National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Paleontological Resource Inventory and Monitoring

Cumberland Piedmont Network

Natural Resource Technical Report NPS/NRPC/NRTR—2009/235



ON THE COVER

Twenty-seven Spider Cave, within Chickamauga & Chattanooga National Military Park, is not only the longest cave in the park, but also contains Pleistocene/Holocene cave fossils. This large bear skull and vertebral column are partially exposed in a mud bank and are particularly dramatic. The ruler is 15 cm (6 in) in length. For more information, refer to the CHCH section of the report. NPS Photo.

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NOTE:
This report provides baseline paleontological resource data to National Park Service administration and resource management staff. The report contains information regarding the location of non-renewable paleontological resources within NPS units.
It is *not* intended for distribution to the general public.

August 2009

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

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Abstract

Paleontological resources (fossils) are any remains of past life preserved in a geologic context. Paleontological resources are non-renewable resources found in more than 214 National Park Service (NPS) units. Despite the abundance and diversity of these resources throughout the NPS, until recently few parks have adequate baseline paleontological resource data.

The NPS National Inventory and Monitoring Program and the NPS Geologic Resources Division have developed various strategies to provide parks with the baseline paleontological resource data necessary for greater understanding and appropriate management of these resources. This report presents a paleontological resource summary for the parks of the Cumberland Piedmont Network. The summary was compiled through extensive literature reviews and interviews with park staff and professional geologists and paleontologists. Preliminary paleontological resource management recommendations are also included for each park. Including this report, summaries have been prepared for 25 of 32 NPS Inventory and Monitoring Networks. The National Inventory and Monitoring Program has provided funding to complete paleontological resource summaries for each of the remaining networks.

The paleontological resources known from the parks of the Cumberland Piedmont Network primarily consist of Paleozoic invertebrate fauna and plant fossils from Abraham Lincoln Birthplace National Historical Park (ABLI), Cumberland Gap National Historical Park (CUGA), Fort Donelson National Battlefield (FODO), Little River Canyon National Preserve (LIRI), Mammoth Cave National Park (MACA), Russell Cave National Monument (RUCA), and Stones River National Battlefield (STRI), along with Pleistocene megafaunal remains from caves at Chickamauga & Chattanooga National Military Park (CHCH), Mammoth Cave National Park (MACA), and Russell Cave National Monument (RUCA). Carl Sandburg Home National Historic Site (CARL) preserves fossils in a cultural context as part of the Sandburg family collection. Fossils were discovered as part of fill material used within the Shiloh Mounds Complex within Shiloh National Military Park (SHIL). Fossils would not be expected from the metamorphic rocks documented from the other parks in the Cumberland Piedmont Network including: Cowpens National Battlefield (COWP), Guilford Courthouse National Military Park (GUCO), Kings Mountain National Military Park (KIMO), and Ninety Six National Historic Site (NISI).

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Additionally, we extend our appreciation to Teresa Leibfreid (Cumberland Piedmont Network Coordinator) for providing background information for the network.

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Dedication

This report is dedicated to Ann Schaffer Elder (1958-2009). Ann began her career with the National Park Service in 1984 at Fossil Butte National Monument as a park technician. She then moved to Dinosaur National Monument and served there as a geology technician, paleontologist and museum curator until 2008. Ann was selected as chief of resource management at Colorado National Monument in 2008 where she worked until her sudden death in March 2009. Ann will long be remembered for her numerous contributions to the field of paleontology and museum curation within the National Park Service.

Introduction

Paleontological resources, or fossils, are any remains of past life preserved within a geologic context. There are two main types of fossils: body fossils and trace fossils. Body fossils are the physical remains of an actual organism (shells, bones, teeth, plant leaves, etc.) while trace fossils (burrows, coprolites, footprints, trackways, etc.) preserve evidence of an organism's activity or behavior. Fossils are non-renewable natural resources that possess great scientific, educational, and interpretive value.

The establishment of baseline paleontological resource data is essential for the appropriate management of fossils found within National Park Service (NPS) areas. Although more than 214 NPS areas have been identified with paleontological resources, few parks have adequate baseline paleontological resource data.

In conjunction with the NPS Geologic Resources Division and the NPS Inventory and Monitoring (I&M) Program, paleontological resource inventories have been initiated in dozens of parks Servicewide and are further described in the Inventory Strategies and Methodology section of this report. This report presents paleontological resource inventory and monitoring data compiled for the parks of the Cumberland Piedmont I&M Network (CUPN).

The Cumberland Piedmont Network is composed of fourteen parks in eight southeastern states (Alabama, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia) as shown in Figure 1. These include Abraham Lincoln Birthplace National Historical Park (ABLI), Carl Sandburg Home National Historic Site (CARL), Chickamauga & Chattanooga National Military Park (CHCH), Cowpens National Battlefield (COWP), Cumberland Gap National Historical Park (CUGA), Fort Donelson National Battlefield (FODO), Guilford Courthouse National Military Park (GUCO), Kings Mountain National Military Park (KIMO), Little River Canyon National Preserve (LIRI), Mammoth Cave National Park (MACA), Ninety Six National Historic Site (NISI), Russell Cave National Monument (RUCA), Shiloh National Military Park (SHIL), and Stones River National Battlefield (STRI). The parks that comprise the Cumberland Piedmont Network range in size from 106.70 ha (263.65 acres) at CARL to 21,379.62 ha (52,830.19 acres) at MACA.

While most Cumberland Piedmont Network parks were established for the preservation of cultural resources, all contain significant natural resources. Examples include the limestone glades found at CHCH and STRI; a pristine bog at CUGA; caves at RUCA, MACA, and Lookout Mountain within CHCH; prairie remnants at COWP; and nationally significant waters found at LIRI and MACA (Leibfreid et al. 2005). The Cumberland Piedmont Network is situated on two main physiographic provinces, the Interior Low Plateaus and the Appalachian Highlands (Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateau), which span six different physiographic regions with ecosystems represented that include three major components: aquatic systems, terrestrial systems, and sub-terrestrial cave systems.

The Interior Low Plateaus is an immense physiographic region that extends across the Laurentian craton of North America. This region was initially formed when land masses collided and joined together 1.9–1.8 billion years ago during the Trans-Hudson orogeny (see the appendix for a geologic time scale). Precambrian metamorphic and igneous rocks now occupy the basement of the Interior Plains and make up the stable nucleus of North America. This area was regularly covered by shallow inland seas during the Paleozoic era. Sediment was deposited in these seas over millions of years and eventually was compressed by the weight of the overlying layers into sedimentary rock. Parks that preserve fossil evidence of these past environments include ABLI, FODO, MACA, SHIL, and STRI.

The other nine CUPN parks are all located within the Appalachian Highlands physiographic region and have experienced a complex geologic history. The Appalachian Mountains are a Paleozoic fold-and-thrust mountain system. Continental rifting of the ancestral North American continent, called Laurentia, began about 750 to 700 million years ago (Late Precambrian). This led to the opening of the Iapetus Ocean, and the formation of the new eastern border of ancestral North America. Rocks of this age show a

transition from a continental setting to a shallow marine environment (the Lower Cambrian Unicoi Formation of the Chilhowee Group; Schwab 1972, 1986; Simpson and Sundberg 1987; Horton and Zullo 1991).These sediments were then covered by predominantly carbonate sediments that formed on the continental shelf during the Cambrian to Middle Ordovician time. As the Iapetus Ocean began to close during the Paleozoic, at the end of the Silurian period, fragments of oceanic crust, volcanic island arcs, and other continental masses collided into one another and were accreted onto the eastern border of ancestral North America (Horton et al. 1989; Horton and Zullo 1991). These accreted masses are known as exotic terranes (groups of rocks bounded by faults whose geologic history differs from the histories of adjacent rocks). This long period of ocean closing and continental accretion was marked by four episodes of collision (often associated with mountain building, commonly called an orogeny), occurring during the Late Cambrian to Early Ordovician (Penobscottian orogeny), Ordovician (Taconic orogeny), Devonian (Acadian orogeny), and Pennsylvanian-Permian (Alleghanian orogeny). These episodes shared related metamorphism and magmatism, although they affected different, but overlapping, areas with varying degrees of strength (Horton and Zullo 1991).

Although the timing of the Taconic orogeny is disputed, it appears to have occurred 470 to 440 million years ago and affected the rocks in what is now COWP, GUCO, KIMO, and NISI. Many of the exotic terranes northwest of the Carolina terrane were accreted to Laurentia, deformed and then metamorphosed during this time (Horton and Zullo 1991; Kish et al. 1979; Vick et al. 1987; Noel et al. 1988).

In the central and southern Appalachian region, accretion of a second terrane took place 380 to 340 million years ago during the Devonian Acadian orogeny, which affected the CARL area. These events appear to be younger in this area than the Acadian orogeny in New England. The Salisbury and Concord Plutonic Suites, which are present in NISI, are dated to 400 million years ago, during the Acadian orogeny in the Carolinas (Glover et al. 1983; Horton et al. 1989; Horton and Zullo 1991).

The continental collision between Laurentia and Gondwanaland occurred during the late Paleozoic Alleghanian orogeny that formed the super-continent of Pangea about 330 to 270 million years ago. Effects of the collision in the Carolinas can be seen in the numerous plutons, specific types of metamorphism and deformation, movement along faults, and westward transportation of rocks that now make up the western Piedmont and Blue Ridge areas (Horton et al. 1989; Horton and Zullo 1991).

The long period of mountain building that formed the Appalachians was ended by rifting during the breakup of Pangea in the Mesozoic. This led to the opening of the present Atlantic Ocean. Continental rifting began in the Late Triassic, as shown by the deposits of the Newark Supergroup. Igneous activity that occurred halfway through the rifting stage during the Early Jurassic (200 million years ago) produced dikes throughout the Carolina Piedmont and sills in the Deep River basin (a rift basin, where the Earth's crust is being pulled apart due to plate movement) of North Carolina. At the end of the Early Cretaceous large quantities of deltaic and marine sediment were deposited due to increased sedimentation to the west and/or local subsidence of the continental margin (Horton and Zullo 1991).

During the Paleocene and Eocene (65-34 million years ago) sea level was high enough to cover these lower areas, allowing the deposition of sedimentary rocks. During the regression of the sea in the Eocene, there was a reduction in the amount of sediment being deposited until much later, when the coastal areas of the Carolinas were again flooded by the sea during the Pliocene (beginning about 5 million years ago). Fossiliferous Oligocene and Miocene rocks are confined to the marine outer Coastal Plain. The Pleistocene depositional record indicates the marine deposits were limited to the outer Coastal Plain, with fluvial influences found inland (Horton and Zullo 1991). Although there are no coastal plain deposits in the CUPN, the NPS networks to the south and east (Gulf Coast and Southeast Coast) are composed primarily of such Coastal Plain sediments.

Collectively, the paleontological resources of the CUPN contribute to a greater understanding of the history of life on earth. Continued paleontological resource inventories will serve to expand this ever-

widening base of paleontological knowledge represented throughout the National Park Service. Although more than 210 parks have already been identified as containing paleontological resources, much of what is to be known about the history of life on Earth, recorded by fossil resources, remains to be discovered.

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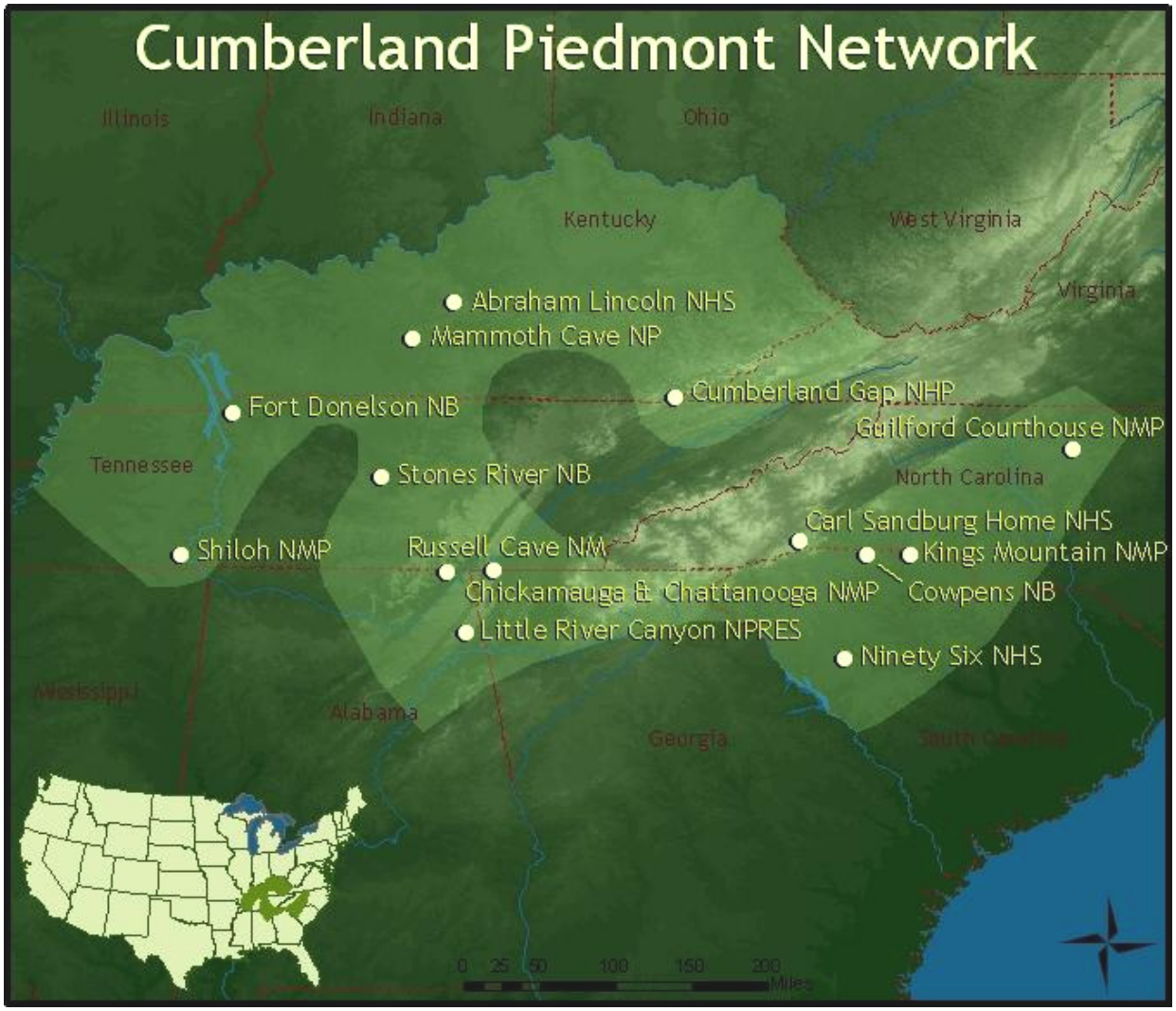


Figure 1. Map of CUPN network parks, courtesy of Cumberland Piedmont Network.

Paleontological Resource Inventory Strategies and Methodology

To better document fossil occurrences and provide baseline paleontological resource data to National Park Service areas, the NPS Geologic Resources Division (GRD) and the NPS Inventory and Monitoring Program (I&M) have established three paleontological resource inventory strategies, each with its own goals and objectives. These strategies include: comprehensive park-specific paleontological resource inventories, Servicewide thematic paleontological resource inventories, and Inventory & Monitoring Network-based baseline paleontological resource inventories. Santucci and Koch (2003) outline basic paleontological resource monitoring strategies and potential threats to fossil resources.

Comprehensive Park-Specific Paleontological Resource Inventories

Comprehensive park inventories are designed to identify all known paleontological resources within a single park unit. A team of specialists from within the NPS and from educational institutions and cooperators work with the targeted park to identify and address all aspects of its paleontological resources, including resource management, museum curation, law enforcement, and interpretation. Paleontology-specific training for park staff is an important component of many comprehensive paleontological inventories. Park-specific comprehensive paleontological resource inventories have been completed at Yellowstone NP (first park to have inventory completed), Amistad NRA (in review), Arches NP, Bighorn Canyon NRA, Death Valley NP, Grand Teton NP, Santa Monica NRA, Walnut Canyon NM, and Zion NP.

Servicewide Thematic Paleontological Resource Inventories

Servicewide thematic paleontological resource inventories compile data regarding specific types of paleontological resources that occur in parks throughout the NPS. The first thematic paleontological resource inventory identified 19 NPS units that preserve fossil vertebrate tracks (Santucci et al. 1998). Subsequent discoveries have increased the number of parks identified with fossil vertebrate tracks to 25 and warranted an updated publication (Santucci et al. 2006). Another thematic inventory identified paleontological resources associated with NPS caves in 35 parks (Santucci et al. 2001). Cave fossils occur in two contexts: First, fossils can be preserved in the marine limestones in which caves develop; second, the remains of Pleistocene/Holocene animals and plants that lived, died or were transported into caves after death are common types of cave fossils. Servicewide thematic inventories have also been initiated for fossil fish (Hunt et al. 2006) and fossils found in cultural resource contexts (Kenworthy and Santucci 2006).

Inventory and Monitoring Network Paleontological Resource Inventories

Network-based paleontological resource inventories compile baseline paleontological resource data for each of the parks within a particular network. Network-based inventories have been completed for 25 of the 32 I&M Networks including: the Appalachian Highlands, Chihuahuan Desert, Cumberland Piedmont (this report), Eastern Rivers and Mountains, Great Lakes, Greater Yellowstone, Gulf Coast, Heartland, Klamath, Mediterranean Coast, Mid-Atlantic, Mojave Desert, National Capital Region, Northeast Coastal and Barrier, Northern Colorado Plateau, Pacific Island, Rocky Mountain, San Francisco Bay Area, Sierra Nevada, Sonoran Desert, Southeast Coast, Southeastern Alaska, Southern Plains, Southwestern Alaska, and Upper Columbia Basin networks. Research for summaries of the Arctic, Central Alaska, North Coast and Cascades, Northern Great Plains, South Florida/Caribbean and Southern Colorado Plateau networks are currently underway. NPS I&M Program funding is targeted to complete paleontological resource summaries for the remaining networks in FY2010. Citations for the completed reports are in the Additional References section.

I&M Network Paleontological Resource Inventory Methodology

Network-based paleontological inventories were funded directly by the individual networks from 2002 to 2006. In FY2006, the National I&M Program provided funds to complete reports for the remaining networks between FY2006-2009. These funds provide stipends or salary for contractors, interns, paleontological technicians, or NPS employees who perform data mining activities. A brief summary outlining the basic techniques used to assemble an I&M Network-based inventory follows below.

The most valuable component of any paleontological resource inventory is an intensive literature search. Various databases contain citations for geology or paleontology themed publications. The American Geological Institute's GeoRef is the primary database for geology references and contains "millions" of references from the middle 1700s through today. GeoRef, available in both online or CD-ROM versions, is accessible at many major university libraries. The NPS NatureBib (which supersedes PaleoBib) is an internet-based database for scientific citations presented as bibliographic references but does not yet contain a comprehensive paleontology bibliography. The U.S. Geological Survey (USGS) Library (main branches in Reston, Virginia; Denver, Colorado; and Menlo Park, California) is a premier repository for geologic publications, and houses most of the publications obtained for the network-based paleontological resource inventories. Many USGS publications are available for free download online at the USGS Publications Warehouse (http://pubs.usgs.gov). Additionally, museum libraries such as at the Smithsonian Institution's National Museum of Natural History, and university libraries provide access to a wide range of geological and paleontological publications. Individual state geological surveys are also excellent sources of information, as are geologists familiar with local geology and paleontology.

The literature search also includes unpublished material (i.e. gray literature) from park files, museum archives, local newspapers, field notes, etc. These are often excellent sources of anecdotal information about park resources. In addition to literature searches, interviews with park staff, university faculty, geologists from the USGS and state geological surveys, and even local amateur geologists or paleontologists can yield information regarding park paleontological resources. These interviews frequently result in capturing data that might otherwise be undocumented and potentially lost or unrecognized.

Bibliographic searches include a search for geologic maps associated with each park. The NPS Geologic Resources Division maintains a database of geological map coverage for many parks (current contact is Tim Connors). A digital geologic map for each park is one product of the NPS GRD Geologic Resource Inventory program. In addition, the USGS National Geologic Map Database (NGMDB; http://ngmdb.usgs.gov) lists maps for a given geographic area or place name and provides information on how to obtain maps. Geologic maps show the types of rocks and the associated geological formations within a park area. These maps, alone, can often indicate the potential for paleontological resources to occur within a park.

Fossils are most commonly found in sedimentary rocks such as sandstones, shales, and limestones. Fossils, with few exceptions, are not found within igneous rocks (volcanic or intrusive origin) or metamorphic rocks (altered by heat, pressure, and/or chemical change) due to the extreme heat and/or pressure associated with their origin and history. The nomenclature for geologic formations can be confusing, but the NGMDB includes a searchable lexicon of valid geologic formation names that can be very useful in clearing up nomenclatural confusion. This lexicon provides a basic summary for each formation, summarizes current and past usage of the various formation names found in the literature, and provides an annotated bibliography for each formation.

Organization of the Reports

Information from these various sources is compiled into a narrative report for each park. Each park report includes an executive summary of the park's significance and a brief description of the geologic background. Geologic formations mapped within the park that are known to preserve fossils within the park are described in the "Sources of Paleontological Resources" section. Geologic formations mapped

within the park that potentially preserve fossils (based on fossil discoveries outside the park) are listed in the section "Potential Sources of Paleontological Resources." Field investigations could determine whether these "Potential Sources" do preserve fossils within the park. The park narratives also include a summary of paleontology specimens in park museum collections and, where applicable, highlight fossils that occur in cultural resource contexts (see Kenworthy and Santucci 2006).

In addition to this geologic and paleontologic content information, the authors suggest preliminary recommendations for each park regarding that park's management of the paleontological resources based on discussion with park staff and other geologists or paleontologists. A comprehensive list of publications related to paleontological research associated with the park is also included. The reports include all bibliographies that may be associated with a park's paleontological resources. However, bibliographic data are subdivided in the report into those cited in the narrative (Literature Cited) and other associated publications (Additional References). Finally, a list of datasets relative to the park's paleontological resources is developed. These data sets include museum collections where fossils from the park are reposited and locations of archives or other files and information relative to the park.

The reports undergo peer review by professional geologists, paleontologists, and staff from each park for accuracy before being submitted to the network. These reports are designed to consolidate baseline paleontological resource data for each park to support management operations and decision-making. Therefore, the reports are written in NPS language and in addition to the scientific information, the reports address issues of resource management, protection, and interpretation.

Within the "Sources of Paleontological Resources" or "Potential Sources" sections, information is synthesized regarding the scope and significance of fossils documented from geologic formations mapped within the park. Fossils are assessed and organized based upon taxonomy, stratigraphy, and paleoecology. Paleontological resources can be divided into six taxonomic groups: protists (unicellular plants and animals – typically plankton), microbes (fossil bacteria – typically found in stromatolites or as coatings on fossils), paleobotany (fossil plants), invertebrates (multicellular animals without backbones), vertebrates (animals with backbones), and trace fossils (evidence of biological activity such as tracks, traces, burrows, etc.). Fossils typically have a finite stratigraphic range and occurrence in geologic time (a geologic time scale is included as an appendix). The period between the first and final occurrences of a fossil species is referred to as the stratigraphic range zone. Thus specific groups of fossils may be identified directly with a particular stratigraphic unit or stratigraphic range. Likewise, rock units often represent specific ancient sedimentary depositional environments. Paleoecologically, fossil groups may occur primarily, or in some instances only, in specific environmental conditions (temperature, aquatic, terrestrial, etc.). Thus many fossils may be useful as indicators of past environmental conditions.

The "Sources" and "Potential Sources" sections are organized stratigraphically presenting the geologic and paleontologic information chronologically from oldest to youngest. Important fossils documented from localities outside a park are often reported in the park inventory, as these data may indicate the potential for fossils in similar stratigraphic units exposed within park boundaries.

Given the tremendous diversity of past life, the existence of life for over a billion years, and the range of environments to which life has adapted, there is a broad spectrum of research interests in paleontology. It is not surprising that most of what is to be learned about the history of life remains to be discovered. Through research, more than 214 NPS areas have been identified as containing paleontological resources. However, the paleontological research for a particular park may vary widely from an incidental fossil discovery, to over a century of intensive paleontological investigations. Therefore, the inventory reports include information on the history of paleontological research, identification of any museums or universities serving as repositories for park fossils, and a complete bibliography.

Paleontological Resource Management Legislation and Guidance

I&M Network reports such as this are meant to provide network parks with sound baseline paleontological resource data that can stimulate future research, interpretation, education, or resource management projects. The proper management of resources identified through these inventories is mandated by many NPS policies including the newly enacted Paleontological Resource Preservation Act.

The Paleontological Resource Preservation Act (PRPA) (P.L. 111-11), signed into law on March 30, 2009, will serve as explicit authority for the management, protection and interpretation of paleontological resources in parks, in addition to the NPS Organic Act of 1916. The PRPA specifically provides the NPS with the following mandates to enhance paleontological resources stewardship:

> §6302 calls for the management and protection of paleontological resources using scientific principles and expertise. The NPS should develop plans for inventory, monitoring, and the scientific and educational use of paleontological resources. Planning should emphasize interagency coordination and collaboration and where possible include non-federal partners, the scientific community and the public.
>
> §6303 calls for the establishment of education programs to increase public awareness about the significance of paleontological resources.
>
> §6304 calls for the development of a specific permit for the collection of NPS paleontological resources. The new legislation and other existing authorities clarify and reaffirm issues of property ownership, accountability, access and confidentiality of locality information associated with the management of NPS paleontological resources.
>
> §6305 calls for the curation of NPS paleontological resources, along with any associated data or records, in approved repositories.
>
> §6306 provides clarity regarding prohibited acts involving paleontological resources and specifies criminal penalties associated with these prohibited acts.
>
> §6307, along with other existing authorities, enables the NPS to seek civil penalties and restitution for the violation of any prohibited activities involving paleontological resources.
>
> §6308 provides the NPS a confidentiality provision with an exemption from the disclosure of any information associated with the nature and specific location of NPS paleontological resources.
>
> §6310 directs the Secretaries of the Interior and Agriculture to issue regulations appropriate to carry out the Act

In addition to the PRPA, several other authorities influence the management of NPS paleontological resources. The 2006 National Park Service Management Policies (§1.4.6) stipulates that paleontological resources are considered park resources and values that are subject to the "no impairment" standard set forth by the NPS Organic Act in 1916. Basic guidelines for management of paleontological resources are found in sections 4.8.2 and 4.8.2.1 of the 2006 NPS Management Policies.

Paleontological resource management issues were the subject of a Report of the Secretary of the Interior in May 2000, prepared in response to a Congressional request for an assessment of the need for a unified federal policy on the collection, storage and preservation of fossils and for standards that would maximize the availability of fossils for scientific study. That report, an "Assessment of Fossil Management on Federal and Indian Lands," summarized a number of principles relating to paleontological resources and their management. The Paleontological Resources Management section of Natural Resource

Management Reference Manual 77 provides guidance and additional information regarding the implementation and continuation of paleontological resource management programs. Links to the above documents are listed in the "Additional References" section.

The Geologic Resources Division and Geological Society of America are assembling a geologic resource monitoring manual that includes chapters on various geologic resources, including *in situ* paleontological resources, and a set of monitoring vital signs that may be applicable to a variety of parks. Monitoring represents the next phase in paleontological resource management, following the initial research inventory (represented by this report) of potential fossils and any subsequent field work to identify fossils within a park. Publication is expected by late 2009. Contact the Geologic Resources Division for more information or to obtain a copy of the report when it is available.

Our knowledge of the fossil record is only as good as our previous field season. The potential for new paleontological discoveries is proportionally related to our understanding as managers and stewards of this non-renewable evidence of life from the past. We believe that the baseline information provided in these reports and the resulting increased understanding of paleontological resources will inevitably result in paving the way for future fossil discoveries in NPS areas.

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General CUPN Information

CUPN I&M Network: http://www.nature.nps.gov/im/units/cupn/index.cfm

Geological Survey Websites

Geological Survey of Alabama: http://www.gsa.state.al.us/

Georgia Geological Survey: http://ggsstore.dnr.state.ga.us/index.php

Kentucky Geological Survey: http://www.uky.edu/KGS/

Mississippi Geological Survey: http://www.deq.state.ms.us/MDEQ.nsf/page/Geology_home

North Carolina Geological Survey: http://www.geology.enr.state.nc.us/

South Carolina Geological Survey: http://www.dnr.sc.gov/geology/

Tennessee Division of Geology: http://www.state.tn.us/environment/tdg/

U.S. Geological Survey: http://www.usgs.gov

Geological Society of America: http://www.geosociety.org

American Geological Institute: http://www.agiweb.org

Library catalogs

U.S. Geological Survey Library Catalog: http://igsrglib03.er.usgs.gov:8080/#focus

Smithsonian Institution Libraries Catalog: http://www.siris.si.edu/

Museums

Alabama Museum of Natural History: http://amnh.ua.edu/

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Illinois State Museum: http://www.museum.state.il.us/

North Carolina Museum of Natural Sciences: http://www.naturalsciences.org/

South Carolina State Museum: http://www.museum.state.sc.us/

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Resource Management/Legislation Documents

NPS 2006 Management Policies (§1.4; Park Management): http://www.nps.gov/policy/mp/chapter1.htm

NPS 2006 Management Policies (§4.8.2.1; Paleontological Resources): http://www.nps.gov/policy/mp/chapter4.htm

NPS 1998 Omnibus Management Act (paleontological resource summary): http://www.nature.nps.gov/geology/paleontology/paleo_5_1/index.htm

NPS Natural Resource Management Reference Manual #77 (paleontology section): http://www.nature.nps.gov/rm77/paleo.cfm

Assessment of Fossil Management on Federal & Indian Lands (2000): http://www.fs.fed.us/geology/fossil.pdf

National Park Service Geology and Paleontology sites

NPS Geologic Resources Division: http://www.nature.nps.gov/geology/

NPS GRD Geologic Resource Inventory products (scoping summaries, GRI reports, digital geologic maps): http://www.nature.nps.gov/geology/inventory/gre_publications.cfm

NPS Paleontology Program: http://www.nature.nps.gov/geology/paleontology/

NPS Park Paleontology Newsletter (published 1999-2004): http://www.nature.nps.gov/geology/paleontology/newsletter.cfm

I&M Network paleontological resource summary project website and PDFs of all reports (InsideNPS): http://inside.nps.gov/waso/custommenu.cfm?lv=4&prg=753&id=4518

NPS Technical Information Center (Denver, repository for technical (TIC) documents): http://etic.nps.gov/

Other Sources of Geology and Paleontology Information

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Paleobiology Database (search for fossil taxonomy, localities, or geologic formations): http://paleodb.org/cgi-bin/bridge.pl

Paleontology Portal (general fossil info based on geographic location or geologic time): http://www.paleoportal.org/

University of California-Berkeley Museum of Paleontology online paleontology exhibits:

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U.S. Geological Survey Geologic Terms Glossary: http://www.nature.nps.gov/geology/usgsnps/misc/glossaryAtoC.html#A

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U.S. Geological Survey National Geologic Map Database (NGMDB): http://ngmdb.usgs.gov/

U.S. Geological Survey Geologic Names Lexicon (GEOLEX; geologic unit nomenclature and summary): http://ngmdb.usgs.gov/Geolex/geolex_home.html

U.S. Geological Survey Geographic Names Information System (GNIS; search for place names and geographic features, and plot them on topographic maps or aerial photos): http://gnis.usgs.gov/

U.S. Geological Survey GeoPDFs (download searchable PDFs of any topographic map in the United States): http://store.usgs.gov (click on "Map Locator").

U.S. Geological Survey Publications Warehouse (many USGS publications are available online): http://pubs.usgs.gov

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Abraham Lincoln Birthplace National Historical Park

Abraham Lincoln Birthplace National Historical Park (ABLI) was originally designated as Abraham Lincoln National Park on July 17, 1916 and administered by the War Department until August 10, 1933, at which time it was transferred to the Department of the Interior. The site was redesignated as Abraham Lincoln National Historical Park on August 11, 1939, and more recently the site was renamed and redesignated as Abraham Lincoln Birthplace National Historic Site on September 8, 1959 (Peterson 1966). The park was again redesignated as a national historical park on March 30, 2009. A log cabin, similar to the one in which Lincoln was born, is preserved in a memorial building near the Sinking Spring at the main unit of the park. Abraham Lincoln Birthplace National Historical Park is located in west-central Kentucky, about 4 km (2.5 miles) south of the town of Hodgenville (Birthplace Unit) and 4 km northeast of White City (Knob Creek Unit). These units are 21 km (13 miles) apart by car. ABLI is listed on the National Register of Historic Places. The entire unit covers 139.41 ha (344.50 acres).

Geologic Background

The Birthplace Unit of ABLI is located between McDougal Creek, and the South Fork and North Fork of the Nolin River, which is a tributary to the Green River. The Knob Creek Unit of ABLI is situated northeast of McDougal Creek along a small tributary of Rolling Fork in the hills of Cecil Ridge. The geology in this area consists of nearly flat-lying sedimentary rocks of Mississippian age (see the appendix for a geologic time scale). The seas which covered the interior of North America, including the area now known as Kentucky, during the Mississippian period were extensive, depositing the limestone-rich units which are susceptible to karstic dissolution. The landscape of the site is characterized by low-lying rolling hills, numerous depressions, small sinkhole lakes and other karstic landscape features including sinkholes, disappearing creeks, and springs (Thornberry-Ehrlich 2006). ABLI is located stratigraphically on the lower Mississippian-aged Borden Formation, and the upper Mississippian Harrodsburg Formation, Salem Limestone, and St. Louis Limestone (Kentucky Geological Survey 2009). While fossils have been observed within the park, likely within the Borden Formation, all of these geologic units could potentially preserve fossils within the park.

The NPS Geologic Resources Division conducted its geologic resources inventory (GRI) scoping session for the park on June 15, 2006 (Thornberry-Ehrlich 2006). The entire state of Kentucky has been mapped at 1:24,000 (7.5-minute) scale, with the entire state also mapped digitally at that scale and available as an online interactive map from the Kentucky Geological Survey (http://kgsmap.uky.edu/website/KGSGeology/viewer.asp). Both units of the park are located entirely within the 7.5-minute Hodgenville quadrangle (Moore 1968; Kentucky Geological Survey 2006).

Sources of Paleontological Resources

Fossils have been observed within ABLI, most likely within the Borden Formation. These fossils present opportunities for resource management (including field surveys, inventory, and monitoring), education, interpretation, and continued or future scientific research.

Borden Formation: Muldraugh Member (Lower Mississippian)

The Muldraugh Member of the Borden Formation is exposed in the lower hills of the Knob Creek Unit. This member is composed of siltstone and two types of limestones: crinoidal and silty. The crinoidal (composed primarily of fossil crinoids) limestone is coarse-grained and thick-bedded, similar to the Harrodsburg Limestone (described below) and occurs in lenses usually less than 9m (30 ft) thick in the upper 18 m (60 ft) of the member. The silty limestone is composed of light-olive-gray, medium-to fine-grained, and has thin-beds that also occur in the upper 18 m (60 ft) and, in some cases makes up the entire exposure (Moore 1968). The NPS Geologic Resources Division scoping summary (Thornberry-Ehrlich 2006) mentioned that crinoids and other Mississippian fossils from the Borden Formation are exposed in

a cutbank of the north fork of Knob Creek across from a visitor use area at the Knob Creek Unit. The fossils are currently unidentified, but likely from the Borden Formation (J. Meiman, CUPN and GULN Hydrologist, pers. comm., June 2009). Further investigation may further identify the fossils and uncover additional fossils within the park.

Potential Sources of Paleontological Resources

Fossils have not been documented in ABLI from the following geologic units. However, future field investigations within the park may yield fossils from one or more (or none) of the geologic units, as fossils are documented from these units outside of the park.

Harrodsburg Limestone (Upper Mississippian)

The Harrodsburg Limestone is composed of limestone and siltstone and is exposed on the hillsides of the Knob Creek Unit. The limestone is coarse- to very coarse grained, thick-bedded, in some areas thickly cross bedded, slightly siliceous, and highly fossiliferous with common crinoid columnals. This crinoidal limestone forms a persistent layer in the top 3 to 6 m (10 to 20 ft) of the formation (Moore 1968).

Salem Limestone (Upper Mississippian)

The Salem Limestone caps the hills surrounding the Knob Creek Unit. These limestones are fine- to coarse-grained, thin- to very thick bedded, and in some areas contain thick cross beds. The fine-grained limestone is silty, argillaceous, with fossils typically sparse except in zones with abundant fenestrate bryozoans (colonial invertebrate). The dominant outcrops of the Salem are coarse-grained limestone, which are slightly siliceous and highly fossiliferous, with crinoid columnals being the most abundant fossils present (Moore 1968). As an interesting aside, Salem Limestone from Indiana was used in the construction of the Lincoln Memorial in Washington, D.C. which displays abundant fossils (Kenworthy and Santucci 2004).

St. Louis Limestone (Upper Mississippian)

The St. Louis limestone is present in the Birthplace Unit of ABLI and generally consists of limestone that is locally dolomitic. The limestone is often light olive-gray to a medium dark gray or yellowish-gray, and has very fine to medium grained texture. It can also be argillaceous, carbonaceous, or silty and can be very thin to thick bedded. The formation contains numerous chert zones and limy shale partings. Springs are common near the base of more argillaceous limestone sections, with karst topography common in the formation. The St. Louis Limestone is often exposed in steams and gullies, and weathers to a red chert-rich clay soil. Fossils are sparse from this unit (Grabowski 1986). The massive colonial coral *Lithostrotion canadense* is an index fossil for this formation and is only found in the St. Louis limestone in Kentucky (Moore 1968). Another species, *L. proliferum* (which also occurs in the overlying Ste. Genevieve Formation, which is not present in ABLI), is also common in the St. Louis Limestone. (Weller 1931).

Park Collections

No fossils are present in the ABLI museum collection.

Cultural Resource Contexts

Limestone used in the construction of park structures such as the memorial plaza and steps and the Lincoln Tavern fireplace might display fossils depending on the source of the stone. Fossils are known from building stones in many other National Park Service units, giving a cultural context to these fossil remains. Kenworthy and Santucci (2006) presented an introduction and cited selected examples of NPS fossils found in cultural resource contexts.

Paleontological Resource Management, Preliminary Recommendations

- NPS Geologic Resources Division-sponsored GRI scoping session was held for ABLI on June 15, 2006. This scoping session included a recommendation for further field investigation into the potential for paleontological resources to be present within the park. Knowledge regarding the extent of paleontological resources in the area may influence future expansion directions for the park.
- Park staff should be encouraged to observe exposed gullies, other erosional bedrock, and streams for fossil material, particularly in the area of the north fork of the Knob Creek cutbank described above, while conducting their usual duties. Given the fossiliferous nature of many of these rock units any exposures would likely yield paleontological resources.
- A field-based inventory of paleontological resources may yield more information regarding the scope and significance of fossils within ABLI. Significant localities should be documented using NPS fossil locality and condition assessment forms that meet GRPA goal 1a9A.
- The park may want to consider long term paleontological resource monitoring of documented sites. A Geologic Resource Monitoring Manual by the Geological Society of America and NPS Geologic Resources Division (publication in late 2009) includes a section on paleontological resource monitoring (Santucci et al. in press).
- Staff should photodocument and potentially monitor any occurrences of paleontological resources that may be observed *in situ*. Fossils and their associated geologic context (surrounding rock) should be documented but left in place unless they are subject to imminent degradation by artificially accelerated natural processes or direct human impacts.
- Investigation of the stone used in park historic structures may yield paleontological resources in a cultural resource context.
- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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Carl Sandburg Home National Historic Site

Connemara Farms, the home of Pulitzer Prize-winning poet and writer Carl Sandburg, was deeded to the National Park Service after his death in 1967 by his wife Lilian. President Lyndon Johnson signed the park enabling act, creating Carl Sandburg Home National Historic Site (CARL) on October 18, 1968, and the park opened to the public in 1974. The site is located in Flat Rock, North Carolina. The NPS manages 107 ha of land (264 total federal acres).

Geologic Background

Carl Sandburg Home National Historic Site is located within the Inner Piedmont physiographic province. Situated near the South Carolina border, these Cambrian age (Paleozoic) rocks are composed of the Henderson Gneiss, paragneiss and schist (metamorphic rocks). The Inner Piedmont is an intensely deformed and metamorphosed segment of the Piedmont and is associated with the Acadian orogeny, which likely obliterated any fossils that may have been preserved in the rocks. The Introduction to this report contains information regarding the basic tectonic history of the area. See the appendix for a geologic timescale.

CARL has been geologically mapped at 1:250,000 scale by the U.S. Geological Survey (Hadley and Nelson 1971). The NPS Geologic Resources Division conducted a geological resources inventory (GRI) scoping session for the park on May 12, 2000 (National Park Service 2000). Fossils are not known from the Cambrian-aged rocks of CARL. There is little potential for discovery of *in situ* fossils within CARL, although the park collections contain fossil specimens.

Sources of Paleontological Resources

While fossils are not found *in situ* within the rocks of the park, there are a small number of fossils curated within the park's museum collection. These fossils may contain historical or interpretive value as curios of the Sandburg family.

Park Collections

There are five paleontological specimens held within CARL collections. These fossils are part of the Carl Sandburg collection, and are assumed to have been collected or purchased by the Sandburg family. As such they are also considered as fossils found in Cultural Resource Contexts, see below.

Cultural Resource Contexts

The fossils include leaf impressions within limestone (CARL 359), a crinoid stem in conglomerate (CARL 6017) and another crinoid in polished sandstone (CARL 6018), small fossils in limestone (CARL 6043), and a brachiopod (CARL 109227). No provenance or collection information is given for these specimens although it is unlikely they came from within the park (A. Tate, CARL Museum Curator, pers. comm., February 2009). A number of historic sites within the NPS contain fossils that were collected or purchased by the individual or family and are interpreted by the park. Such fossils are found in the collections of Marsh-Billings-Rockefeller National Historical Park, Vermont, and John Muir National Historic Site, California (Elder et al. 2008). Kenworthy and Santucci (2006) summarize and provide selected examples of fossils found in other cultural resource contexts throughout the NPS.

Paleontological Resource Management, Preliminary Recommendations

- The NPS Geologic Resources Division sponsored a GRI scoping session for CARL on May 12, 2000. No *in situ* paleontological resources were identified in that report and there were no recommendations regarding fossils.
- Due to the lack of documented *in situ* fossil occurrences within the park, and the unlikelihood of extensive macrofossil discovery within the park, establishment of a paleontological resource management plan is not necessary.
- The identification of the fossil specimens in the park collection is very tentative. A better identification of these fossils may yield more information related to their source and provenance.
- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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Chickamauga & Chattanooga National Military Park

Chickamauga & Chattanooga National Military Park (CHCH) spans the Georgia-Tennessee border, and was originally established in 1890 for the purpose of "preserving and suitably marking for historical and professional military study the fields of some of the most remarkable maneuvers and most brilliant fighting of the war of the rebellion…" (Paige and Greene 1983). Chattanooga, Tennessee was a key rail center during the mid 19th century and viewed as the gateway to the heart of the Confederacy. The 1863 Campaign for Chattanooga was one of the most complex and involved military and political operations in the American Civil War. The campaign was fought by approximately 150,000 men and resulted in over 47,000 casualties. Primary fighting involved the Battle of Chickamauga (September 18-20, 1863) and the Battles for Chattanooga (November 23-25, 1863) which ended in Union control of the City and set the stage for the Atlanta Campaign, Gen. Sherman's "March to the Sea", and ultimately the end of the American Civil War. The park was established to preserve the site of a major Confederate victory on Chickamauga Creek in Georgia on September 19 and 20, 1863. The legislation to create CHCH was the first to authorize the preservation of an American battlefield, and it laid the basis for the national historical park concept in the United States. In addition, the creation of the park was an effort shared by veterans of both sides of the war. CHCH was managed by the War Department until it was transferred to the Department of the Interior on August 10, 1933 (Paige and Greene 1983). The park was listed on the National Register of Historic Places on October 15, 1966. The park includes two primary land tracts, Chickamauga Battlefield and Lookout Mountain, as well as a number of smaller areas around the city of Chattanooga. Moccasin Bend was added as a new unit of CHCH on February 20, 2003 and had previously been designated a National Historic Landmark on September 8, 1986. This site is located directly across the Tennessee River from Lookout Mountain. CHCH encompasses 3,656.86 ha (9,036.31 acres; federal: 8,973.27 acres, non-federal: 63.04 acres).

Geologic Background

Geologically, CHCH spans portions of two physiographic provinces consisting of Paleozoic rocks which span in age from the Cambrian-Ordovician (Knox Group) to the Pennsylvanian (Crab Orchard Group). The area around Lookout Mountain, the southern extension of the Appalachian Plateau, contains exposures of Carboniferous (Mississippian-Pennsylvanian) rocks which were deposited in shelf, delta front, barrier bar, lagoon, delta plain and coal-bearing environments. The oldest rocks in this area of Tennessee were mapped as the Upper Devonian Chattanooga Shale whereas the youngest rocks are the Lower Pennsylvanian Rockcastle Sandstone (also known as the Sewanee Conglomerate in Tennessee). A geologic time scale is presented in the appendix.

Lookout Mountain is a broad, gently undulating syncline, with the youngest rocks (Rockcastle Sandstone) in the topographically high area (now structurally low; Cramer 1986). Chickamauga Battlefield and Missionary Ridge are located just east in the Valley and Ridge Province of Tennessee and Georgia. Extensive folding and faulting in the region developed a series of northeast-southwest trending ridges and valleys where Lower Ordovician carbonates were thrust northwestward to overlie younger formations. These geomorphic features formed during the Alleghanian orogeny at the end of the Paleozoic when this active continental margin collided with Gondwanaland (an ancient supercontinent that existed in the southern hemisphere 200 to 500 million years ago, consisting of South America, Africa, Antarctica, and Australia). The carbonate rocks were then detached from the underlying rocks, folded, and cut by thrust faults (Henderson 2004). Stratigraphy of this report follows the terminology of Thomas and Cramer (1979), Culbertson (1963) and Crawford et al. (1989).

The NPS Geologic Resources Division conducted a geologic resources inventory scoping session in March 2009. CHCH is present on six 7.5 minute USGS quadrangles: East Chattanooga, Chattanooga (Tennessee; Hayes 1892; Finlayson et al. 1964), East Ridge, Fort Oglethorpe, Hoooker, and Ringgold (Georgia and Tennessee). A geologic map of Hamilton County, Tennessee, is available at 1:48,000 scale

(Milici et al. 1979). A thematic inventory on cave paleontology within National Park Service units included a discussion on CHCH caves (Santucci et al. 2001).

Sources of Paleontological Resources

Fossils have been documented from the following geologic formation and caves within CHCH. These fossils present opportunities for resource management (including field surveys, inventory, and monitoring), education, interpretation, and continued or future scientific research in the park.

Monteagle and Bangor Limestones (Lower Mississippian)

The Monteagle Limestone conformably overlies the Tuscumbia Limestone (see below). On Lookout Mountain the Bangor Limestone rests on the Monteagle. The Monteagle and Bangor are lithologically similar and cannot always be distinguished from one another. These two formations were deposited on a carbonate bank and are predominantly bioclastic (composed of shell fragments) and oolitic (containing round accretionary bodies), and unlike the Tuscumbia, contain no chert (Thomas and Cramer 1979; Cramer 1986). Fossils in the Bangor Limestone in the Lookout Mountain area (outside of the park) include corals, bryozoans, brachiopods, mollusks, and echinoderms (Waters 1980). Foraminifera have been found in the Monteagle Limestone outside of CHCH in northwestern Georgia and south-central Tennessee (Rich 1980). Although no calcareous algae or foraminifera have been described from within the park at this time, both the Monteagle and Bangor contain the remains of calcareous algae in northwestern Georgia and southwestern Tennessee, (Rich 1974). The fossiliferous nature of these formations suggests that additional fossil remains might be found within the park during future field investigations.

Nine caves have been documented at CHCH. Many caves are cut into the limestones associated with Lookout Mountain, some of which have entrances outside park boundaries. However, the subsurface features of the caves may extend into CHCH. The Monteagle Formation contains numerous Paleozoic invertebrates, including corals (D. Curry, Cave Management Specialist, pers. comm., 2001). Both formations are prominently exposed throughout the park and contain numerous large pits (Santucci et al. 2001). In Byers Cave (Dade County, Georgia), the remains of a cladoselachian shark were recovered from what is thought to be the Bangor Limestone (Cramer and Falls 1966). The caves within CHCH preserve Pleistocene-Holocene fossils as described below in the "Paleontological Resources associated with CHCH Caves" section.

Paleontological Resources associated with CHCH Caves (Pleistocene)

Two caves, Kitty City and 27 Spider, are solution caves in the Cumberland Plateau Cave Area. Kitty City Cave has casts of big cat paw prints and claw marks on the walls. Preliminary assessment of the fossil remains suggests the cats fell into the pit, attempted to climb out, and subsequently died. Twenty-seven Spider Cave is the longest cave in the park with a 305 m (1,000 ft) passage. The lower part of the cave was mapped by the National Speleological Society. Twenty-seven Spider Cave contains a large skull and vertebral column which are partially exposed in a mud bank (see report cover). There are also teeth exposed in the cave wall. In 1995, a large oil spill in the park forced the closure of all of the caves, which were monitored for two years and then re-opened (D. Curry, Cave Management Specialist, pers. comm., 2001; Santucci et al. 2001).

Fossils are common in other caves in the vicinity of CHCH. For example, Gaudin et al. (1999) described Pleistocene microvertebrates from three caves on the northern end of Lookout Mountain, Tennessee. It is unclear if these caves are in the park but their tunnels could extend under CHCH property. Fauna described include birds (*Tympanuchus*), moles (*Condylura*), skunk (*Conepatus*), armadillo (*Dasypus bellus*), peccary (*Mylohyus*), and mastodon (*Mammut*). Lookout Cave in Hamilton County, Tennessee, contains the remains of a tapir (*Tapirus haysii*; Mercer 1894; Cope 1899; Hay 1923; Corgan 1976; Bogan et al. 1980). Additional tapir remains (*Taprius*; Parmalee and Graham 2002) have also been located in Ruby Falls Cave, a commercially operated cave in Lookout Mountain (which may extend under the park),

Hamilton County, Tennessee, and Anderson Springs Cave in Dade County, Georgia (Cramer and Gray 1962; Gray and Cramer 1961). Other remains from Ruby Falls Cave include jaguar (*Panthera onca*) and a giant beaver (*Castoroides*) (Parmalee and Graham 2002).

Potential Sources of Paleontological Resources

Fossils have not yet been documented from the following geologic units within CHCH. However, future field investigations within the park may yield fossils from one or more (or none) of the following geologic units. Fossils are documented from these units outside of the park.

Knox Group: Mascot Dolomite (Ordovician)

The Mascot Dolomite is exposed at the Chickamauga National Cemetery in Tennessee. It is finely crystalline and well bedded with chert nodules. The Mascot commonly contains weathered calcite veins that produce a characteristic "butcher block" pattern. Fossiliferous limestone beds are present including remains of the gastropod *Ceratopea* (Wilson 1979; M. Hoyal, Assistant State Geologist, Tennessee Division of Geology, pers. comm., April 2009).

Chickamauga Limestone (Ordovician)

Thin to thickly bedded fossiliferous limestones of the Chickamauga Limestone are present within the Tennessee portion of CHCH. The type section of this formation is exposed along Chickamauga Creek, east of Chattanooga, in south-central Tennessee, and branches of that creek in the Ringgold 7.5' quadrangle of northwestern Georgia. This formation may contain poorly exposed bentonite beds, typically 0.6 to 0.9 m (2 to 3 ft) thick, overlying a very distinctive 5 to 8 cm (2 to 3 in) chert bed. Branching bryozoans and fucoids (unidentified trace fossils) are typical in the lower portion (M. Hoyal, Assistant State Geologist, Tennessee Division of Geology, pers. comm., April 2009).

Chattanooga Shale (Upper Devonian)

The oldest fossiliferous formation exposed within the Lookout Mountain portion of the park is the Upper Devonian Chattanooga Shale. Downwarping of the basin during the Devonian resulted in oxygen-starved conditions, and the deposition of the Chattanooga Shale (Henderson 2004). The black and fissile shale usually weathers to gray and occasionally red color. This lagoon deposit contains the remains of graptolites, inarticulate brachiopods, criccoconarids, ostracods, gastropods, conodonts, fish bones, shark teeth, plants (*Callixylon*), the spore-like *Tasmanites* and trace fossils. These are found elsewhere in the state and are not yet known from exposures within CHCH (Cramer 1986; Conant and Swanson 1961; Hass 1956; Jones and Dennison 1970; Maisey 1989; Maher and Dunkle 1955).

Maury Shale (Lower Mississippian)

The Maury Shale conformably (or grades from one formation into another without a known break in deposition) overlies the Chattanooga Shale on Lookout Mountain, and in certain locations it is difficult to distinguish the two formations. This formation is a silty to sandy, green and gray shale that is less than 1.5 m (5 ft) thick. It often contains the greenish mineral glauconite as well as phosphate nodules (Cramer 1986; Wheeler 1955). Conodonts from exposures outside the park indicate that the Maury is Lower Mississippian in age (Hass 1956). Other fossils from this formation elsewhere in the state (exposed in parks of the GULN) include brachiopods, cephalopods, crustaceans, conodonts, various fish bone fragments and plant remains (Conant and Swanson 1961; Kenworthy et al. 2007)

Fort Payne Chert (Lower Mississippian)

The Fort Payne Chert conformably overlies the Maury Shale and is composed of bedded chert and chert dolostone (magnesium-rich carbonate rock). The shallow marine shelf deposit is about 60 m (200 ft) thick on Lookout Mountain (Thomas and Cramer 1979; Cramer 1986). Coral, brachiopods trilobites and crinoids, are known outside of the park from the Fort Payne Chert in Alabama, Tennessee, northwest

Georgia and parks of the GULN (Rich 1966; Bassler 1932; Morrow and Wilson 1963; Harris et al. 1963a, 1963b; Szabo et al. 1988; Kenworthy et al. 2007).

Tuscumbia Limestone (Lower Mississippian)

Gradationally overlying the Fort Payne Chert is the Tuscumbia Limestone. This bioclastic limestone contains abundant chert fragments with local beds of lime mudstone and finely crystalline dolostone. This unit formed from an open marine shelf in the Lower Mississippian (Thomas and Cramer 1979; Cramer 1986). The Tuscumbia Limestone is equivalent to the St. Louis and Warsaw limestones in Tennessee and is known to contain caves elsewhere in the southeastern United States. Foraminifera, corals, bryozoans, brachiopods, crinoid stem plates, and conodonts have been found in the Tuscumbia Limestone outside of CHCH in Alabama, northwestern Georgia and south-central Tennessee (Rich 1980; Szabo et al. 1988; Waters et al. 1993; Harris et al. 1963a; Hassler and Stock 1993; Ruppel 1979).

Pennington Shale (Lower Mississippian)

Conformably overlying the Bangor Limestone is the Pennington Shale. These prodelta and delta sedimentary rocks are distinguished by maroon and green shale with interbedded limestones and mudstone, which grade upward into a gray shale with interbedded siltstone, sandstone, siderite (important iron-bearing mineral) and thin coal seams. This formation is mapped along the lower flanks of Lookout Mountain within the Hooker and Ft. Oglethorpe quadrangles in the park. Fossils from the Pennington outside of the park include bryozoans, calcareous algae and trace fossils (Thomas and Cramer 1979; Cramer 1986; Windham 1956; Rindsberg 2007; Rich 1974). The Pennington Formation is also present in RUCA and as the Pennington Group in CUGA.

Gizzard Group (Lower Pennsylvanian)

The Gizzard Group is composed of three formations on Lookout Mountain (in stratigraphic order from lowest and oldest to highest and youngest): the Raccoon Mountain, Warren Point and Signal Point formations. The Mississippian-Pennsylvanian boundary is not easily distinguishable in the Lookout Mountain area, making it difficult to differentiate between the Pennington Shale and the Raccoon Mountain Formation of the Gizzard Group. The Raccoon Mountain Formation is composed of gray shale with interbedded sandstone, siderite and coal which formed in a near-shore delta setting. Marine fossils and plants are known from this formation. The Warren Point Sandstone Formation disconformably overlies the Raccoon Mountain Formation. This member possibly formed in a barrier-bar setting and is composed of coarse-gained, cross bedded, conglomeratic sandstones with a small amount of coal and plant material. The Signal Point Shale is likely a lagoonal deposit, and is composed of gray shale with discontinuous sandstone and coal beds. No fossils are known from the Warren Point Sandstone or the Signal Point Shale (Cramer 1986, Wilson et al. 1956).

Crab Orchard Mountains Group (Lower Pennsylvanian)

The uppermost unit on Lookout Mountain is the Crab Orchard Mountains Group, which is composed of five formations likely deposited in a lower delta plain environment. These formations are (in stratigraphic order from lowest and oldest to highest and youngest): the Sewanee Conglomerate, Whitwell Shale, Newton Sandstone, Vandever Formation and Rockcastle Conglomerate. Fossils are only known from the Whitwell and Vandever shales. The Whitwell Shale lies conformably on the Sewanee Conglomerate and consists of gray shale with interbedded coals and thin sandstone beds. Marine invertebrate and plant fossils are known from this formation. A five-toed amphibian trackway (*Cincosaurus cobbi*) was also collected from this formation at an abandoned coal mine on Lookout Mountain in Chattooga County, Georgia, outside of the park (Schneck and Fritz 1985). This specimen represented the first report of Paleozoic amphibian remains from Georgia.

The Vandever Shale is predominantly gray shale with interbedded sandstone and many well-developed, persistent coal seams (known as the Durham coals). Fossils known from this formation include abundant plants (Cramer 1986). Hudson (1980) describes collecting plant specimens from these coals in the Durham, Georgia area (outside of CHCH) that include lycopod scales (commonly referred to as the “scale

tree," *Lepidodendron*), horsetails (*Calamites*), ferns (*Neuropteris, Alethopteris, Sphenopteris*), and fronds from the earliest known tree (a woody shrub called *Archeopteris*). A marine invertebrate "fossil zone" is found about 7.6 m (25 ft) up from the base of this member (of which the upper 91 m [300 ft] of this "fossil zone" interval is present in the park; Crawford 1989).

Park Collections

There are no fossils present in the CHCH collections (D. West, CHCH Collections Manager, pers. comm., February 2009).

Cultural Resource Contexts

Often, memorials, monuments, and park infrastructure may consist of rocks from the local area or even other states and those constructed of sedimentary rocks (such as limestone) may preserve fossils. Further investigation may identify the type of limestone used in the historic structures within CHCH and whether they display fossils. Historic structure building stone is just one potential source of fossils preserved in cultural resource contexts Kenworthy and Santucci (2006) present a summary of NPS fossils in a cultural resource context.

Paleontological Resource Management, Preliminary Recommendations

- The NPS Geologic Resources Division conducted its GRI scoping session in March 2009. The scoping session summary is being developed at this time.
- Park staff should continue to be made aware of the potential for discovery of fossil material during other field work, particularly along river bluffs, caves, sink holes, road cuts, streams, creeks, gullies, and during erosional events.
- Staff should photodocument and potentially monitor any occurrences of paleontological resources that may be observed *in situ*. Fossils and their associated geologic context (surrounding rock) should be documented but left in place unless they are subject to imminent degradation by artificially accelerated natural processes or direct human impacts.
- Battlefield monuments sometimes incorporate rocks from outside of the park; they may contain fossil resources from other regions or states. Such occurrences are documented at a number of parks in the NPS (e.g. Gettysburg NMP) but are not yet known from CHCH. Kenworthy and Santucci (2006) presented an introduction to fossils in cultural resource contexts throughout the NPS.
- The paleontological resources in the park caves are excellent candidates for continued inventory, assessment, documentation, and monitoring.
- The park may want to consider long term paleontological resource monitoring of documented sites. A Geologic Resource Monitoring Manual by the Geological Society of America and NPS Geologic Resources Division (2009, in press) includes a section on paleontological resource monitoring (Santucci et al. in press).
- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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Cowpens National Battlefield

Cowpens National Battlefield (COWP) was originally established on March 4, 1929, to preserve and interpret the Revolutionary War Battle of Cowpens. The battle took place on January 17, 1781, when Brigadier General Daniel Morgan successfully led the American troops over British Lieutenant Colonel Banastre Tarleton and his forces. The site was originally administered by the War Department and on August 10, 1933 the site was transferred to the National Park Service. The park was listed on the National Register of Historic Places on October 15, 1966 and redesignated Cowpens National Battlefield on April 11, 1972. The National Park Service manages 340.57 ha (790.90 federal acres, 50.66 nonfederal acres; Binkley and Davis 2002).

Geologic Background

Located near the North Carolina border, Cowpens National Battlefield is approximately 5 km (3 miles) east of Chesnee, South Carolina in the Inner Piedmont geologic province. The Inner Piedmont province consists of Neoproterozoic ("Precambrian", see the appendix for a geologic time scale) to earliest Cambrian metamorphic rocks, predominantly varieties of biotite gneiss and lesser amounts of sillimanite-mica schist. The Inner Piedmont province is among the most intensely deformed and metamorphosed segment of the Piedmont. The rocks of this area range from 500 to 750 million years old, with metamorphism taking place at a later time (Horton and Zullo 1991). The Introduction of the report contains information regarding the tectonic history of the area.

COWP has been geologically mapped at the 1:250,000 scale by the U.S. Geological Survey (USGS; Goldsmith et al. 1988, Gair 1989) and at the 1:24000 scale by the South Carolina Geological Survey (SCGS; Boland 2000). The NPS Geologic Resources Division conducted a geologic resources inventory (GRI) scoping session for the park on April 26, 2005. Fossils are not known from the Neoproterozoic rocks of COWP, with no potential for discovery of fossils within the battlefield. The continental slope-rise setting of Laurentia was not favorable for the preservation of fossils. In addition, the subsequent intense deformation and metamorphism would have likely destroyed any fossils that were preserved.

Park Collections

No fossils are present in the COWP collection (V. Fowler, COWP park ranger, pers. comm. February 2009).

Cultural Resource Contexts

Often, memorials, monuments, and park infrastructure may consist of rocks from the local area or even other states and those constructed of sedimentary rocks (such as limestone) may preserve fossils. Further investigation may identify the type of stone used in these monuments within COWP and whether they display fossils. Historic structure building stone is just one potential source of fossils preserved in cultural resource contexts Kenworthy and Santucci (2006) present a summary of NPS fossils in a cultural resource context.

Paleontological Resource Management, Preliminary Recommendations

- The NPS Geologic Resources Division sponsored a GRI scoping session for COWP on April 26, 2005. No *in situ* paleontological resources were identified in that report and there were no recommendations regarding paleontological resources.
- Due to the lack of documented *in situ* fossil occurrences within the park, and the unlikelihood of extensive macrofossil discovery within the park, establishment of a paleontological resource management plan is not necessary.

- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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Cumberland Gap National Historical Park

Cumberland Gap National Historical Park (CUGA) encompasses a mountain pass on the Wilderness Road explored by Daniel Boone in 1775. The Gap was developed into a main artery of the great trans-Allegheny migration for settlement of the "Old West." The Gap was also an important military objective during the Civil War. CUGA was established as a unit of the National Park Service on June 11, 1940, and is located at the border between Kentucky, Tennessee, and Virginia. The National Park Service manages 9,394.37 ha (23,214 acres; federal: 23,198.76 acres, non-federal: 16.27 acres).

Geologic Background

Regional dipping of stratigraphic units, geologic structures, and faulting in the area controlled the formation of Cumberland Gap. Cumberland Mountain sits between Pine Mountain and the Middlesboro syncline (rocks folded convex down) to the west and the Owen Valley anticline (rocks folded convex up; Powell Valley anticline further north) to the east along a back thrust fault (Doublings fault zone) of the Pine Mountain thrust sheet. The Pine Mountain thrust sheet is a large mass of rock about 1,200 m (4,000 ft) thick that slid westwards along a detachment surface deep within the Earth's crust during the formation of the Appalachian Mountains. Movement along local faults resulted in uplift and tilting of the originally horizontal rock layers. Internal stresses within the Pine Mountain thrust sheet caused the formation of tear faults such as the Rocky Face Fault that runs through Cumberland Gap perpendicular to the Pine Mountain and Doublings faults. The deformation associated with the Rocky Face Fault created a local zone of weakness. This zone preferentially weathered in contrast to the rest of Cumberland Mountain. Wind and water carved the gap through this faulted zone.

Sharp cliffs, narrow ridges, notches, and steep "V-shaped" valleys characterize the landscape at Cumberland Gap National Historical Park. Exposed in the park and surrounding areas are geologic units from the Mississippian and Pennsylvanian periods (see the appendix for a geologic time scale). Cherts and limestones make up the rock of the Mississippian Period (the Newman Limestone and Pennington Group), the dissolution of which formed caves such as Gap, Skylight, and Big Salt caves. Pennsylvanian-age sandstones of the Breathitt Group (Warrens Point Sandstone, Bottom Creek Formation, Sewanee Sandstone, Alvy Creek Formation, Bee Rock Sandstone, Grundy, Pikesville, and Hyden Formations) support the ridge tops and form steep cliffs. Within the Breathitt Group the Bottom Creek Formation, Sewanee Sandstone, and Bee Rock Sandstone are not known to contain fossils at this time. The Middle and Upper Mississippian Newman Limestone, the Upper Mississippian Pennington Group, and the Lower Pennsylvanian "Lee Formation" are three fossil-bearing units exposed at Cumberland Gap National Historic Park. The rocks of the "Lee Formation" have been placed into the Pennington and Breathitt groups leading to some nomenclatural differences between publications, as described below. See also Rice et al. (1994) for addition interpretations of the geologic nomenclature of the area. The excavation for the Cumberland Gap Tunnel a 1,400 m (4,600 ft) road tunnel, cut through the Lee, Pennington, and Newman formations in the park and yielded a few plant and animal fossils which have not yet been identified (R. Collier and F. Ettensohn, University of Kentucky, pers. comm., 2001).

The NPS Geologic Resources Division conducted a geologic resources inventory (GRI) scoping session for the park on June 6-7, 2007 (Thornberry-Ehrlich 2008). CUGA is located within all or part of six 7.5 minute USGS quadrangles: Middlesboro North, Varilla, Ewing, Kentucky; Fork Ridge, Middlesboro South, Wheeler, Tennessee (Brent 1988; Conley 2003; Crawford 2003; Englund 1964; Englund et al. 1963a, 1963b, 1964; Harris 1965; Harris et al. 1962; Johnson 2003; Kohl and Sykes 1991; Maughan and Tazelaar 1973; Thompson 2003; Mullins 2003; Rice and Maughan 1978; and Sparks and Lambert 2003). A thematic inventory on cave paleontology within National Park Service units includes a discussion on CUGA caves (Santucci et al. 2001).

Sources of Paleontological Resources

Fossils are known to occur in the following geologic units within the park. The fossils of CUGA present opportunities for education, interpretation, and continued or future scientific research in the park.

Newman Limestone (Upper Mississippian)

The Newman Limestone is exposed only in the Middlesboro South 7.5' quadrangle of the park. This formation is composed of a medium-gray to olive-gray, partly argillaceous (containing clay) limestone with skeletal calcarenites. It is interbedded with a medium-gray to medium-dark-gray shale that is partly calcareous (Englund 1964). The oolitic and skeletal limestone of the lower portion of this formation formed in the clearer and more turbulent water of the shallow-marine shelf (Grabowski 1986). Complete fossils are uncommon in the Newman Limestone due to the lack of horizontal bedding planes.

Caves have been found in the Newman Limestone, but are not described in the park (Santucci et al. 2001). Fossils from this formation were discovered within the park during the Cumberland Gap Tunnel excavation, which yielded a few plant and animal fossils, none of which have been identified at this time. These fossils are currently held at the University of Kentucky (R. Collier and F. Ettensohn, University of Kentucky, pers. comm., 2001, 2009). The fossiliferous nature of this formation suggests that additional fossil remains might be found within the park during future field investigations. Fossils from this formation discovered outside of the park include crinoids, blastoids, conodonts, and worm tubes (Ettensohn and Bliefnick 1982; Ettensohn 1981, 1975; Strimple and Coney 1982).

Pennington Group (Upper Mississippian - Lower Pennsylvanian)

The Pennington Group is composed predominantly of shale and represents marine and marginal-marine depositional environments. Because it is composed largely of soft shale, it is easily eroded and covered. Hence it is rarely exposed at the surface (Santucci et al. 2001). This group is present in the Middlesboro South, Middlesboro North and Varilla 7.5' quadrangles within the park (Englund et al. 1963a, 1964; Englund 1964). The Pennington Group is split into upper and lower formations with the lower formation composed of a very light gray to light olive-gray, very fine to fine-grained sandstone. It is partly ripple-marked with abundant clay-rich layers, and few thin beds of light olive-gray shale and siltstone. The upper formation consists of a medium-gray to light-olive-gray shale with local thin coal beds and underlying clay (called "underclay") in the lower portion.

This upper formation lies stratigraphically above what was formerly referred to the lower tongue of the "Lee Formation" (Chesnut 1992; Kuehn et al. 2003). Because the Pennington Group now includes rocks from what used to be called the "Lee Formation," there can be some differences between publications. Englund (1964) formally named a sandstone in the Pennington Group (then the Pennington Formation) the "Pinnacle Overlook Member" of the Lee Formation. It is possible that this lower tongue refers to different sandstone units in the same general part of the stratigraphic section, correlated now with the Princeton Sandstone, a member of the Pennington Group (Rice 1984, 1986; Kuehn et al. 2003). The interval that is equivalent to this lower tongue or below it is medium gray, greenish-gray and grayish-red, partly calcareous shale that contains thin beds of light olive-gray argillaceous limestone (Englund 1964).

During the excavation of the Cumberland Gap Tunnel within the park a few plant and animal fossils which have not yet been identified were found within this formation and are presently held at the University of Kentucky (R. Collier and F. Ettensohn, University of Kentucky, pers. comm., 2001, 2009). The Pennington Group is known to yield marine fossils elsewhere outside of the park, similar to those found in the underlying Newman Limestone (Santucci et al. 2001, Englund 1964). Fossils discovered outside of the park include crinoids, blastoids, conodonts, spores, and burrows (Greb 2006, Beaver 1996, Ettensohn and Bliefnick 1982, Ettensohn and Peppers 1979, Merrill 1973). The fossiliferous nature of this formation suggests that additional fossil remains might be found within the park during future field investigations.

Pennington and Breathitt groups: "Lee Formation" rocks (Upper Mississippian - Lower Pennsylvanian)

The rocks that compose the formation referred to as the "Lee Formation" in older literature are now grouped within the Pennington and Breathitt groups (Chesnut 1992; Kuehn et al. 2003). The type area for the "Lee Formation" is along the Cumberland Mountain outcrop in nearby Lee County, Virginia (Kuehn et al. 2003). When originally described, the "Lee Formation" included a coarse-grained, conglomeratic, cross-bedded sandstone, with occasional limestone and coal, representing the channels of an ancient braided stream and marginal marine settings. Although fossils are rare in the "Lee Formation," a few fossil plants are preserved. Petrified log jams have been found in these ancient stream deposits (F. Ettensohn, University of Kentucky, pers. comm., 2001; Santucci et al. 2001; Rice 1986; Kuehn et al. 2003). Fossils from this formation were discovered within the park during the Cumberland Gap Tunnel excavation. These fossils have not yet been identified and are presently held at the University of Kentucky (R. Collier and F. Ettensohn, University of Kentucky, pers. comm., 2001, 2009). The Pinnacle Overlook member of the Lee Formation is Upper Mississippian in age and is composed of a white to very light gray, fine- to coarse-grained, quartzose sandstone. This member is also thick-bedded to massive with cross beds and is partly conglomeratic with well-rounded quartz pebbles (Englund 1964).

Paleontological Resources associated with CUGA Caves (Pleistocene)

Several caves are known to contain fossils within CUGA. The remains of a partially articulated, poorly preserved black bear (*Ursus americanus*) were observed in Gap Cave, but have not been collected and the condition of the bones appears poor for dating (R. Toomey, Director Mammoth Cave International Center for Science and Learning, pers. comm., January 2009). The caves of CUGA are currently under study and no other information regarding the specific fossil occurrences are available at this time (April 2009). However, fossils may be exposed on cave walls.

In 1885, J. A. Allen described dog remains discovered in Ely Cave (outside of CUGA, but near the park in Virginia) by Professor N. S. Shaler. The remains consist of a scapula, a humerus, a femur, and a tibia, all belonging to the right side, and a pelvis.

Potential Sources of Paleontological Resources

Fossils have not yet been documented from the following geologic units within CUGA. However, future field investigations within the park may yield fossils from one or more (or none) of the following geologic units.

Breathitt Group: Warren Point Sandstone (Lower-Middle Pennsylvanian)

The Warren Point Sandstone is the basal (oldest) formation of the Breathitt Group. Three members of the "Lee Formation" (see above) are now considered part of the Warren Point Sandstone. In the CUGA area these members include: Sandstone Member A, White Rock Sandstone Member, and the Chadwell Member (Kuehn et al. 2003; Chesnut 1992; Englund 1964; Englund et al. 1963a, 1963b, 1964). Sandstone Member A is composed of white to very light gray, fine- to coarse-grained, quartzose sandstone. It is massive, partly conglomeratic with well-rounded quartz pebbles, and cross bedded (Englund 1964; Englund et al. 1963a). The White Rock Sandstone Member is named from exposures at White Rocks, a prominent cliff on Cumberland Mountain (Englund et al. 1963b). It is composed of a white to very light gray, fine- to coarse-grained, massive and crossbedded quartzose sandstone with a well-rounded quartz pebble conglomerate. This member wedges out northwestward within the Varilla 7.5' quadrangle (Englund et al. 1963a). In the Ewing 7.5' quadrangle a center bed of very fine grained wavy-bedded light olive-gray sandstone is present in the member (Englund et al. 1963b). The Chadwell Member is a white to very light gray, fine- to coarse-grained quartzose sandstone exposed in the Middlesboro North 7.5' quadrangle. Massive crossbedded sequences are present, with a well-rounded quartz pebbles conglomerate in the lower part of the member (Englund et al. 1964). No fossils from this formation have been noted within the park, although plant fossils have been noted from the Warren Point Sandstone outside of the park (Churnet and Bergenback 1986).

Grundy Formation (Lower-Middle Pennsylvanian)

Siltstone, sandstone, and coal make up the rocks of the lower Hance (or Bennetts Fork) coal zone of the Grundy Formation, which lies below the Mason coal bed and above the Clear Fork coal bed of the Grundy. The lower portion of the Hance coal zone is present in the upper Grundy Formation, with the upper portion of the Hance found in the overlying lower Pikeville Formation. The Hance coal zone, which is poorly exposed in the Middlesboro North 7.5' quadrangle, consists of as many as five coal beds (Englund et al. 1964). This zone is a medium-gray to black shale with common siderite (important iron-bearing mineral) nodules. Interbedded and intergraded siltstone and sandstone are present and commonly rooted throughout. This member also contains a few interbeds of light-gray, very fine to fine-grained micaceous sandstone, siltstone, coal, and underclay. The Hance coal beds become thin in the Little Clear Creek area near the western border of the Middlesboro North 7.5' quadrangle (Rice and Maughan 1978, Englund et al. 1964). The lower part of the Hance Formation in the Varilla 7.5' quadrangle is composed of a medium- to dark-gray shale with common ironstone nodules. A thin coal bed and underclay are also present at the base in some areas. Eastern Varilla 7.5' quadrangle exposures are light-gray, very fine grained, micaceous, thin-bedded sandstone at the approximate stratigraphic position of the Naese Sandstone Member of the Bee Creek Sandstone (Englund et al. 1963a).

The interval below the Hance (Bennetts Fork) coal zone and above the Yellow Creek Sandstone Member in the Middlesboro North 7.5' quadrangle (present just to the north of the park and in the Sugar Run area of CUGA) consists of sandstone, siltstone, shale, limestone, and coal. The sandstone is generally light- to medium-gray in color, mostly fine grained and composed predominantly of quartz with minor feldspar, mica, and rock fragments in a matrix of clay and clay-size quartz. Siltstone and shales are medium- to dark-gray in color, sandy to clayey in texture, slightly micaceous and in some areas calcareous, with most being planar laminated. The shale unit above the Mason Rider coal bed contains sparse marine fossils in some areas, brown-weathering siderite concretions, and thin layers and other concretions of medium-dark- to dark-gray limestone. An unnamed sandstone member below the Mason coal bed is very fine to fine-grained, ripple-bedded in the upper part, cliff forming, with the lower part in some areas filling channels (Englund et al. 1964).

The Yellow Creek Sandstone Member is a very fine- to medium-grained, micaceous, thick bedded, cliff forming sandstone. No fossils have been described from this member. In the northwest part of the Middlesboro North 7.5' quadrangle, the Yellow Creek in some areas merges with, and is mapped with lithologically similar sandstone at the top of the underlying Naese Sandstone Member of the Bee Rock Sandstone Formation (Englund et al. 1964).

Pikeville Formation (Lower-Middle Pennsylvanian)

The Pikeville Formation contains five members, or zones in the CUGA area: the Hance (or Bennetts Fork) coal zone, the Betsie Shale member, a middle member, the Mingo (or Harlan) coal member, and an upper member. While fossils are known from this formation, they have yet to be described from within the park. The interval above the Mingo (Harlan) coal bed in the Middlesboro North 7.5' quadrangle (outside of the park) consists of siltstone, sandstone and coal. The siltstone is slightly micaceous, clayey to sandy, and medium- to dark-gray in color. The siltstone is locally interbedded with a very fine grained sandstone and contains thin lenses of siderite. Generally light- to medium-gray, the sandstones of this zone are mostly fine- to very fine grained. Fine- to medium-grained sandstone beds commonly occur above the Harlan coal bed (Englund et al. 1964).

The upper portion of the Hance (Bennetts Fork) coal zone is located in the lower Pikeville Formation outside of the park. It is composed of shale, silty shale, siltstone, sandstone, underclay, and coal. Within this zone is a medium- to dark-gray shale and silty shale, in some areas interbedded with siltstone very fine grained sandstone. It contains fossil plant imprints and common siderite nodules. The sandstone is very light to light gray, very fine to medium grained, thin to thick bedded, and micaceous, with cross laminated beds ranging from nearly a meter to 12 m (40 ft) in thickness. This is followed by a medium-gray

argillaceous siltstone in some areas, particularly in the Varilla 7.5' quadrangle (Englund et al. 1963a). Clay underlies the coal beds and contains abundant fossil root casts (*Stigmaria*; Englund 1964).

In the interval below the Mingo coal bed and above the Hance (Bennetts Fork) coal zone in the Middlesboro North 7.5' quadrangle, the Betsie Shale Member is composed of siltstone, shale, sandstone, and coal. The siltstone and shale are clayey to sandy, mica-rich, medium- to dark-gray in color, and in some areas (Middlesboro North 7.5' quadrangle) contain carbon or are bioturbated. The siltstone and shale layers are also interbedded with beds and thin layers of very fine grained sandstone. The sandstone is generally light- to medium-gray in color, and is mostly composed of quartz with minor amounts of feldspar, rock fragments, mica, and dark minerals. The Betsie Shale Member is an upward-coarsening bay-fill sequence of clay, shale, siltstone, and sandstone, containing irregular flat concretions of siderite in the basal part with diffuse bands of siderite in the middle and upper parts. No marine fossils have been found in this area (Englund et al. 1964).

The Mingo (Harlan) coal member is composed of shale, silty shale, siltstone, sandstone, coal, and underclay and can also be found in the lower Hyden Formation. The Harlan coal bed is also known as the "Mason" or "Mason/Mingo" coal bed. This report follows usage described by Englund and others (1963, 1964) and assigns the name "Mason" to a coal bed about 168 m (550 ft) below the Harlan coal bed. The Mingo coal bed may be channeled out and replaced by a sandstone in areas southwest of Fuson Branch. The shale is medium-gray to black and contains fossil leaf and stem imprints. The shale is commonly interbedded with, or grades into a silty shale, siltstone, and very fine grained sandstone. The sandstone is mostly light gray, buff to brown when weathering, thin to thick bedded, and micaceous. A massive, medium-grained, crossbedded sandstone is present in the upper part. There are several thin beds of light- to medium-gray underclay with abundant *Stigmaria* (fossil root cast) are described by Englund (1964). Marine fossils are abundant in calcareous shale and siltstone beds of the Mingo found in the Varilla 7.5' quadrangle on Little Black Mountain just northeast of the park (Englund et al. 1963a).

Hyden Formation (Lower-Middle Pennsylvanian)

The Hyden Formation consists of five members in the Ewing 7.5' quadrangle of CUGA: the Puckett Sandstone, the Catron, the Hignite, the Jesse Sandstone, and the upper Mingo members. While fossils are known from this formation, they have yet to be described from within the park. The Puckett Sandstone Member is a fine-grained, massive, light-gray micaceous sandstone. The Catron is a very fine to fine-grained, light-gray, massive micaceous sandstone with interbedded medium-gray shale, siltstone, coal and underclay. The "Hignite" is a medium-gray shale with a very fine to medium-grained, thin bedded to massive sandstone. A calcareous shale containing the remains of marine fossils is found about 24 m (80 ft) above the base; however, this shale is not yet known from the park. The Jesse Sandstone Member is a fine- to coarse-grained, light-gray, massive micaceous sandstone and well rounded quartz pebble conglomerate. The upper portion of the Mingo is also present in the area of CUGA, where it consists of a medium-gray shale with interbedded very fine to fine-grained sandstone, siltstone, coal and underclay (Englund et al. 1963b).

In the Middleboro North 7.5' quadrangle, the Hyden Formation consists of sandstone, siltstone, shale, and coal. The sandstone is generally light- to medium-gray, mostly very fine grained, is commonly crossbedded, and composed principally of quartz, with minor amounts of mica, feldspar, and rock fragments. The sandstone above the Poplar Lick coal bed is resistant and forms cliffs. Shale and siltstone are clayey to sandy, medium- to dark-gray in color, slightly micaceous and mostly planar laminated. The Kendrick Shale Member, though poorly exposed, is typically very dark gray, with a poorly fissile silty claystone at the base that grades upward to clayey siltstone. The Kendrick Shale member contains thin, discontinuous lenses of siderite in middle and upper parts with marine fossils reported in the Kayjay 7.5' quadrangle adjacent to the park's western boundary but outside of the park (Rice and Maughan 1978, Englund et al. 1964). Fossils outside of the park in the Kendrick Shale include coral, brachiopods, cephalopods, gastropods, crinoids, and vertebrate remains (Greb et al. 1999). The fossiliferous nature of

this formation suggests that additional fossil remains might be found within the park during future field investigations.

Park Collections

There are two fossil specimens in the CUGA collections: a piece of Pennsylvanian siltstone bearing the impression of a plant (*Lepidodendron*, originally cataloged as *Stigmaria*, but not appearing in the current lexicon), and a piece of limestone containing a brachiopod and crinoid stem. These specimens are for interpretive use and are not part of the park's official museum collection (J. Beeler, CUGA Resource Management Specialist, pers. comm. January 2009). Plant and animal fossils collected from the park during the excavation of the Cumberland Gap Tunnel have not yet been identified and are presently held at the University of Kentucky (R. Collier and F. Ettensohn, University of Kentucky, pers. comm., 2001, 2009).

Cultural Resource Contexts

Often, memorials, monuments, and park infrastructure may consist of rocks from the local area or even other states and those constructed of sedimentary rocks (such as limestone) may preserve fossils. Further investigation may identify the type of stone used in the historic structures of CUGA and whether they display fossils. Historic structure building stone is just one potential source of fossils preserved in cultural resource contexts Kenworthy and Santucci (2006) present a summary of NPS fossils in a cultural resource context.

Paleontological Resource Management, Preliminary Recommendations

- The NPS Geologic Resources Division sponsored a GRI scoping session for CUGA on June 6-7, 2007. Participants in the scoping session recommended a comprehensive field-based paleontological resource survey of the park, including vertebrate fossils within park caves (Thornberry-Ehrlich 2008).
- Identification of the fossils from the Cumberland Gap Tunnel excavation (currently held at the University of Kentucky) would provide additional information regarding these paleontological resources.
- Based on the complicated stratigraphy and high potential for fossil discovery in the park, the park may want to consider a field-based paleontological resource survey. Significant localities should be documented using NPS fossil locality and condition assessment forms that meet GPRA goal 1a9A.
- Park staff should be encouraged to observe exposed gullies, other erosional bedrock, and streams for new fossil material while conducting their usual duties. Given the fossiliferous nature of many of these rock units many exposures would likely yield paleontological resources.
- Staff should photodocument and potentially monitor any occurrences of paleontological resources that may be observed *in situ*. Fossils and their associated geologic context (surrounding rock) should be documented but left in place unless they are subject to imminent degradation by artificially accelerated natural processes or direct human impacts.
- The park may want to consider long term paleontological resource monitoring of documented sites. A Geologic Resource Monitoring Manual by the Geological Society of America and NPS Geologic Resources Division (publication in late 2009) includes a section on paleontological resource monitoring (Santucci et al. in press).
- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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Data Sets

Cumberland Gap National Historical Park Paleontological Archives
5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

Cumberland Gap National Historical Park Museum Collections
1940-present. (museum specimens; associated specimen notes; collection records; maps; etc.). Originated by CUGA staff; status: Active.

University of Kentucky Geology Department Collections
2001-present. (specimens; associated specimen notes; collection records; maps; etc.). Originated by F. Ettensohn; status: Active.

Cumberland Gap National Historical Park Digital Geologic Map
2006-present. (geologic map data; electronic files; GIS metadata; associated report). Originated by NPS-Geologic Resource Inventory staff; status: Active. Online.
http://science.nature.nps.gov/nrdata/datastore.cfm?ID=47055.

Fort Donelson National Battlefield

On March 26, 1928, Fort Donelson National Battlefield (FODO) was established. Originally managed by the War Department, it was transferred to the Department of the Interior on August 10, 1933. The park was listed on the National Register of Historic Places on October 15, 1966. FODO was redesignated as a national battlefield on August 16, 1985. The park preserves the American Civil War-era forts Donelson and Heiman, where Union General Ulysses S. Grant and Admiral Andrew Hull Foote captured three forts, and opened two rivers–the Tennessee and Cumberland rivers. The main unit of FODO (Fort Donelson) is located in Dover, Tennessee, and Fort Heiman is located in nearby Calloway County, Kentucky. The National Park Service manages 407.22 ha of FODO (1,006.27 acres; federal: 930.11 acres, non-federal: 76.16 acres).

Geologic Background

Fort Donelson is located in the northwestern corner of the Highland Rim Plateau. Fort Heiman is located on the eastern shore of Kentucky Lake in Calloway County, Kentucky. Rocks exposed in FODO include the Mississippian Fort Payne Formation, Warsaw and St. Louis limestones, and the Cretaceous McNairy Formation and Tuscaloosa Gravel. During the Mississippian Period, sediments on the floor of a shallow continental sea that that covered most of North America, were forming the deposits that would later be compressed into limestone. The Cretaceous rocks within the park (the Tuscaloosa Gravel and the McNairy Formation) represent fluvial deposits composed of gravel, sand and clay (Olive and McDowell 1986). These rocks are commonly exposed on ridge tops within the park. No fossils have been described from within FODO at this time, although rock formations within the park units are fossiliferous elsewhere in Kentucky and Tennessee. A geologic time scale is presented in the appendix.

FODO is present on the Dover, Tennessee and Hamlin, Kentucky 7.5 minute USGS quadrangles (Marcher et al. 1965; Blade 1966; Tyra 2002). The NPS Geologic Resources Division conducted a geologic resource inventory (GRI) scoping session in March 2009.

Sources of Paleontological Resources

Fossils have been documented from the following geologic formations within FODO. These fossils present opportunities for resource management (including field surveys, inventory, and monitoring), education, interpretation, and continued or future scientific research in the park.

St. Louis Formation (Upper Mississippian)

The St. Louis Formation is a fine-grained, somewhat argillaceous, cherty limestone that is only present in the Fort Donelson unit of the park. The formation was deposited in an open shelf shoal environment (marine), ranging from relatively deep, quiet water to shallow, agitated water, with the different environments favored by different faunas. Foraminiferal limestone and shaly limestone are common in some areas. Within FODO boundaries, along Saline Creek and in the bluffs on either side of the historic Cumberland River, fine- to coarse-grained fossil-fragmental calcarenites have been described by Marcher et al. (1965). These calcarenites are composed of broken and abraded crinoid and echinoid ossicles (or numerous small plates that make up parts of the exoskeleton), bryozoan fragments, and brachiopod shells. Encrustations of fibrous algae are also present on some of these fragments (Marcher et al. 1965). The massive colonial coral *Lithostrotion canadense* is an index fossil for this formation and is only found in the St. Louis limestone in Kentucky (not yet noted from FODO). Fossils known from the St. Louis Limestone outside of the park also include brachiopods (*Schellwienella*, *Schuckertella*, *Dielasma*, *Brachythyris altonensis*, *Eumetria verneuiliana*) and gastropods (*Bellerophon*; Weller 1931). The fossiliferous nature of this formation suggests that additional fossil remains might be found within the park during future field investigations.

Warsaw Limestone (Upper Mississippian)

The Warsaw Limestone is a medium- to coarse-grained, massive, limestone that was deposited in an open shelf, shoal environment. Fossil-fragmental calcarenites present in this formation contain abundant crinoid fragments and identifiable remains, with horn corals, bryozoan, brachiopod shells, echinoid spines and plates also being present in the park as described by Marcher et al. (1965). This formation is present in both units of FODO (Marcher et al. 1965; Blade 1966). Within the Warsaw Limestone at Fort Donelson, quick field surveys by geologists from the Tennessee Division of Geology revealed the presence of crinoid segments, and "shell hash" (a mixture of broken chunks of brachiopods and bryozoans). Some coral was present in a gully wash near the Confederate Monument within clasts of clayey, weathered chert. Brachiopods are present in gullies in the park. Devonian shells (possibly from weathered Chattanooga shale) are found nearby in Paris Landing State Park (Thornberry-Ehrlich 2009). Trilobite fossils have been found in the Warsaw Limestone outside of FODO in Dickson County, Tennessee (Bradley 1991). The fossiliferous nature of this formation suggests that additional fossil remains might be found within the park during future field investigations.

Potential Sources of Paleontological Resources

Fossils have not yet been documented from the following geologic units within FODO. However, future field investigations within the park may yield fossils from one or more (or none) of the following geologic units. Fossils are documented from these units outside of the park.

Fort Payne Chert (Upper Mississippian)

The Fort Payne Chert is composed of bedded chert and chert dolostone and is present in both FODO units, with exposures found in the Standing Rock, Leatherwood and Cross Creek areas of the Dover 7.5' quadrangle. The Fort Payne Chert was deposited in deep, quiet water farther out in the basin. In some areas the formation contains cherty crinoid and bryozoan fossil-fragmental calcarenite beds, which are mapped within park boundaries but have not been observed by park staff (Marcher et al. 1965; Blade 1966). Coral, brachiopods trilobites and crinoids are known outside of the park from the Fort Payne Chert in Alabama, Tennessee, northwest Georgia and in parks of the GULN (Rich 1966; Bassler 1932; Morrow and Wilson 1963; Harris et al. 1963a, 1963b; Szabo et al. 1988; Kenworthy et al. 2007).

McNairy Formation (Cretaceous)

The Cretaceous McNairy Formation is present in the Fort Heiman Unit and is composed of sand, clay, and gravel. The sand is very fine- to medium-grained, and is composed predominantly of quartz, with minor amounts of chert and localized abundant heavy minerals. The clay occurs as small, tabular fragments along bedding planes within the sand. Small tubes, up to 2.5 cm (1 in) in diameter, have been identified from outside of the park as the trace fossil *Halymenites major*. Gravel is commonly tan or gray and is composed of angular to rounded granules, pebbles, and cobbles of chert. A dark gray silty clay from Grindstone Creek of the western and southwestern part of the Hamlin 7.5' quadrangle (not in the park) were examined for plant microfossils and interpreted to be from the Cretaceous, similar to the age of the McNairy Formation (R. H. Tschudy, written communication (1964) to Blade 1966).

Tuscaloosa Gravel (Cretaceous)

The Tuscaloosa Gravel is composed of sub-rounded to well-rounded chert gravel in a sandy clay matrix. Many of these chert gravels contain the remains of fossils, such as brachiopods, that are derived from the underlying Mississippian formations (Marcher et al. 1965). They have not yet been noted from the park. Thin lenses of very-fine grained to fine grained quartz sandstone are found in some areas in the Dover 7.5' quadrangle. Most of the gravels are discontinuous and are found on ridge tops in the Fort Donelson area (Marcher et al. 1965). About 3 km (2 miles) southwest of Hamlin, Kentucky (outside of the park), plant microfossils are known, which are interpreted as being clearly different and older than those known from the McNairy Formation (R. H. Tschudy, written communication (1964) to Blade 1966).

Park Collections

No fossils are present in the Fort Donelson National Battlefield collections (J. Jobe, FODO Historian, pers. comm., January 2009).

Cultural Resource Contexts

Often, memorials, monuments, and park infrastructure may consist of rocks from the local area or even other states and those constructed of sedimentary rocks (such as limestone) may preserve fossils. Depending upon its source, the limestone could possibly be fossiliferous, and may present an opportunity for future investigation. Kenworthy and Santucci (2006) present a summary of NPS fossils in a cultural resource context.

Paleontological Resource Management, Preliminary Recommendations

- NPS Geologic Resources Division-sponsored GRI scoping session was held for FODO on March 23, 2009. A summary report from this meeting is currently (June 2009) being prepared.
- Battlefield monuments and other historic structures may incorporate rocks from outside of the park; they may contain fossil resources from other regions or states. Such occurrences are documented at a number of parks in the NPS (e.g. Gettysburg NMP) but have not yet been investigated at FODO. Kenworthy and Santucci (2006) presented an introduction to fossils in cultural resource contexts throughout the NPS.
- Park staff should be encouraged to observe exposed gullies, other erosional bedrock, and streams for fossil material while conducting their usual duties. Given the fossiliferous nature of many of these rock units any exposures would likely yield paleontological resources.
- Staff should photodocument and potentially monitor any occurrences of paleontological resources that may be observed *in situ*. Fossils and their associated geologic context (surrounding rock) should be documented but left in place unless they are subject to imminent degradation by artificially accelerated natural processes or direct human impacts.
- The park may want to consider long term paleontological resource monitoring of documented sites. A Geologic Resource Monitoring Manual by the Geological Society of America and NPS Geologic Resources Division (publication in late 2009) includes a section on paleontological resource monitoring (Santucci et al. in press).
- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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Data Sets

Fort Donelson National Battlefield Paleontological Archives
5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

Guilford Courthouse National Military Park

Guilford Courthouse National Military Park (GUCO) was established on March 2, 1917 and was the first Revolutionary War battlefield set aside as a National Park Service area. The Battle of Guilford Courthouse was fought on March 15, 1781 near what is now the city of Greensboro, North Carolina. Nearly 2,000 British troops led by Lord Charles Cornwallis fought an American force of 4,400 led by Major General Nathanael Greene. The British tactically defeated the much larger American force, but in doing so the British lost a quarter of their own men. More importantly, after the battle, Cornwallis gave up his southern campaign and moved north to Virginia, where he would surrender seven months later. Greene, meanwhile, having escaped from the Guilford Courthouse battle with his army essentially intact, continued to fight and wrapped up the campaign in South Carolina soon afterward. The park was transferred from the War Department to the National Park Service on August 10, 1933. The park was listed on the National Register of Historic Places on October 15, 1966. The National Park Service manages a total of 92.90 ha (229.57 total federal acres; Reid 1959).

Geologic Background

Guilford Courthouse National Military Park is situated on Neoproterozoic (Late Proterozoic and also known as "Precambrian;" refer to the appendix for a geologic time scale) felsic intrusive rocks (rocks containing a large amount of feldspar and silica minerals that cooled below the surface of the earth). These rocks are part of the Virgilina sequence of the Carolina terrane, which consists mostly of igneous rocks, which formed during the Taconic orogeny (Horton and Zullo 1991; Kish et al. 1979; Vick et al. 1987; Noel et al. 1988). The Introduction to this report contains more information regarding the tectonic history of the area.

GUCO is present on the Lake Brandt and Greensboro 7.5-minute USGS quadrangles and on one small scale geologic map (Carpenter 1982). The NPS Geologic Resources Division conducted a geologic resources inventory (GRI) scoping session for the park on September 20, 2000 (National Park Service 2000). The rocks beneath GUCO are composed predominantly of granite and granodiorite, which formed deep beneath the surface of the earth. There is no potential for discovery of fossils within the Neoproterozoic rocks of GUCO.

Park Collections

No fossils are present in the GUCO collection (J. Durham, GUCO park ranger, pers. comm. February 2009).

Cultural Resource Contexts

Often, memorials, monuments, and park infrastructure may consist of rocks from the local area or even other states and those constructed of sedimentary rocks (such as limestone) may preserve fossils. The vast majority of historic structures within the park contain granite, which does not preserve fossils due to its molten origin. Some of the monuments however are constructed of nonspecific "stone" such as the Jethro Sumner Monument. Further investigation may identify the type of stone used in these monuments and whether they display fossils. Historic structure building stone is just one potential source of fossils preserved in cultural resource contexts Kenworthy and Santucci (2006) present a summary of NPS fossils in a cultural resource context.

Paleontological Resource Management, Preliminary Recommendations

- The NPS Geologic Resources Division sponsored a GRI scoping session for GUCO on September 20, 2000. No paleontological resources management issues were identified in that report.

- Due to the lack of documented *in situ* fossil occurrences within the park, and the unlikelihood of extensive macrofossil discovery within the park, establishment of a paleontological resource management plan is not necessary for GUCO.
- Because battlefield monuments can incorporate rocks from outside of the park, they may display fossil resources from other regions or states. Such occurrences are documented at a number of parks in the NPS (e.g. Gettysburg NMP) but are not yet known from GUCO. This could be a source of paleontological resources in the future. Kenworthy and Santucci (2006) presented an introduction to fossils in cultural resource contexts throughout the NPS.
- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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Data Sets

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5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

Guilford Courthouse National Military Park Digital Geologic Map
2006-present. (geologic map data; electronic files; GIS metadata; associated report). Originated by NPS-Geologic Resource Inventory staff; status: Active. Online.
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Kings Mountain National Military Park

Kings Mountain National Military Park (KIMO) was established on March 3, 1931 to commemorate the battle of Kings Mountain, which took place on October 7, 1780 during the Revolutionary War. Frontier militia devoted to the United States overwhelmed the Loyalist American militia. This was one of a few major battles of the war fought entirely between Americans; no British troops served in the battle. The National Park Service manages a total of 1,596.60 ha (3,945.29 total acreage; Mackenzie 1955). The park is adjacent to Kings Mountain State Park.

Geologic Background

Kings Mountain National Military Park is located in the southern Appalachians of York County, South Carolina. The major rock formation found within the park is the Neoproterozoic (Late Proterozoic and also known as "Precambrian," refer to the appendix for a geologic time scale) Battleground Formation. This area spans a major geologic boundary between the Inner Piedmont and Carolina terranes. These two areas are separated by the Kings Mountain shear zone, which also separates the Battleground Formation from the Blacksburg Formation. These formations have undergone as many as five episodes of folding and related deformation (Horton 2008). The Battleground Formation in the KIMO area consists of metamorphosed igneous rocks, predominantly of plagioclase-crystal metatuff, with lesser amounts of mottled phyllitic metatuff, siliceous metatuff, volcanic metaconglomerates, and metatonalites (Horton 2008). These rocks have all been metamorphosed (altered by high temperature and/or pressure) during their active geologic history. The Introduction to this report contains more information regarding the tectonic history of the area.

KIMO is present on the Kings Mountain, Grover, Filbert and Kings Creek 7.5 minute USGS quadrangles (Horton 2008; Howard 2004; Nystrom 2003; Folsom 1982). The NPS Geologic Resources Division conducted a geologic resources inventory (GRI) scoping session for the park on September 19, 2000 (National Park Service 2000). Fossils are not known from the Neoproterozoic rocks of KIMO, and given their previously molten and/or metamorphosed nature, fossils would not be expected. Thus, there is little potential for discovery of fossils within KIMO.

Park Collections

Records from the Harpers Ferry Center museum center indicate that one fossil may be within the collections of KIMO (K. Byrne, HFC museum registrar, pers. comm., 2007). However, fossil specimens were not found within the KIMO collection according to C. Revels (KIMO Chief Ranger, pers. comm. February 2009). Future efforts may resolve this apparent discrepancy in documentation.

Cultural Resource Contexts

Often, memorials, monuments, and park infrastructure may consist of rocks from the local area or even other states and those constructed of sedimentary rocks (such as limestone) may preserve fossils. However, the vast majority of historic structures within the park contain granite (which does not preserve fossils due to its molten origin) and local unfossiliferous stones. Historic structure building stone is just one potential source of fossils preserved in cultural resource contexts Kenworthy and Santucci (2006) present a summary of NPS fossils in a cultural resource context.

Paleontological Resource Management, Preliminary Recommendations

- The NPS Geologic Resources Division sponsored a GRI scoping session for KIMO on September 19, 2000, and no paleontological resources management issues were identified in that report (National Park Service 2000).

- Due to the lack of documented *in situ* fossil occurrences within the park, and the unlikelihood of extensive macrofossil discovery within the park, establishment of a paleontological resource management plan is not considered necessary for KIMO.
- Battlefield monuments and other historic structures may incorporate rocks from outside of the park; they may contain fossil resources from other regions or states. Such occurrences are documented at a number of parks in the NPS (e.g. Gettysburg NMP) but have not yet been investigated at KIMO. Kenworthy and Santucci (2006) presented an introduction to fossils in cultural resource contexts throughout the NPS.
- Continued investigation may resolve the discrepancy between HFC and KIMO museum records regarding the presence of fossils in the park collections.
- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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Little River Canyon National Preserve

Little River Canyon National Preserve (LIRI) was established on October 21, 1992 to protect and preserve the significant biological diversity and habitat for unique assemblages of vegetation and wildlife, and some of the most rugged scenery in the southeast, including forested uplands, canyon rims and bluffs, pools, boulders, and sandstone cliffs. The spectacular scenic resources include Little River Falls, a 14 m (45 ft) waterfall at the beginning of the canyon. Park resources also include threatened, endangered and rare plants and animals; historical and archeological resources; and formal designation of the river as "Outstanding National Resource Waters." Recreational activities include hunting, hiking, overlooks, water activities, fishing, and picnicking with some of the southeast's most challenging whitewater and climbing areas. LIRI is located on top of Lookout Mountain near Fort Payne, Alabama and DeSoto State Park. The National Park Service manages a total of 5,517.06 ha (10,338.15 federal acres, 3,294.81 non-federal acres; L. Beane, LIRI park ranger, pers. comm. March 2009).

Geologic Background

Northern Alabama is divided into two physiographic provinces: the Appalachian Plateau and Interior Low Plateau (or Coastal Plain). LIRI lies within the Appalachian Plateau physiographic province which is composed of sandstones and shale synclinal (or convex downwards) plateaus with modest relief. The area is underlain by Paleozoic sedimentary rocks that range from Cambrian to Pennsylvanian in age. Within the park, the Lower Pennsylvanian Pottsville Formation is present, deposited originally as barrier-island and delta plain facies (Hobday 1974; Ferm and Ehrlich 1967; Bowles 1941). LIRI is located on Lookout Mountain, which stretches from Etowah County, Alabama northeast through Georgia ending in Chattanooga, Tennessee (Raymond et al. 1988). Lookout Mountain is a broad, gently undulated syncline, with the youngest rocks in the topographically high area (Cramer 1986). This syncline formed during the Alleghanian orogeny at the end of the Paleozoic when the eastern continental margin collided with Gondwanaland (an ancient supercontinent that existed in the southern hemisphere 200 to 500 million years ago, and consisted of South America, Africa, Antarctica, and Australia). These rocks were then detached from the underlying rocks, folded, and cut by thrust faults (Henderson 2004). The Little River has incised Lookout Mountain, forming the Little River Canyon. Another CUPN park, Chickamauga & Chattanooga National Military Park (CHCH), is also partially located on Lookout Mountain in Tennessee and Georgia to the northeast.

The NPS Geologic Resources Division conducted its geologic resources inventory (GRI) scoping session on March 25-26, 2009. LIRI is present on the Valley Head, Dugout Valley, Little River, Jamestown, and Fort Payne 7.5 minute USGS quadrangles. A geologic map of Cherokee County is available at 1:63,360 scale (Causey 1965a).

Sources of Paleontological Resources

Fossils have been documented from the following geologic formation within LIRI. These fossils present opportunities for resource management (including field surveys, inventory, and monitoring), education, interpretation, and continued or future scientific research in the park.

Pottsville Formation (Lower Pennsylvanian)

In northeastern Alabama, the Pottsville Formation overlies the Pennington, which is not exposed within the park. The Pottsville Formation caps Lookout Mountain within LIRI and consists of an estimated 90 to 120 m (300 to 400 ft) of tan and gray, thin- to thick-bedded, well cemented sandstone, and a tan to dark-gray sandy shale, with lesser amounts of coal, conglomerate and clay (Causey 1965b). Only the lower portion of the Pottsville is present. It is dominated by massive, conglomeratic, orthoquartzite sandstones with alternating shale, siltstone, and thin irregular coal beds. The lower Pottsville was deposited in a prodelta/barrier/back-barrier system (Raymond et al. 1988, Smith 1979; Horsey 1981; Rheams and

Benson 1982). Carbonized plant fragments are often found within the conglomeratic beds in northern Alabama (Culbertson 1963).

LIRI staff reported several known fossil localities within the preserve. An *in situ* specimen of the primitive tree *Lepidodendron* is exposed at Little River Falls. The remains of the horsetail fossil *Calamites* occur on a ledge adjacent to a wayside exhibit at Canyon View. Fossils, including *Calamites* and bark impressions, are found on the floor of a rock shelter near Hawks Glide. An abundance of crinoid remains are preserved in a limestone boulder at the north end of the Long Flat Rock section of the Powell to Eberhart Point Trail. This purple to pink fossiliferous limestone boulder is from a local outcrop (L. Beane, LIRI park ranger, pers. comm. March 2009). The Pottsville Formation is also present at RUCA (see below).

The exposure and visibility of these *in situ* fossils present concerns of theft or vandalism. Visitors have been encountered at Little River Falls attempting to collect fern fossils preserved in loose pebbles (L. Beane, LIRI park ranger, pers. comm. March 2009). The horsetail (*Calamites*) specimens at Canyon View and just west of Lower Two Mile Trail are highly visible to the public and at risk of vandalism or theft.

Fossils are common in the Pottsville from localities outside of the park and include: bryozoans, brachiopods, mollusks, echinoderms, the plant spores *Laevigatosporites ovalis* and *Endosporites globifermis* (Smith 1979), horsetails (*Calamites*), and scale trees (*Lepidodendron*), with hundreds of amphibian tracks and a single insect wing found within the Union Chapel Mine in Walker County (203 km [126 miles] southeast of LIRI; Buta et al. 2005). The fossiliferous nature of this formation suggests that additional fossil remains might be found within the park during future field investigations.

Park Collections

No fossils are present in the LIRI collection (M. Shew, Resource Management Specialist, pers. comm., February 2009).

Cultural Resource Contexts

There are currently no documented occurrences of fossils occurring in a cultural resource context within LIRI. According to the List of Classified Structures, there are no historic structures within the park. Historic structure building stone is just one potential source of fossils preserved in cultural resource contexts, and one common in other CUPN parks. Kenworthy and Santucci (2006) present a summary of NPS fossils in a cultural resource context.

Paleontological Resource Management, Preliminary Recommendations

- The NPS Geologic Resources Division conducted a GRI scoping session for the park in March 2009, and no paleontological resources management recommendations were identified in the session.
- Park staff should be encouraged to observe exposed gullies, other erosional bedrock, and streams for fossil material while conducting their usual duties. Given the fossiliferous nature of many of these rock units exposures would likely yield paleontological resources.
- Staff should photodocument and potentially monitor any occurrences of paleontological resources that may be observed *in situ*. Fossils and their associated geologic context (surrounding rock) should be documented but left in place unless they are subject to imminent degradation by artificially accelerated natural processes or direct human impacts.
- Given the known fossil resources in the park and the instances of unauthorized collection of fossils in LIRI, the park may want to consider a field-based paleontological resource survey. Significant localities should be documented using NPS fossil locality and condition assessment forms that meet GPRA goal 1a9A.

- Continued interpretation and education regarding paleontological resource protection and NPS stewardship may help address unauthorized fossil collection within the park.
- The park may want to consider long term paleontological resource monitoring of documented sites, particularly those where unauthorized collecting has occurred. A Geologic Resource Monitoring Manual by the Geological Society of America and NPS Geologic Resources Division (publication in late 2009) includes a section on paleontological resource monitoring (Santucci et al. in press).
- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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Mammoth Cave National Park

Mammoth Cave National Park (MACA) was established on July 1, 1941 to preserve the largest cave (which was later found to be part of the largest cave system in the world), the Green and Nolin rivers, and the local landscape. Mammoth Cave consists of over 563 km (350 miles) of explored passages within the karst topography of Kentucky. MACA also protects segments of the Green River and Nolin River valleys as well as the hills of west-central Kentucky within the Interior Low Plateau on the southeastern edge of the Illinois Sedimentary Basin (Kenworthy et al. 2006; Thornberry-Ehrlich 2006). The park became a World Heritage Site on October 27, 1981, and a UNESCO Man and the Biosphere Program International Biosphere Reserve on September 26, 1990. The National Park Service manages 21 379.62 ha (52,830.18 acres; federal: 52,003.24 acres, non-federal: 826.95 acres).

Geologic Background

During the Mississippian Period (345-305 million years ago; see the appendix for a geologic time scale) North America was near the equator and partially covered by a shallow continental sea. Calcium carbonate accumulating on the floor of that sea formed limestone, the main rock type found at Mammoth Cave, along with smaller amounts of sand, silt and clay transported in from land to the north. The balance of limestone to sandstone and clay shifted over time with increasing clastic sediments later in the Mississippian and into the Pennsylvanian. The largest caves of MACA formed within three limestone formations: the St. Louis Limestone, the Ste. Genevieve Formation, and the Girkin Formation. The St. Louis Limestone is approximately 61 m (200 ft) thick, although Mammoth Cave passages are found only in the upper half of the formation. Gypsum beds are common at depth in the formation, but ground water solution has removed the near surface deposits (Palmer, 1995). The Ste. Genevieve Formation, overlying the St. Louis, ranges between 30 and 37 m (100-120 ft) thick, with Mammoth Cave passages throughout the thickness of this formation. Representing a more humid environment than the St. Louis, the Ste. Genevieve does not contain gypsum. Thin silty beds represent encroachment of detrital sediments. The Girkin Formation consists of limestone members interspersed with thin silty limestones and shales, which combine to a total thickness of 41-43 m (135-140 ft). Although minor Mammoth Cave passages and shafts are found throughout the thickness of the Girkin, only one major passage is found in its upper half (Palmer 1995). Smaller caves also occur in the Haney and Glen Dean limestones

Above the Ste. Genevieve Formation are younger rocks, composing the Chester Series of the Upper Mississippian (Girkin, Golconda Formation, Hardinsburg Formation, Glen Dean Limestone, and the Leitchfield Formation). This series forms a resistant cap rock on the underlying limestone formations. During a continent-wide drop in sea level, extensive erosion of the Mississippian rock layers occurred. This interval was followed by a rise in sea level during the early Pennsylvanian, which deposited the conglomerates and sandstones of the Pennsylvanian Caseyville Formation over this erosional surface. Late in the Paleozoic, weathering and erosion removed portions of the Caseyville and exposed portions of the Mississippian-age limestones resulting in the development of karst features in these exposed areas. It is believed that the initial formation of Mammoth Cave took place around 30 to 5 million years ago, with the lower levels of the cave forming later during the Pleistocene Period (Palmer 1995; Granger et al. 2001).

The NPS Geological Resources Division conducted its geologic resources inventory (GRI) scoping session on June 15-16, 2006 (Thornberry-Ehrlich 2006). The entire state of Kentucky has been geologically mapped at 7.5-minute (1:24,000) scale. This map series is available digitally at that scale and available online from the Kentucky Geological Survey. Mammoth Cave is located on the Mammoth Cave, Rhonda, Nolin Lake, Bee Spring, Cub Run, Brownsville, Park City, and Smiths Grove 7.5' quadrangles (Davidson 2002; Gildersleeve 1965, 1968; Haynes 1962, 1964; Klemic 1963; Mullins 2002a, 2002b; Sandberg and Bowles 1965; Richards 1964; Thompson 2002a, 2002b; Toth 2002a, 2002b).

Sources of Paleontological Resources

Fossils have been documented from both the geologic units in which the caves are formed and from within the caves of MACA. These fossils present opportunities for resource management (including field surveys, inventory, and monitoring), education, interpretation, and continued or future scientific research in the park.

St. Louis Limestone (Upper Mississippian)

The St. Louis Limestone generally consists of limestones that in some areas contain dolomite. The limestones are often light olive-gray to a medium dark gray or yellowish-gray and are very fine to medium grained in texture. They can also contain clay or carbon, or silty and are very thin to thick bedded. The formation contains numerous chert zones and limy shale partings. Springs are common near the base of more argillaceous (containing higher amounts of clay) limestone sections, with karst topography common in the formation. The St. Louis limestone is often exposed low in steams and gullies and will weather to a red chert-rich clay soil.

Fossils are sparse from this unit (Grabowski 1986). The massive colonial coral *Lithostrotion canadense* is an index fossil for this formation and is only found in the St. Louis Limestone in Kentucky (this formation is also present at Cumberland Gap National Historical Park and mapped together with a portion of the Newman Limestone). Another species, *L. proliferum* (which ranges upward into the Ste. Genevieve formation), is also common in the St. Louis Limestone (Weller 1931). Other fossils from this formation include corals (*L. hemisphaerica*, and *Syringopora*), bryozoans (*Cystodictya lineate*, *Stenopora*, *Rhombopora*, *Dichotrypa*, *Fenestella* and *Polypora*), bivalves (*Schizodus*, *Aviculopecten*), pelecypods (*Myalina sancti-ludovici*), brachiopods (*Orthotetes* cf. *keokuk*, *Productus marginicinctus*, *P. ovatus, P. scitulus, Dielasma sinuate, Spiriferina*, *Spirifer pellaensis*, *Reticularia setigera*, *Cliothyridina*, *Composita trinuclea*), gastropods (*Straparollus* and *Naticopsis*), crinoids (*Platycrinus* cf. *penicillus*), echinoderms (*Archaeocidaris*) the shark *Deltodus,* and plants (*Triplophyllum* sp.; Weller 1927; G. McDonald, NPS Senior Curator of Natural History, pers. comm., January 2009). Fossils known from exposures of this formation at Rocky Hill, 24 km (15 miles) south of the park, include bryozoans (*Fenestella*), brachiopods (*Schellwienella*, *Schuckertella*, *Dielasma*, *Brachythyris altonensis, Eumetria verneuiliana*), gastropods (*Bellerophon*; Weller 1931) and echinoderms (*Archaeocidaris*).

Ste. Genevieve Formation (Upper Mississippian)

The Ste. Genevieve Formation is a light-gray fossiliferous limestone, found in medium- to thick-beds. It is typically fine- to coarse-grained, contains chert, which is occasionally fossiliferous, and is in part oolitic (made up of round accretionary bodies). The rocks of this formation originated as sandbars and shoals on a shallow-marine shelf, which sustained a rich fauna. The Ste. Genevieve is composed of three members: the Fredonia Limestone, the Rosicliare Sandstone, and the Levias Limestone. The basal (oldest) Fredonia Limestone Member, the most massive of the three, is a very light gray, cross bedded, oolitic to fossiliferous limestone distinguished by the crinoid *Platycrinites* (Sandberg and Bowles 1965, Haynes 1964). The overlying Rosicliare Sandstone Member is calcareous sandstone and shale, with the Levias Limestone Member composed of an oolitic to fossiliferous limestone similar to the Fredonia. Clusters of the pencil-like coral *Lithostrotion genevievensis* (formerly *L. harmodites*; McFarlan 1943) are locally abundant in upper 18 m (60 ft) of the formation (Haynes 1964).

Other fossils known to occur in the Ste. Genevieve within MACA include bryozoans, brachiopods (*Pugnoides ottumwa*), echinoderms (*Platicrinus penicillus*), crinoids (*Talarocrinites* sp.), conodonts (*Gnathodus bilineatus*, *Cavusgnathus charactis*) and isolated teeth, fin spines, and calcified cartilage from sharks (Weller 1927; R. Toomey, Director Mammoth Cave International Center for Science and Learning, pers. comm., January 2009; G. McDonald, NPS Senior Curator of Natural History, pers. comm., January 2009). Many fossil “hash zones” have been identified in this formation within the park and are exposed in cave passages at New Discovery, Fossil Avenue, Mammoth Cave, Rodgers Avenue (including the shark cartilage locality); and Marion Avenue and Katherine's Domes (R. Toomey, pers. comm., February 2009).

The Ste. Genevieve Formation is well exposed in the deep parts of Cedar Sink (found in southeast part of the Rhonda quadrangle), but contains few diagnostic fossils (Weller 1927).

Girkin Formation (Upper Mississippian)

The Girkin Formation is composed of limestones, shale and siltstones. The limestones are typically gray, thin-bedded to massive (occasionally oolitic), locally cross-bedded or silty, consisting of fossil fragments cemented together with microcrystalline calcite (Haynes 1964).

A green to grayish-green shale occurs locally below the upper contact. Interbedded gray and green silty shale and brownish-green calcareous siltstone are locally present in the uppermost section of the Girkin and include plentiful fossils of the brachiopod *Inflatia inflate,* and small amounts of gray to grayish-blue chert lenses and nodules (Gildersleeve 1965, Haynes 1964). The middle portion of the Girkin Formation contains colonies of fossil coral (*Lithodrumus veryi*) that are present throughout the formation but mainly present in two zones, one just below a chert bed and the other just above the basal bed. The crinoid *Talarocrinus* is present throughout the middle of the formation but decreases in size and abundance downward through the section. Characteristic of lower part of the Girkin are clusters of small quartz crystals as well as chert beds and lenses up to 20 cm (8 in) thick (Haynes 1964). In the lower part of the Girkin Formation, fragmental to oolitic fossiliferous limestone contains abundant crinoid calyxes (*Talarocrinus*) and fragmentary crinoid columnals (*Platycrinites*). Echinoids are also present in the northern part of the Cub Run quadrangle outside of the park (Sandberg and Bowles 1965). Fossils from this formation include horn corals, spiriferid and productid brachiopods (Sandberg and Bowles 1965), and abundant crinoids (calyxes of the crinoids *Talarocrinus* and *Agassizocrinus*). Fossil "hash zones" found within the park, most likely from the Girkin Formation can be found at Long Cave, Echo Avenue and Proctor Cave, and the south end of Frost Avenue (R. Toomey, pers. comm., February 2009).

The contact between the Ste. Genevieve, Girkin and Golconda formations can also be found in a road cut within the park along Highway 70, near Turnhole Bend and Cedar Sink. Fossils from the Girkin Formation at this location in the park include a fossil hash bed in the upper portion ("Elwren Sandstone") of the formation, containing bryozoans, brachiopods, and gastropods. Below this fossil has zone, in the "Reelsville Limestone," large crinoid stems and brachiopods (*Composita subquadrata*, *C. trinuclea*, and *Spiriferina spinosa*), followed by the lower "Sample Sandstone" which contains bryozoans and brachiopods (*Diaphragmus* cf. *montasance*, *Productus ovatus*, *Girtyella*, *Spiriferina*; Pohl and Cushman 1964).

Golconda Formation (Upper Mississippian)

The Golconda Formation consists of two members in the MACA area: the Big Clifty and the Haney Limestone. The Big Clifty Member forms the base of the Golconda Formation and is composed of sandstone, limestone, shale, and interbedded sandstone and shale (Palmer 1995). The sandstone is composed of a grayish-white, light-yellowish-brown, tan, and buff, very fine to medium grained quartz sandstone. This cliff-forming sandstone can be thin-bedded to massive with cross-beds and green shale partings found locally (Haynes 1964).

Lepidodendron tree trunks are commonly preserved in the middle of the Big Clifty Member (Cub Run quadrangle, outside of the park, and near the former site of Union City, within the park; Pohl and Cushman 1964) in lenses of massive, strongly cross bedded sandstones. A dark-gray limestone containing abundant crinoids (*Agassizocrinus*) and horn corals is present along Cane Run in MACA within a greenish-gray shale 6.6 m (2 ft) above base (Sandberg and Bowles 1965). Foraminifera are known from the lower part of the Big Clifty-Fraileys Member of the Golconda Formation outside of the park (Pohl et al. 1968).

Shales that occur in the middle and at the base of the Big Clifty are very dark gray, gray, green and light brown in color and unfossiliferous (Haynes 1964). The Haney Limestone Member of the Golconda Formation consists of a light-olive-gray, medium-gray, and light-brown, finely- to medium-crystalline,

thin- to thick-bedded limestone. Thin lenses and partings of gray shale occur throughout this unit, with chert present locally. The Haney Limestone has been extensively thinned during the formation of the karst topography, causing the overlying Hardinsburg Sandstone to collapse and slump. Microcrystalline calcite is more abundant as a cementing material in the basal part of the unit. Fossil fragments mostly consisting of horn corals, bryozoans, and crinoid stem plates, are cemented by sparry calcite or microcrystalline calcite in many areas of the park (see Haynes 1964; Gildersleeve 1965, 1968). The contact between the Girkin and Golconda formations can be found in a road cut within the park along Highway 70, near Turnhole Bend and Cedar Sink. Fossils in the Haney Limestone at this location within the park include echinoderms (*Triplophillites spinulosa*, *Pentremites abruptus*, *P. pyriformis*, *P. welleri*, *Eupachicrinus*, *Agossizocrinus ovalis*, and *A. conicus*) found in a white residual chert (Pohl and Cushman 1964).

Glen Dean Limestone (Upper Mississippian)

The limestones of the Glen Dean Limestone are poorly exposed, but known to be light-gray to medium-dark-gray and finely to medium-crystalline in texture. This thin-bedded to massive limestone is locally argillaceous and weathers to a medium gray to dark gray. Lenses and partings of greenish-gray calcareous shale are more abundant in the upper part of the unit (Haynes 1964; Gildersleeve 1965). The Glen Dean outcrops on the hillsides above Nolin River throughout Edmonson County with the exception of a stretch between Pine and Dismal creeks. It is heavily exposed along the courses of First, Second, Dismal, Brier, Davis and Longfall creeks in the park area (Weller 1972). Abundant fossil fragments and entire casts, consisting of horn corals, bryozoans, brachiopods, crinoids, and blastoids, are found in sparry calcite matrix are present in the Glen Dean within MACA, although no specific locations have been identified (Haynes 1964; Gildersleeve 1965).

Additional fossils known from this formation outside of the park near the town of Brownsville include corals (*Amplexus* and *Triplophyllum spinulosum*), bryozoans (*Fistulipora montifera*, *Eridopora punctitera*, *Tabulopora tuberculata*, *Anisotrypa symmetrica*, *A. solida*, *Fenestella tenax*, *F. serratula*, *Archimedes swallovanus*, *A. proutanus*, *A. terebriformin*, *Polypora cestriensis*, *Lyropora*, *Reteporina flexuosa*, *Septopora subquadranus*, *S. cestriensis*, *Streblotrypa nicklesi*, *Prismopora serrulata*, *Glyptopora*, *Rhombopora*), brachiopods (*Productus ovatus*, *Diaphragmus elegans*, *Spiriferina spinosa*, *Spirifer leidyi*, *Cliothyridina sublamellosa*, *Composita trinuclea*, *Martinia sulcata*), gastropods (*Platyceras chesterensis*, *Bellerophon*), trilobites (*Phillipsia*), crinoids (*Pterotocrinus*), blastoids (*Pentremites brevis*, *P. okawensis*), and a shark (*Psephodus*; Weller 1927). Due to the close proximity of the town of Brownsville to MACA, similar fossils could potentially be found within the park.

Paleontological Resources associated with MACA Caves (Pleistocene/Holocene)

Significant paleontological resources have been documented from caves in Mammoth Cave National Park for nearly 40 years (Santucci et al. 2001). Jegla and Hall (1962) reported a desiccated bat guano deposit dated to more than 38,000 years before present. Within the guano deposit were skeletal remains of *Myotis* (bat), *Tadarida* (free-tailed bat), and *Peromyscus* (deer mice; Colburn 2005). Ron Wilson, a National Park Service employee, collected paleontological resources from throughout Mammoth Cave during the late 1970s. Wilson (1981, 1985) reported a tapir (*Tapirus*), extinct peccary (*Platygonus*), and the extinct short-faced bear (*Arctodus*), and a mammoth or mastodon from the Proctor section of Mammoth Cave.

In order to more fully document the paleontological resources from within the caves of Mammoth Cave National Park, the Illinois State Museum and the Cave Research Foundation entered into a cooperative research endeavor with MACA to inventory fossil vertebrate remains. The inventory was initiated in 1997 and continued through 2001 (Colburn 2005). One component of the project focused on historic bat use in the cave, especially around the historic cave entrance area. Evidence of bat activity was noted early in the study. Large quantities of *Procyon lotor* (raccoon) scat containing a high percentage of bat bones were documented (Toomey et al., 1998). Additional evidence of bat roosts was also discovered in the more inaccessible areas and passages of the cave. The most common bat species from the Historic Entrance area is the medium-sized species of *Myotis*, either *M. lucifugus* (little brown bat) or *M. sodalis* (Indiana bat;

Toomey et al. 1998); diagnostic fossil and historical mammalogical material indicates that both species were present, but that Indiana bats were probably dominant. Other species of *Myotis* include *M. griscesens* (gray bat) and *M. leibii*. Less common bat genera found near the Historic Entrance area include *Eptesicus fuscus* (big brown bat), *Pipistrellus subflavus* (eastern pipistrelle), *Lasiurus borealis* (red bat), and *Corynorhinus* (big-eared bat; Toomey et al. 1998). Bat bones, bat guano, and raccoon scat were radiocarbon dated with ages ranging from 8,700 years old to just 100 years old. Most of the material yielded dates to less than 1,000 years old (Toomey et al. 1998). Portions of the research focusing on bat use in the Historic Entrance area was presented at the 2001 Indiana Bat Symposium (R. Olson, MACA Ecologist, pers. comm., 2001; Toomey et al. 2002).

A more general vertebrate paleontological inventory was designed to locate, identify, describe, and map paleontological resources in caves throughout the park in order to assist in paleoenvironmental reconstruction, interpretation, and resource management (Toomey et al. 1998). An additional benefit of the inventory was the development of better models for the different contexts in which paleontological remains have been found within the cave (Toomey et al. 2000). Paleontological resources were identified in four contexts including: 1) recent surficial remains (often less than 4,000 years old); 2) relictual deposits representing the cave surface before human utilization of the cave; 3) older surficial deposits (such as bat guano); and, 4) very old (hundreds of thousands to millions of years old) deposits associated with the primary water-lain sediments in the cave (Toomey et al. 2000). This inventory focused on the remains of animals that inhabited/utilized the cave after cave development. Examples of such remains include isolated bones, groups of bones, partial or whole skeletons, partial or whole mummified animals, guano or scat, and traces (scratchings, footprints, trails, and staining; Toomey et al. 1998). Plant and invertebrate remains were not actively inventoried during this project, nor were marine invertebrates exposed in the Mississippian limestones of Mammoth Cave. However, such resources are noted when they are encountered near vertebrate remains.

During the first year of the general vertebrate paleontological inventory (1998) the data revealed that bat remains were by far the most common vertebrate resource found in the cave. Of the bats, indeterminate medium-sized *Myotis* (*M. lucifugus* or *M. sodalis*) bones were the most common (Toomey et al. 1998). Identifiable specimens of *M. lucifugus* and *M. sodalis* were also very common. A number of other bat species were noted. These species include *M. griscesens*, *M. leibii*, *M. septentrionalis* (northern long-eared bat), *Pipistrellus subflavus*, *Eptesicus fuscus*, *Lasiurus borealis*, *L. cinereus* (hoary bat), *Corynorhinus* (big-eared bat), *Tadarida*, and *Desmodus* (vampire bat) (Toomey et al. 1998). In addition to the extensive bat remains found in the caves, other vertebrates were also noted. Bones of the packrat, *Neotoma*, deer mice, *Peromyscus*, raccoon *Procyon lotor*, domestic chicken, *Gallus gallus* (apparently left by humans as trash within the last 100 years), white-tailed deer, *Odocoileus virginianus*, domestic pig, *Sus scrofa* , and various amphibians were all found in Mammoth Cave system (Toomey et al. 1998). Radiocarbon dating has not been undertaken, however, much of the material appears to be less than 1,000 years old. Some material may be as old as 1 to 2.5 million years old based on tentative correlations to sediments that have been dated using Aluminum/Beryllium (R. Olson, pers. comm., 2001; Toomey et al. 1998; Granger et al. 2001). Some specimens appear to be extremely recent, less than five years old.

The remains of the hellbender, *Cryptobranchus*, vampire bat, *Desmodus*, and some unidentified bat bones were found in the upper level laminated slackwater flood sediments of Backsliders Alley. These remains appear to represent the oldest vertebrate remains found in the cave. The *Desmodus* remains were field identified as belonging to a now extinct species that lived during the Pliocene-Pleistocene, rather than the modern *D. rotundus* (Toomey et al. 1998). The lower part of the sediments from which these were recovered date to 2.2 million years ago (Granger et al. 2001).

A paved trail cut from the Frozen Niagara Entrance to the cave, extending approximately 35 m (115 ft) into the cave, exposed a rich faunal assemblage. This material has not been fully analyzed; however, vertebrates of a wide taxonomic range have already been identified. Amphibians (both frogs and salamanders), reptiles (turtles, snakes, and lizards), birds, and mammals have all been identified (Colburn et al. 2000). The mammalian remains include three extinct species, *Equus* (horse), *Platygonus* (flat-headed

peccary) and *Dasypus bellus* (beautiful armadillo). Large extant taxa were also recovered including *Odocoileus* and *Procyon lotor*. A wide variety of bat taxa were also documented. Rodents found in the deposit include the pocket gopher (*Geomys* sp), and round-tailed water rat *Neofiber* leonardi. The *Neofiber* remains are of particular interest because they may represent the modern *Neofiber* species. Modern *Neofiber* which today is found only in the subtropics of Florida and Southern Georgia, presenting a strong argument for an interglacial age, probably Sangamonian (the Sangamonian interglacial refers to the time period between approximately 75,000 and 125,000 years ago) (Colburn 2005; Colburn et al. 2000). Uranium series dates were obtained from the carbonate crust sealing the top of the deposit and yielded an age of 125,000-126,000 years before present (Colburn et al. 2000). These dates may represent the age of the bone-bearing layers, which would make the deposit one of the very few well dated Sangamonian faunas in the central United States (Colburn et al. 2000). None of the other known Sangamonian faunas have the wide taxonomic range displayed in the Frozen Niagara deposit (Colburn et al. 2000), making this a particularly significant site.

A large number of mummified bats were found preserved near Star Chamber. The quality of preservation ranges from a few bones with tissue attached to complete desiccated bats of the *Myotis* (Toomey et al. 1998). The age of this material has not yet been determined. Another result of this survey was the determination that the *Tadarida* guano deposit described by Jegla and Hall (1962) is much more extensive than previously thought (Toomey et al. 1998, 2000).

Potential Sources of Paleontological Resources

Fossils have not yet been documented from the following geologic units within MACA. However, future field investigations within the park may yield fossils from one or more (or none) of the following geologic units. Fossils are documented from these units outside of the park.

Hardinsburg Formation (Upper Mississippian)

Sandstones and interlaminated siltstone and shale make up the Hardinsburg Formation around Mammoth Cave. The sandstone is a very light gray, yellowish-brown to reddish brown, very fine to fine-grained quartz. It can be thin to thick bedded, with thinly laminated or gently to strongly cross bedded sections found locally. The uppermost part of the sandstone is parallel bedded, and is well indurated when fresh but becomes friable where weathered. The siltstone and shale are medium-gray to light-brown and occur in the basal part of the Hardinsburg Formation. This formation is well-exposed on the north slope of ridge just south of Houchins Ferry (Haynes 1964, Gildersleeve 1965). Cast and impressions of invertebrate fossils have been observed in the residual block from the Hardinsburg in Warren County, outside of the park. However, no fossiliferous horizon has been observed *in situ* (Weller 1927).

Leitchfield Formation (Upper Mississippian)

The Leitchfield Formation is not continuously present in the park, and is often poorly exposed. Within MACA, it is exposed in the gullies on the north side of State Route 70, southwest of Houchins Ferry. The formation is composed of limestone, sandstone, shale and siltstone. The limestone is dark-gray on fresh surfaces and will weather to brown. It is predominantly very fine to fine-grained and can form massive beds, as thick as 49 m (15 ft). A brown, fine- to medium-grained sandstone is present at the base of the formation, which grades laterally into a sandy shale. The shale and siltstone are soft and green and gray-green in color. These shales and siltstones weathers to pale-green or yellowish soil that when wet become plastic.

Fossil occurrences from this formation outside of the park include fragments of brachiopods and bryozoans at a locality 2.1 km (1.3 miles) northwest of Wingfield School in Edmonson County (Haynes 1964, Gildersleeve 1965). North of Richardsville, the basal limestone contains the remains of bryozoans (*Meekopora clausa*, *Tabulopora tuberculata*, *Archimecles swallowanus*, *A. sublaxus*, *Lyropora*, *Septopora subquadrans*, *Rhombopora*, *Streblotrypa subpinosa*, and *Heliotrypa bifolia*) and brachiopods (*Orthotetes*

kaskaskiensis, *Spiriterina spinosa*, *Spiriter increbescens*, *S. leidyi*, *Eumetria costata* and *Composita subquadrata*; Weller 1927).

Caseyville Formation (Lower Pennsylvanian)

The Caseyville Formation lies unconformably on the Glen Dean Limestone, and occasionally the Hardinsburg Sandstone, in some areas. This formation caps the highest hills in this area, and also forms deeply undercut cliffs in northwestern part of Mammoth Cave National Park. Conglomerate, sandstone, and siltstone characterize the Caseyville Formation. The conglomerate is composed of a cobble and pebble size clast interbedded with a pebbly to granular sandstone in lower part and sandstone in the upper part. Conglomerate clast are composed of white and very light gray quartz and quartzite with reddish-brown and black silica and manganese cement. The sandstones of the Caseyville Formation are white, yellowish-gray, yellowish-orange, and grayish-orange in color, thick-bedded to massive, fine to very coarse grained, with conglomerate and locally cross bedded. The siltstones occur as thin partings and seams. In areas near the park, poorly preserved plant remains are known from this formation (cast of roots and stems), which is typically sparsely fossiliferous (Haynes 1964).

Park Collections

The MACA park collections contain 24 paleontology specimens. The MACA list of paleontology specimens contains many more specimens that have either poor or no provenience data, some of which may not be from within the park. Many of these specimens probably come from locations related to a 1935 geological mapping effort (R. Toomey, Director, Mammoth Cave International Center for Science and Learning, pers. comm., May 2009). There are 66 specimens held from MACA at the Carnegie Museum, which are Pleistocene cave fossils collected by Ronald C. Wilson from 1978 to 1980. The Illinois State Museum (ISM) curates the largest collection of MACA fossil remains associated with park caves. A total of 1,562 accessioned remains (sometimes multiple items logged from individual points) are currently housed at the ISM. The final repository status for these remains has not been determined at this time, pending the completion of analysis (C. Widga, Assistant Curator of Geology, Illinois State Museum, pers. comm., January 2009). A single echinoid (sea urchin; *Melonechinus indianaensis*; PAL 380837) specimen is curated at the National Museum of Natural History from Edmonson Co., Kentucky. It is thought that this specimen is possibly from MACA, although the provenience is unclear (pers. comm.. between F. E. Buffaire, Acting Chief, National Museum of Natural History and P. E. Brown, MACA Superintendent, 1959; G. McDonald, Senior Curator of Natural History, pers. comm., January and February 2009; R. Toomey, Director, Mammoth Cave International Center for Science and Learning, pers. comm., January 2009).

Cultural Resource Contexts

Given the fossiliferous nature of the limestones within park and the surrounding area, historic structures within the park constructed from these limestones may display fossils. Fossils are known from building stones in many other National Park Service units, giving a cultural context to these fossil remains. Kenworthy and Santucci (2006) presented an introduction and cited selected examples of NPS fossils found in cultural resource contexts.

Paleontological Resource Management, Preliminary Recommendations

- The NPS Geologic Resources Division sponsored a GRI scoping session for MACA on June 15-16, 2006. Recommendations for paleontological resources made in that summary report include expanding the fossil inventory beyond the first 3-5 km (2-3 miles) of the Mammoth Cave (Thornberry-Ehrlich 2006).

- Park staff should be encouraged to observe exposed gullies, other erosional bedrock, and streams for fossil material while conducting their usual duties. Given the fossiliferous nature of many of these rock units any exposures would likely yield paleontological resources.
- Staff should photodocument and potentially monitor any occurrences of paleontological resources that may be observed *in situ*. Fossils and their associated geologic context (surrounding rock) should be documented but left in place unless they are subject to imminent degradation by artificially accelerated natural processes or direct human impacts.
- The park may want to consider a comprehensive field-based paleontological resource inventory to further inventory, document, and assess paleontological resource localities in the Paleozoic limestones and the Pleistocene/Holocene cave fossils. Significant localities should be documented using NPS fossil locality and condition assessment forms that meet GPRA goal 1a9A.
- The park may want to consider long term paleontological resource monitoring of documented sites. A Geologic Resource Monitoring Manual by the Geological Society of America and NPS Geologic Resources Division (publication in late 2009) includes a section on paleontological resource monitoring (Santucci et al. in press).
- Further research into the sources of the fossils within the park museum collections may yield additional information including more complete identifications and more robust locality information.
- NPS catalog numbers and information for the specimens curated at the Carnegie Museum should be entered in ANCS+.
- Investigation of the stone used in park historic structures may yield paleontological resources in a cultural resource context.
- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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Carnegie Museum of Natural History Museum Collections
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Illinois State Museum Collections
early/mid 1900s-present. (museum specimens; associated specimen notes; collection records; maps; etc.). Originated by ISM staff; status: Active.

Smithsonian National Museum of Natural History Museum Collections
mid 1900s-present. (museum specimens; associated specimen notes; collection records; maps; etc.). Originated by NMNH staff; status: Active.

Ninety Six National Historic Site

Ninety Six National Historic Site (NISI) was established on August 19, 1976 and was dedicated on October 1, 1977 to preserve the village of Ninety Six—the site of the first battle of the Revolutionary War fought south of New England. The village was a Loyalist stronghold early in the war and was fortified by the British in 1780. From May 22 to June 18, 1781, the Continental Army, led by Major General Nathanael Greene, lay siege against the fort. The Continental Army was unsuccessful in taking the village. The site is located 3.2 km (2 miles) south of present day Ninety Six, South Carolina. State administration of the battle site began in 1968, with the park designated as a National Historic Landmark by the Secretary of the Interior. The National Park Service manages 413.56 ha (1021.94 federal acres; Greene 1979).

Geologic Background

Ninety Six National Historic Site is located in the Charlotte metamorphic belt of the Carolina Terrane, formed during the Taconic orogeny. Situated in western South Carolina, these Mississippian and Devonian aged igneous rocks are composed of predominantly hornblende gabbro of the Concord Plutonic Suite and lesser amounts of granitic and dioritic gneiss. There are a number of different interpretations of the geologic history of the Charlotte metamorphic belt. One thought is that the Charlotte portion of the Carolina Terrane is composed of broken, angular rock fragments enclosed in a fine-grained matrix located above a former subduction zone (a mélange complex; Nelson et al. 1987, 1998; Higgins et al. 1988, 1989). Another idea is that the area originated as a metamorphosed igneous complex disrupted by the extreme temperature conditions that took place during metamorphism. The extreme temperatures and pressures of metamorphism may have caused partial melting of pre-existing rocks (migmatizations) deep in the crust. Subsequent faulting may have brought these rocks closer to the surface where they are now exposed (Griffin 1978; Nelson et al. 1998). The Introduction to this report contains additional information regarding the tectonic history of the area.

NISI has been geologically mapped at the 1:500,000 scale (Horton and Dicken 2001) and the 1:250,000 scale by the U. S. Geological Survey (Nelson and Clarke 1978; Nelson et al. 1987, 1989, 1998). A Bouguer (gravity)-anomaly map at the 1:24,000 scale has also been produced by the South Carolina Geological Survey (Lawrence and Chalcraft 1979). The NPS Geologic Resources Division conducted a geologic resources inventory (GRI) scoping session for the park on April 26, 2005. Due to the igneous (previously molten) and metamorphic (altered by high temperature and/or pressure) nature of the rocks in the park, fossils would not be expected.

Park Collections

No fossils are present in the NISI collection (K. Byrne, NPS Museum Program, pers. comm., April 2009).

Cultural Resource Contexts

Given the primarily granite construction of memorials and markers within the park, fossils preserved in a cultural resource context, such as historic structures, is unlikely at NISI. Kenworthy and Santucci (2006) present a summary of NPS fossils in a cultural resource context.

Paleontological Resource Management, Preliminary Recommendations

- The NPS Geologic Resources Division sponsored a GRI scoping session for NISI on April 26, 2005, and no paleontological resources management issues were identified in the scoping summary report.

- Due to the lack of documented *in situ* fossil occurrences within the park, and the unlikelihood of extensive macrofossil discovery within the park, establishment of a paleontological resource management plan is not necessary for NISI.
- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

Russell Cave National Monument

Russell Cave National Monument (RUCA) was established on May 11, 1961 by President John F. Kennedy to preserve more than 10,000 years of archeological record in and around Russell Cave. The cave provided shelter, and the surrounding forest provided food, tools and fuel for early North America inhabitants, and the cave shelter archeological site contains the most complete record of prehistoric cultures in the Southeast. Archeological resources in the park range from Late Paleolithic age (approximately 10,000 to 8,500 years before present) to about the year 1650. The water that follows though RUCA comes from an underground stream that originates on Ormh Mountain. Russell Cave was named for Colonel Thomas Russell and his descendents who were owners of the property when the area was mapped. The monument is located in northeastern Alabama, near the town of Bridgeport in Jackson County. The monument consists of 125 ha (310 acres) of land which was donated by the National Geographic Society to the American people and set aside to protect the site and its surroundings. The Monument was listed on the National Register of Historic Places on October 15, 1966.

Geologic Background

Northern Alabama is divided into two physiographic provinces: the Appalachian Plateau and Interior Low Plateau (or Coastal Plain). RUCA lies on the Appalachian Plateau region, which is composed of sandstones and shale plateaus with modest relief. The area is underlain by Paleozoic sedimentary rocks that range from Cambrian to Pennsylvanian in age. The park includes marine rocks of Mississippian and Pennsylvanian age that formed over 300 million years ago at the bottom of an inland sea (Cramer 1986; Henderson 2004). This area of Alabama was very close to the equator during the Paleozoic. The large amount of limey mud that was deposited during the Mississippian, forming limestone, has been slowly dissolved over time, forming Russell Cave. Around 9,000 to 11,000 years ago, the collapse of a cavern roof beneath a hillside near Doran's Cove created a sinkhole and exposed Russell Cave. The entrances to Russell Cave are at the base of the northeastern flank of Montague Mountain. Fossils are common throughout the park, with horn corals and crinoid stems making up the majority of the observed fossil fauna (L. Beane, LIRI Park Ranger, pers. comm., 2001). Brachiopods, crinoids, and blastoids, have been found in the roof and walls of RUCA, although it is unclear which formation contains such fossils. All of the formations present within the park, with the exception of the Pottsville Formation, are possibilities (Santucci et al. 2001).

The NPS Geologic Resources Division conducted a geologic resources inventory (GRI) scoping session for the park on March 25 and 26, 2009. RUCA is present on the Doran Cove 7.5 minute USGS quadrangle. A geologic map of Jackson County is available at 1:24,000 scale (Hack 1966). A thematic inventory of paleontological resources associated with National Park Service caves includes a discussion on RUCA (Santucci et al. 2001).

Sources of Paleontological Resources

Fossils have been documented from the following geologic formation, caves, park collections, and cultural resource contexts within RUCA. These fossils present opportunities for resource management (including field surveys, inventory, and monitoring), education, interpretation, and continued or future scientific research in the park.

Monteagale Limestone (Upper Mississippian)

Historically referred to as the “Gasper Formation” (a geologic name abandoned in Alabama by Thomas in 1972), the Monteagle Limestone is noted by Jones and Daniel (1960) to crop out on the lower slopes of Montague Mountain and to consist of massive and fossiliferous limestone, interbedded with thin shaly limestone partings. This formation is also grouped with the overlying Bangor Limestone in the area. A basal disk from the crinoid *Agassizocrinus coniens*, a common crinoid in the Monteagle Limestone, was

found in the roof of Russell Cave (Jones and Daniel 1960). The entrances, roof and walls of the cave are within this formation. Oolitic beds typical of the Monteagle are also present in the cave (Jones and Daniel 1960). The fossiliferous nature of this formation suggests that additional fossil remains might be found within the park during future field investigations.

Paleontological Resources associated with RUCA Caves (Pleistocene/Holocene)

Santucci et al. (2001) summarized fossils from caves throughout the NPS, including RUCA. Remains of an extinct Pleistocene peccary, *Mylohyus* cf. *M. nasutus*, have been found in Russell Cave (L. Beane, LIRI park ranger, pers. comm., 2001). These remains mark the first known occurrence of *Mylohyus* in Alabama. Similar peccary fossil assemblages have been noted in Montague Cave, about 1.6 km (1 mile) southeast of Russell Cave's northern entrance, outside of the park. The current location of the peccary teeth is presently unknown (further details can be found in the Park Collections section below). Ridley Cave, 0.8 km (0.5 mile) northwest of Russell Cave, but within the park boundaries, may also contain similar fossils. Ridley Cave may be linked to Russell Cave (Jones and Daniel 1960).

Potential Sources of Paleontological Resources

Fossils have not yet been documented from the following geologic units within RUCA. However, future field investigations within the park may yield fossils from one or more (or none) of the following geologic units. Fossils are documented from these units outside of the park.

Bangor Limestone (Upper Mississippian)

The Bangor Limestone consists of massive-bedded, bioclastic, crystalline and oolitic beds with smaller amounts of interbedded shale and mudstone (Jones and Daniel 1960). This formation contains a complex of marine shelf carbonates (Thomas 1972, 1979). Within RUCA, the Bangor Formation crops out on the slopes of Montague Mountain (Jones and Daniel 1960). A few small masses of coral can be found in the limestone beds, although none are yet reported from RUCA (Jones and Daniel 1960). The lower portion of the Bangor contains the bryozoans *Prismopora serrulata* and the echinoderms *Pentremites pyramidatus* and *Pentremites brevis*, whereas the upper portion of the formation contains the crinoid *Pterotocrinus triecbrachiatus* (Thomas 1972).

Pennington Formation (Upper Mississippian)

Conformably overlying the Bangor Limestone is the Pennington Formation, which is present along the upper slopes of Montague Mountain (Jones and Daniel 1960). These prodelta and delta clastic rocks are distinguished by maroon and green shale with interbedded limestones and mudstone, which grade upward into a gray shale with interbedded siltstone, sandstone, siderite and thin coal seams. These sediments grade eastward into sandstones, shale and carbonate beds recording depositional environments such as marine bays, small bars, coastal lagoons and marshes. These sediments grade upward into the sandstones of the Pottsville Formation, which is also present in LIRI (Thomas 1979; Thomas and Cramer 1979). Coal bearing units in the upper Pennington can be correlated to the Raccoon Mountain Formation of Tennessee. In eastern Alabama, gastropods along with molds of fenestrate bryozoans and brachiopods are present in the olive mudstones of the Pennington. Sandstones in this area commonly contain plant fragments as well (Thomas 1972). The Pennington Formation is also present in CHCH and as the Pennington Group in CUGA.

Pottsville Formation (Lower Pennsylvanian)

The Pottsville Formation overlies the Pennington Formation and caps Montague Mountain within RUCA. The formation consists of an estimated 91 to 122 m (300 to 400 ft) of tan and gray, thin- to thick-bedded, well cemented sandstone, and a tan to dark-gray sandy shale, with lesser amounts of coal, conglomerate and clay (Causey 1965). Only the lower Pottsville is present and is dominated by massive, conglomeratic orthoquartzite sandstones with alternating varying amounts of shale, siltstone, and thin irregular coal beds. The lower Pottsville was deposited in a prodelta/barrier/back-barrier system (Raymond et al. 1988; Smith 1979; Rheams and Benson 1982). Carbonized plant fragments are often

found within the conglomeratic beds of this formation in northern Alabama (Culbertson 1963). At least seven abandoned coal mine tunnels are present within Montague Mountain (Jones and Daniel 1960). The Pottsville Formation is also exposed within LIRI and preserves the fossilized remains of *Lepidodendron*, *Calamites*, bark impressions, and crinoids.

Park Collections

An accession file record for paleontological collections in the monument indicates horn corals and additional fossils were collected from a sinkhole in 1987. Accessions also include *Calamites* bark impressions (possibly from the Pottsville Formation), horn corals, the bryozoan *Archimedes*, brachiopods, gastropods, and crinoids. These fossils were surface collected by park staff and used for interpretive purposes (L. Beane, LIRI park ranger, pers. comm., 2009). A blastoid, *Pentremites pyriformis*, was discovered along a trail near a shelter over the main entrance. *Pentremites pyriformis* does not occur in strata below the Gasper Formation (Monteagle Limestone) and likely is from the Bangor Limestone (Jones and Daniel 1960, Santucci et al. 2001).

The Pleistocene peccary, *Mylohyus* cf. *M. nasutus*, remains excavated from Russell Cave from 1956 to 1958 by the National Geographic Society were thought to be held in the Alabama Museum of Natural History at University of Alabama, with an additional two teeth excavated by the NPS held at the Southeastern Archeological Center (SEAC) in Tallahassee, Florida (L. Beane, LIRI park ranger, pers. comm. 2009). However, both institutions have no record of these remains within their collections (M. Bade, Director of Museum Collections, and M. Uhen, Curator of Paleontology, Alabama Museum of Natural History, pers. comm., May 2009; T. Parsons, Museum Technician, Southeastern Archeological Center, pers. comm., May 2009). Two *Mylohyus* teeth are on display at RUCA although it is unclear if these are the "missing" peccary teeth (L. Beane, LIRI park ranger, pers. comm., 2009).

The SEAC collections do include 16 specimens identified as fossils collected from within Russell Cave. The fossils are primarily crinoids although there are two mammal specimens (RUCA 13285 and 12208) and one identified as "Carnivora" (RUCA 12694). And additional three unidentified specimens (RUCA 3037, 3051, and 3065) are cataloged as fossils from Cedar Knoll. SEAC collection information was provided by Brinnen Carter of SEAC, now cultural resource manager at Delaware Water Gap NRA, in 2006.

Cultural Resource Contexts

Depending on their source, the limestone blocks associated with the Cotton Patch Mound in the park could display fossils. One specimen (RUCA 15320) in SEAC collections is tentatively identified as a fossil fragment found at the Cotton Patch Mound. Further investigation may identify the type of stone used and whether they display fossils, although the surface stones may have been removed from the mound, according to the RUCA List of Classified Structures. Stones associated with historic structures are just one potential source of fossils preserved in cultural resource contexts Kenworthy and Santucci (2006) present a summary of NPS fossils in a cultural resource context.

Paleontological Resource Management, Preliminary Recommendations

- The NPS Geologic Resources Division sponsored a GRI scoping session for RUCA on March 25-26, 2009. A summary report from this meeting is currently (June 2009) being prepared.
- Park staff should be encouraged to observe exposed gullies, other erosional bedrock, and streams for fossil material while conducting their usual duties. Given the fossiliferous nature of many of these rock units any exposures would likely yield paleontological resources.
- Staff should photodocument and potentially monitor any occurrences of paleontological resources that may be observed *in situ*. Fossils and their associated geologic context (surrounding

rock) should be documented but left in place unless they are subject to imminent degradation by artificially accelerated natural processes or direct human impacts.

- Based on the potential for continued fossil discovery, the park may want to consider a field-based paleontological resource survey. Significant localities should be documented using NPS fossil locality and condition assessment forms that meet GPRA goal 1a9A.
- The park may want to consider long term paleontological resource monitoring of documented sites. A Geologic Resource Monitoring Manual by the Geological Society of America and NPS Geologic Resources Division (publication in late 2009) includes a section on paleontological resource monitoring (Santucci et al. in press).
- Further investigation into the museum specimens may yield additional information regarding the whereabouts of the peccary teeth and the potential cultural resource contexts of the fossils.
- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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Data Sets

Russell Cave National Monument Paleontological Archives
5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

Russell Cave National Monument Museum Collections
1961-present. (museum specimens; associated specimen notes; collection records; maps; etc.). Originated by RUCA staff; status: Active.

Southeast Archeological Center Collections
1961-present. (museum specimens; associated specimen notes; collection records; maps; etc.). Originated by SEAC staff; status: Active.

Shiloh National Military Park

Shiloh National Military Park (SHIL) was established on December 27, 1894 to preserve the American Civil War battlefield at Shiloh, Tennessee. SHIL was originally managed by the War Department until it was transferred to the Department of the Interior on August 10, 1933. The park was listed on the National Register of Historic Places on October 15, 1966. The Shiloh Battlefield unit includes the Shiloh National Cemetery and Shiloh Indian Mounds Site. SHIL was expanded to include the Corinth Battlefield on September 22, 2000, which had been designated a National Historic Landmark on May 6, 1991. Shiloh National Military Park is located in Hardin County, southwest Tennessee, on the west bank of the Tennessee River. The Corinth Battlefield unit of SHIL is located 37 km (23 miles) southwest of Shiloh, in the city of Corinth, Mississippi. The National Park Service manages 2,048.31 ha of SHIL (5,061.49 acres; federal: 4,134.41 acres, non-federal: 927.08 acres; Shedd 1954).

Geologic Background

Shiloh National Military Park is located on Cretaceous and Quaternary (Pleistocene-Holocene) Tennessee River terrace deposits. These deposits were originally an extensive series of step-like alluvial terrace surfaces and deposits of the ancient Tennessee River (see the appendix for a geologic time scale). The Late Cretaceous sediments (Eutaw Formation and Coffee Sands) were deposited along the margin of the uplands present in Western Tennessee during this time, which unconformably overlie strata ranging in age from Ordovician to Mississippian, but are not exposed within the park. Over time these terraces have become dissected by modern streams, which deposited the Quaternary terrace deposits.

No fossils have been described *in situ* from within SHIL, although fossils have been discovered in association with excavations of the Shiloh Mound Complex. Rock formations mapped within the park are fossiliferous elsewhere in Mississippi and Tennessee. Devonian fossil fish are buried beneath 1 to 120 m (3 to 400 ft) of younger sedimentary overburden, but may appear where they have been exposed along the Tennessee River bottom where they appear to have washed in from upstream.

Pleistocene fossils such as mastodons and other mammals are found in the region in caves and washes, but none have been found within park boundaries (Thornberry-Ehrlich 2009). SHIL is present on the Counce and Pittsburg Landing, Tennessee and Corinth, Mississippi 7.5 minute USGS quadrangles (Russell and Parks 1975; Russell 1968, 1964). The NPS Geologic Resources Division conducted its geologic resource inventory (GRI) scoping session on March 25-26, 2009.

Sources of Paleontological Resources

Fossils have been documented within the park in association with excavations of the Shiloh Mound Complex, as described in the Cultural Resource Contexts section below. It is unknown which geologic unit (or units) produced the fossils found within the Mound Complex, although the potential sources are described in greater detail below.

Potential Sources of Paleontological Resources

Fossils have not yet been documented *in situ* from the following geologic units within SHIL. However, the fossils associated with the Shiloh Mound Complex were originally preserved in one or more of the following geologic units. Future field investigations within the park may yield fossils from one or more (or none) of these units. Fossils are also documented from these units outside of the park.

Eutaw Formation (Upper Cretaceous)

The Eutaw Formation is composed of nearshore marine sands and clays deposited in a transgressive (sea level rising) sequence. The sands consists of well-sorted, glauconitic, quartz sands with lesser amounts of

thin-bedded to laminated, montmorillonitic clays, with a pebbly layer at the base of the formation in most areas (Russell and Parks 1975). This formation is present in the park along the eastern riverfront area, in the vicinity of the National Cemetery, Shiloh Indian Mounds National Historic Landmark, and Browns Landing.

In southern Hardin County, the Tombigbee Sand Member is present, which consists of silty, massive-bedded marine sands. Outside the park, about 2.7 km (1.7 miles) north of Montgomery, Tennessee in Decatur County, basal conglomeratic and glauconitic sands ("greensands") have yielded the remains of silicified logs (Russell and Parks 1975). Other fossils from this formation elsewhere in the state include plant material, carbonized wood, mollusks (*Exogyra erraticostata*) and trace fossil borings (*Ophiomorpha nodosa;* Russell and Parks 1975). Bivalves discovered in association with excavations of the Shiloh Mound Complex might have originated from this unit, although their taxonomic identification and original stratigraphic location is unknown.

Selma Group: Coffee Sand (Upper Cretaceous)

The Coffee Sand is the basal (lowest) member of the Selma Group and rests unconformably (or where two adjacent rock masses of different age are separated by a gap in the rock record, suggesting a period of erosion or non-deposition occurring between the two) on the Eutaw Formation. The Coffee Sand is characterized by sand and clay deposited in lagoonal, barrier bar, and shoreline environments during the Upper (Late) Cretaceous. This formation is present in the Corinth and Shiloh battlefields. While the Coffee Sand is named for exposures near Coffee Landing (13 km [8 miles] north of the park), exposures are poor in west-central Hardin County, Tennessee. Where outcrops are present, they are found below terrace gravels and in valley walls of larger streams. The Coffee Sand is composed of loose, fine- to very fine-grained, finely glauconitic, micaceous, and quartzose sands. Lignitic clay shales are present with poorly bedded sands that may contain chips and flakes of white kaolinitic clay (a clay mineral composed of aluminum silicate) in the SHIL area.

In the Shiloh Battlefield area the formation is present near the W. Manse George cabin and Fraley Field. Shale exposures outside of the park frequently contain plant remains, but are often too poorly preserved to identify. Mollusks (*Pyconodonta convexa* and *Exogyra erraticostata*) and trace fossil borings (*Ophiomorpha nodosa*) have been noted in the upper sands of McNairy County, Tennessee (Russell and Parks 1975). Bivalves discovered in association with excavations of the Shiloh Mound Complex might have originated from this unit, although their taxonomic identification and original stratigraphic location is unknown. Outside of the park, at Coffee Landing parts of an insect were found in amber, with 13 genera and 16 species of plants also described from this area (Cockerell 1917; Berry 1919; Russell and Parks 1975).

Selma Group: Demopolis Chalk (Upper Cretaceous)

The Demopolis Chalk is composed of chalk and marly chalk throughout the Corinth Battlefield unit of SHIL, and contains fewer impurities than underlying and overlying formations. The Demopolis Chalk rests unconformably on the older Coffee Sand and conformably below the younger Ripley Formation (the Arcola Limestone and Mooreville Chalk are not present within the park and would typically be found between the Coffee Sand and the Demopolis Chalk).

The marine fossils of the Demopolis Chalk are characterized by one crinoid species ("Echinodermata"), three species of annelid worms, one brachiopod species ("Molluscoidea" of Stephenson and Monroe 1940), 35 bivalve species, at least two gastropod species, three ammonites, and occasional vertebrate remains. While information compiled by Thornberry-Ehrlich (2009) suggests that the Eutaw Formation and Coffee Sands may be the only formations exposed within the park, the Demopolis Chalk contains crinoids, and may be a source of the crinoid material described from the Shiloh Mounds excavations. Bivalves of the Shiloh Mound Complex might also have originated from this unit, although their taxonomic identification and original stratigraphic location is unknown. Fossils from the Demopolis Chalk in Mississippi and Alabama are dominated by shark teeth, mosasaurs, sea turtles, plesiosaurs, a

crocodile and a possible ornithiscian and hadrosaurine dinosaur in addition to less common fish (e.g. Derstler 1988; Russell 1988; Daly 1992).

Selma Group: Ripley Formation (Upper Cretaceous)

The Ripley Formation of the Selma Group is present in the Corinth Battlefield area and is composed of gray to greenish-gray, fine glauconitic sand, clay, and sandy limestone. This formation rest conformably above the older Demopolis Chalk and is the youngest formation exposed within the park. The McNairy sand member is red and white cross-bedded, micaceous sand and white sandy clay.

Marine fossils from the Ripley Formation are common, and could indicate good potential for finding similar fossils within SHIL. Stephenson and Monroe (1940) presented an extensive list of fossils from the Ripley Formation which includes coral, three species of crinoids, two serpulid worms, two annelid worms, 59 species of bivalves, two species of scaphopods ("tusk shells"), 48 species of gastropods, six ammonite and nautiloid species, a "muffin crab," ghost shrimp, and sharks teeth from two dozen USGS localities in northeastern Mississippi, many near the city of Pontotoc (see also Priddy 1943; Kenworthy et al. 2007 for information on exposures in parks of the GULN). A review of the vertebrate fauna of the Ripley Formation includes shark teeth, fish bones and otoliths, and the Cretaceous crocodile *Thoracosaurus*, collected in Oktibbeha County (Daly 1992). This specimen represents the most complete North American skeleton of the poorly understood genus *Thoracosaurus* (Carpenter 1983; Daly 1992; Kenworthy et al. 2007). While information compiled by Thornberry-Ehrlich (2009) suggests that the Eutaw Formation and Coffee Sands may be the only formations exposed within the park, the Ripley Formation contains crinoids, and may be a source of the crinoid material described from the Shiloh Mounds excavations. Bivalves of the Shiloh Mound Complex might also have originated from this unit, although their taxonomic identification and original stratigraphic location is unknown.

Park Collections

The collections of the Southeast Archeological Center (SEAC) in Tallahassee, Florida contain 111 specimens (some 135 items) cataloged as fossils (SEAC collection information provided by Brinnen Carter of SEAC, now cultural resource manager at Delaware Water Gap NRA, in 2006). The vast majority of the specimens were discovered in association with excavations of the Shiloh Mound Complex during the early 2000's. These are described below in the Cultural Resource Contexts section. One crinoid fossil in the collections (SHIL 30976) was discovered near "Grant's Left Flank." An unidentified fossil (SHILC 584) was collected near "Battery Robinette." No additional identification or stratigraphic information is given for either of these specimens.

Cultural Resource Contexts

Fossils discovered during excavations of the Shiloh Mound Complex (accessions SHIL 00294, 00295, and 00306) account for all of the SEAC-curated specimens save for the two specimens described above. While not all of the fossils have been identified, the majority of identified fossils are crinoids. Bivalves and coral fossils are also catalogued. According to John Cornelison (SEAC Archeologist, pers. comm., July 2009), it was originally thought that the specimens were in association with archeological artifacts. However further investigation suggested that the fossils were "excavated" by the Mississippian prehistoric peoples when they constructed the mounds. Thus the fossils were likely part of the fill material used to build the mounds. Any of the geologic units referenced above contain bivalve fossils, but only the Demopolis Chalk and Ripley Formation commonly preserve crinoids. Further identification of the SEAC specimens may yield additional information about the original stratigraphic provenance of the fossils.

Often, memorials, monuments, and park infrastructure may consist of rocks from the local area or even other states and those constructed of sedimentary rocks (such as limestone) may preserve fossils. Of the 156 monuments commemorating the battle of Shiloh, 22 incorporate limestone, with more than 100 bridges and culvert headwalls also incorporate limestone. Along the 2.1 km (1.5 miles) of Tennessee River

shoreline in the park, limestone has been used to armor the bank. The commemorative monuments and ornamental stonework located at Corinth Battlefield are constructed of granite and limestone. Locally quarried conglomerate has been used for erosion control, stream bank protection, and older headwall work (S. Allen, SHIL Chief of Interpretation & Resource Management, pers. comm., January 2009). Depending upon its source, the limestone and conglomerate could possibly be fossiliferous, and may present an opportunity for future investigation. Kenworthy and Santucci (2006) present a summary of NPS fossils in a cultural resource context.

Paleontological Resource Management, Preliminary Recommendations

- The NPS Geologic Resources Division sponsored a GRI scoping session for SHIL on March 23, 2009. The scoping summary report (Thornberry Ehrlich 2009) mentioned the potential for fossil resources in the park but did not make any additional recommendations for paleontological resource management.
- Park staff should be encouraged to observe exposed gullies, other erosional bedrock, and streams for fossil material, while conducting their usual duties. Given the fossiliferous nature of many of these rock units any exposures might yield paleontological resources.
- Staff should photodocument and potentially monitor any occurrences of paleontological resources that may be observed *in situ*. Fossils and their associated geologic context (surrounding rock) should be documented but left in place unless they are subject to imminent degradation by artificially accelerated natural processes or direct human impacts.
- A field-based inventory of paleontological resources may yield more information regarding the scope and significance of fossils within SHIL. Significant localities should be documented using NPS fossil locality and condition assessment forms that meet GRPA goal 1a9A.
- The park may want to consider long term paleontological resource monitoring of documented sites. A Geologic Resource Monitoring Manual by the Geological Society of America and NPS Geologic Resources Division (publication in late 2009) includes a section on paleontological resource monitoring (Santucci et al. in press).
- Further identification of the SEAC specimens may yield additional information about the original stratigraphic provenance of the fossils.
- Because battlefield monuments can incorporate rocks from outside of the park, they may display fossil resources from other regions or states. Such occurrences are documented at a number of parks in the NPS (e.g. Gettysburg NMP) but are not yet known from SHIL. This could be a source of paleontological resources in the future. Kenworthy and Santucci (2006) presented an introduction to fossils in cultural resource contexts throughout the NPS.
- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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Shiloh National Military Park Paleontological Archives
5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

Southeast Archeological Center Collections
2001-present. (museum specimens; associated specimen notes; collection records; maps; etc.). Originated by SEAC staff during Shiloh Mound Complex excavations; status: Active.

Stones River National Battlefield

Stones River National Battlefield (STRI) contains a portion of the land upon which the Battle of Stones River occurred. This was the key American Civil War battle in the struggle for middle Tennessee. The battle took place over three days, December 31, 1862 to January 2, 1863, and resulted in a Union victory. Construction of the Hazen Brigade Monument in 1863 and the establishment of the Stones River National Cemetery on March 29, 1864 were the first commemorative acts at the site. Stones River was established as a national military park by Congress on March 3, 1927. STRI was managed by the War Department until it was transferred to the Department of the Interior on August 10, 1933. The park now encompasses 287.31 ha of land in Murfreesboro, Tennessee (709.97 acres; federal: 645.15 acres, non-federal: 64.82 acres; Styles 2004).

Geologic Background

Stones River National Battlefield is located in Rutherford County, Tennessee on the Middle Ordovician rocks of the Stones River Group. This area is the type section (place of original description) for the Stones River Group. The Stones River Group was named by Safford (1851) for the Stones River where the most complete exposures of the section may be seen. The Stones River Group is composed of seven subunits in central Tennessee (from oldest to youngest): Pond Spring Formation, Jewell Bluff Formation, and the Murfreesboro, Pierce, Ridley, Lebanon, and Carters Limestones. The Murfreesboro, Pierce and Ridley limestones are mapped within STRI.

Stones River National Battlefield and General Rosecrans Headquarters Site are located on the Ridley Limestone, with the Artillery Monument, Redoubt Brannan, Curtain Wall No. 2, Lunette Thomas, Lunette Palmer, and General Bragg Headquarters Site mapped on Pierce and Murfreesboro limestones (Wilson 1964a, 1964b; Galloway 1919). The rocks present within STRI are some of the oldest exposed in Tennessee and were deposited during a time when large seas covered most of North America. During the Middle Ordovician, the future central Tennessee was near the equator, and the seas were warm, shallow and often clear, with abundant life forms present (Galloway 1919).

The NPS Geologic Resources Division conducted a geologic resources inventory (GRI) scoping session for the park on March 23-24, 2009. Within the Ordovician limestone at Stones River, quick field surveys by the Tennessee Division of Geology staff and the GRI field trip revealed bryozoans, gastropods, cephalopods, and a large trilobite (identified here as the ammonite *Gonioceras occidentale* from the Ridley Limestone, which can resemble a trilobite in cross section). Some coral was present in cedar glades along with remnant chert clasts (Ordovician in age, formation unknown at this time). Sinkholes within the park (in the Ridley Limestone) may contain Pleistocene fossilized remains (Thornberry-Ehrlich 2009; M. Hoyal, Assistant Tennessee State Geologist, pers. comm., May 2009). STRI is present on the Walterhill and Murfeesboro 7.5 minute USGS quadrangles (Wilson 1964a, 1964b).

Sources of Paleontological Resources

Fossils have been documented from the following geologic formation within STRI. These fossils present opportunities for resource management (including field surveys, inventory, and monitoring), education, interpretation, and continued or future scientific research in the park.

Ridley Limestone (Middle Ordovician)

The Ridley Limestone is composed of massive limestones with some shale partings and chert found locally and that composes the majority of the STRI bedrock. These limestones were deposited during a transgressive (sea level rising) period in the Middle Ordovician, very similar to the conditions that would have also been present in the rock record of the Murfreesboro Limestone. The water was probably less than 60 m (200 ft) deep at the time of deposition, with abundant marine invertebrates present (Galloway

1919). Prior to this inventory, STRI staff was aware of unidentified fossils exposed within the park. These remains have been identified as cross sections of shells similar to those of the coiled-shell cephalopod (squid-like animal) *Gonioceras occidentale* (possibly *Gonioceras anceps*; R. Hanger, University of Wisconsin-Whitewater geologist, pers. comm., January 2009; J. Lewis and T. Hogan, STRI Ranger and Ecologist, pers. comm., January 2009). Other fossils known from this formation outside of the park include sponges (*Stromatocerium*), bryozoans (*Anolotichia*, *Orbignyella sublamellosa*), brachiopods (*Rafinesquina, Camerella, Herbertella bellarugosa, Protorhyncha ridleyana*), ostracodes, cephalopods (*Gonioceras anceps*), and gastropods (*Liospira convexa;* Galloway 1919). The fossiliferous nature of this formation suggests that additional fossil remains might be found within the park during future field investigations.

Potential Sources of Paleontological Resources

Fossils have not yet been documented from the following geologic units within STRI. However, future field investigations within the park may yield fossils from one or more (or none) of the following geologic units. Fossils are documented from these units outside of the park.

Murfreesboro Limestone (Middle Ordovician)

The Murfreesboro Limestone is composed of fine grained to cryptocrystalline limestones with some thin lenses of dark gray to black-brown chert. These medium to dark gray (occasionally brownish black) limestones are present in medium to thick beds (Wilson 1964a, 1964b; Galloway 1919). The Murfreesboro Limestone was deposited during a transgressive (sea level rising) period in the Middle Ordovician, very similar to the conditions that would have also been present in the Ridley Limestone. The inland sea in which these rocks were deposited would have been warm, shallow, and clear, with abundant marine invertebrates present (Galloway 1919). While fossils have not yet been documented from this formation within any of the STRI units, fossils are known from this formation outside of the park. These include ostracodes (*Leperditia fabilities*) and multiple species of gastropod (*Liospira abrupt, Salterella billingsi*?, *Lophospira perangulata, Helicotoma tennesseensis, H. declivis*; Galloway 1919). The fossiliferous nature of this formation suggests that fossil remains might be found within the park during future field investigations.

Pierce Limestone (Middle Ordovician)

The Pierce Limestone is composed of very-fine grained to cryptocrystalline limestones with some thin shale partings. These limestones are brown-gray, yellowish-brown and medium gray in color (Wilson 1964a, 1964b; Galloway 1919). The Pierce Limestone was deposited in an environment where the water was shallower than during deposition of the Murfreesboro and Ridley limestones. The sea would have alternated between muddy and clear, which caused thin layers of shale to form in the resulting rock. Ripple marks and shell fragments present in the Pierce suggest this area was affected by currents, undertow and waves (Galloway 1919). The Pierce is very rich in fossils, although none have been documented in the park. Common varieties known from this formation outside of the park include bryozoans (*Nicholsonella pulchra*, *Anolotichia explanata*, *Stictoporella cribrilina*, and *Batostoma*) and brachiopods (*Pianodema stonensis*; Galloway 1919). The fossiliferous nature of this formation suggests that fossil remains might be found within the park during future field investigations.

Park Collections

No fossils are present in the Stones River National Battlefield collections, although fossils have been observed *in situ* within the park (J. Lewis, STRI Ranger, pers. comm., January 2009).

Cultural Resource Contexts

Often, memorials, monuments, and park infrastructure may consist of rocks from the local area or even other states and those constructed of sedimentary rocks (such as limestone) may preserve fossils. Due to

the fossiliferous nature of the local rocks and the number of memorials present at STRI, the possibility for fossils in these stones is an opportunity for future investigation. Historic structure building stone is just one potential source of fossils preserved in cultural resource contexts Kenworthy and Santucci (2006) present a summary of NPS fossils in a cultural resource context.

Paleontological Resource Management, Preliminary Recommendations

- The NPS Geologic Resources Division conducted its GRI scoping session on March 23-24, 2009. Participants noted paleontological resources within the park, and the potential for continued discovery.
- Park staff should be encouraged to observe exposed gullies, other erosional bedrock, and streams for fossil material while conducting their usual duties. Given the fossiliferous nature of many of these rock units any exposures would likely yield paleontological resources.
- Staff should photodocument and potentially monitor any occurrences of paleontological resources that may be observed *in situ*. Fossils and their associated geologic context (surrounding rock) should be documented but left in place unless they are subject to imminent degradation by artificially accelerated natural processes or direct human impacts.
- A field-based inventory of paleontological resources may yield more information regarding the scope and significance of fossils within STRI. Significant localities should be documented using NPS fossil locality and condition assessment forms that meet GRPA goal 1a9A.
- The park may want to consider long term paleontological resource monitoring of documented sites. A Geologic Resource Monitoring Manual by the Geological Society of America and NPS Geologic Resources Division (publication in late 2009) includes a section on paleontological resource monitoring (Santucci et al. in press).
- The University of Georgia Stratigraphy Lab maintains a website documenting and describing common fossils known from the Ordovician rocks near Nashville, Tennessee. This website may be a future resource for identifying fossil remains found in the park: http://www.uga.edu/~strata/nashville/index.html.
- Because battlefield monuments can incorporate rocks from outside of the park, they may display fossil resources from other regions or states. Such occurrences are documented at a number of parks in the NPS (e.g. Gettysburg NMP) but are not yet known from STRI. This could be a source of paleontological resources in the future. Kenworthy and Santucci (2006) presented an introduction to fossils in cultural resource contexts throughout the NPS.
- Contact the NPS Geologic Resources Division for paleontological resource management assistance.

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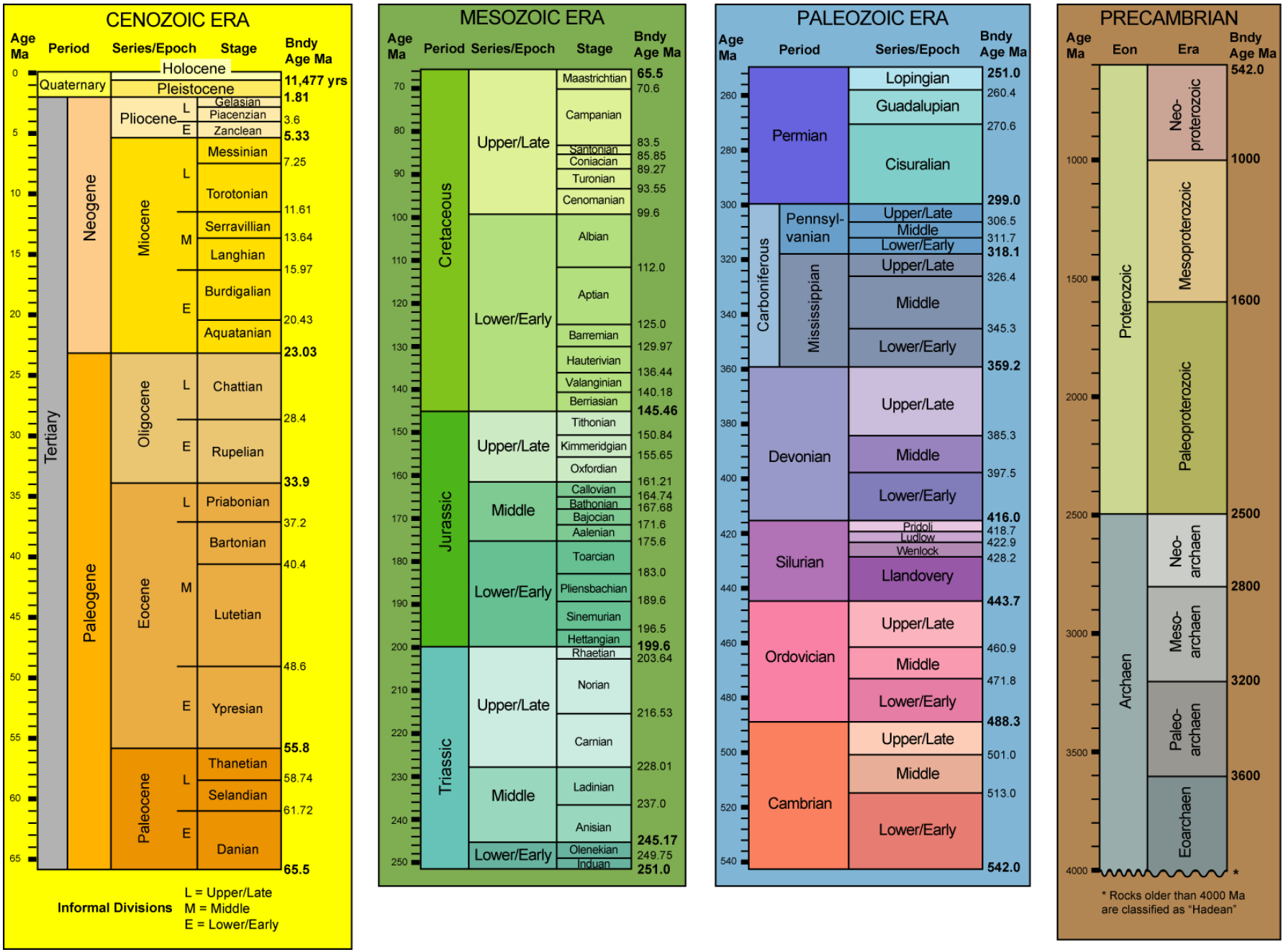
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Data Sets

Stones River National Battlefield Site Paleontological Archives
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Appendix. Geologic Time Scale. *Ma = Millions of year old. Bndy Age = Boundary Age*. Colors are USGS standard colors found on geologic maps. Modified from 1999 Geological Society of America Time scale (www.geosociety.org/science/timescale/timescl.pdf). Boundary dates and additional information from 2004 International Commission on Stratigraphy (www.stratigraphy.org/gssp.htm) and U.S. Geological Survey Fact Sheet 2007-3015 (http://pubs.usgs.gov/fs/2007/3015/).

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