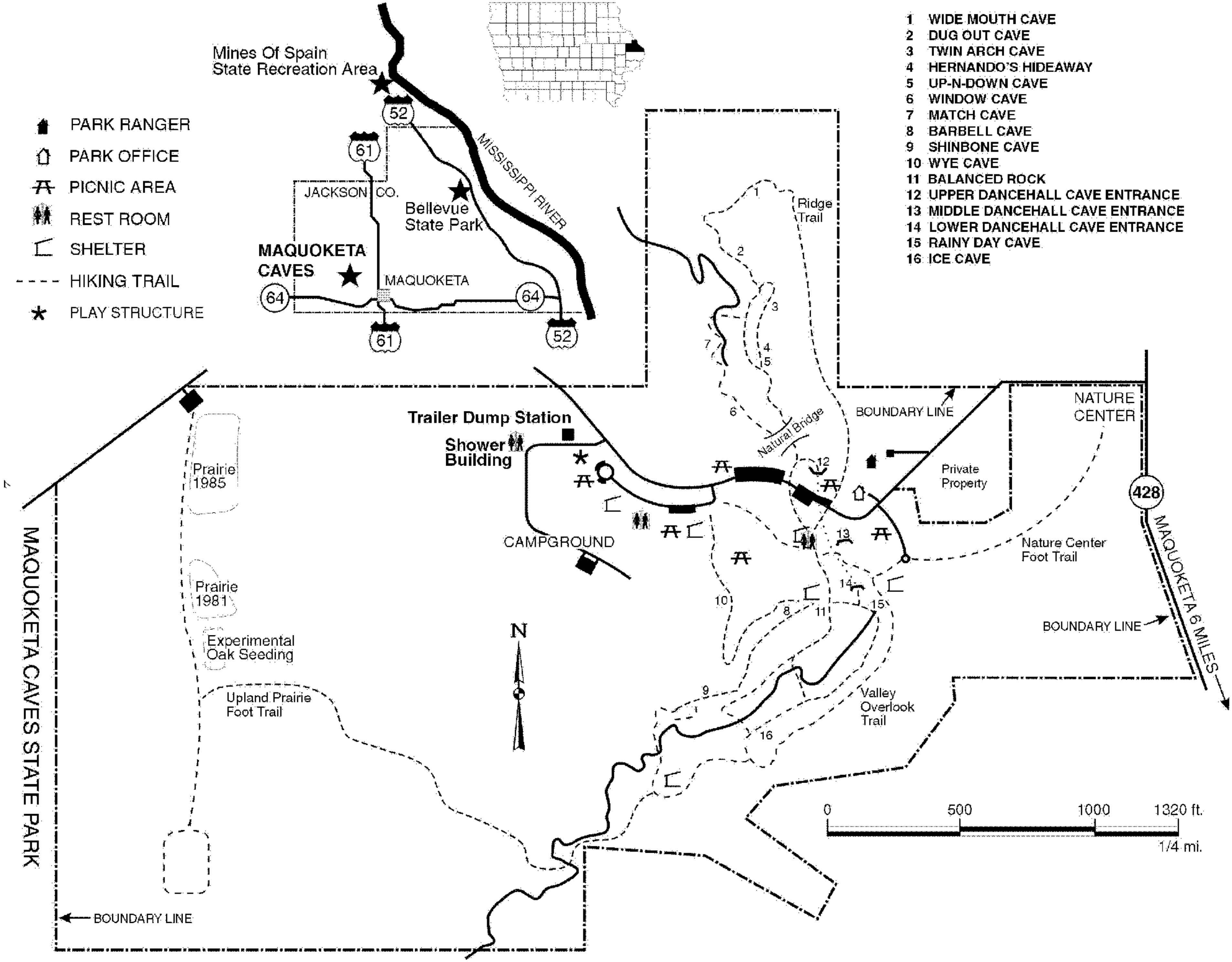


Figure 14. Photograph of the southern two lime kilns at Hurstville.

Geological Society of Iowa
109 Trowbridge Hall
Iowa City, Iowa 52242-1319
http://www.igsb.uiowa.edu/gsi/

MAQUOKETA CAVES STATE PARK



1 WIDE MOUTH CAVE
2 DUG OUT CAVE
3 TWIN ARCH CAVE
4 HERNANDO'S HIDEAWAY
5 UP-N-DOWN CAVE
6 WINDOW CAVE
7 MATCH CAVE
8 BARBELL CAVE
9 SHINBONE CAVE
10 WYE CAVE
11 BALANCED ROCK
12 UPPER DANCEHALL CAVE ENTRANCE
13 MIDDLE DANCEHALL CAVE ENTRANCE
14 LOWER DANCEHALL CAVE ENTRANCE
15 RAINY DAY CAVE
16 ICE CAVE