THE NPS CAVE VISITOR IMPACT VITAL SIGNS MONITORING PROTOCOL

Rodney D. Horrocks
Wind Cave National Park
26611 US Highway 385
Hot Springs, South Dakota, 57747-6027, USA, RodHorrocks@nps.gov

Abstract
The national Cave Visitor Impact Vital Signs Monitoring Protocol is an attempt to standardize visitor impact monitoring in all National Park Service managed caves. With standardized monitoring in place, it will be feasible for the first time to compare monitoring data from caves across the country. This cave monitoring protocol was initiated at the NPS Cave Vital Signs Workshop held in Lakewood, Colorado in 2008. That workshop identified the vital signs that were common to all caves, including cave visitor impact. A committee convened at that workshop decided that the cave visitor impact monitoring protocol would address four parameters of human impact on caves, which include: cave visitation, visitor touching, speleothem breakage, and cave visitor traffic. This protocol is now in draft form and is being presented to the wider cave management community for review purposes.

Background
It has been demonstrated many times by using photomonitoring techniques, that in low-energy cave environments, gradual change is almost imperceptible to humans. Because of this, long-term monitoring methods have been developed for caves. These changes, which have cumulative impact, can be caused by cave visitation. There have been a couple of important tools that have been developed to monitor cave visitor impact in caves, including photomonitoring and visitor impact mapping. Impact mapping is a better tool to determine impact over large areas, while photomonitoring is more capable of detecting small amounts of change in smaller areas. Although, these tools have often been used separately, when combined they can provide an effective method of documenting impacts in caves.

In 1995, Hans Bodenhamer first introduced the concept of cave visitor impact monitoring, which he described as the process of recording cumulative visitor impact on a static cave environment (Bodenhamer, 1995). Using this system requires the use of large scale cave maps 1:240 (2.5 m/cm or 20'/inch). Bodenhamer suggests that impact mapping is a viable alternative if the area to be monitored is expansive or if damages to resources need to be quantified. Bodenhamer developed two types of impact maps, one that locates and describes individual impacts points or sites and a second that classifies and locates impacted areas within a cave. The resulting maps provide a quantitative measure of impacts that can then be monitored.

Traditionally, photomonitoring in caves is conducted using a camera, tripod, compass, and plumb line. Photomonitoring is good at documenting a range of change over time. A special type of photomonitoring system was developed by Jim and Val Werker, from Southwest Composites and Photography (Hildreth-Werker, 2006). Their system establishes relatively unobtrusive, permanent stations that can be used to quickly repeat specific photos over time. Individual stations consist of a small stainless steel tube that is epoxied into a three-inch hole drilled in non-decorated rock surfaces. A specially designed camera mount and custom fabricated monorod are then used to take a series of photos that can be repeated at specified intervals. The disadvantage of this system is that there is some impact from installing the mounts. The disadvantage of all photomonitoring is that it is difficult to analyze the resulting photographs.

The cave management community has been using these two methods to monitor cave visitor impact for a long time. However, these efforts tended to be individual efforts developed for a single cave or park and usually did not include protocols or even Standard Operating Procedures (SOP’s). Although individual efforts were occasionally reported in the National Cave and Karst Management Symposiums, no attempt was made to...
understanding of cave and karst resources. Monitoring helps managers determine patterns of impact and to develop measures to limit or stop future impact.

Monitoring techniques are an important tool for cave managers, as they allow them to determine the type and extent of impacts to cave resources. They are used to document imperceptible changes over time and thus justify mitigation measures. These monitoring efforts also provide baseline data, which can then be used for comparison purposes.

The parameters developed in this protocol apply to both developed and undeveloped caves and the tools used to quantify resource impacts are often the same for both types of caves. The four parameters discussed in this protocol are cave visitation, touching, speleothem breakage, and cave visitor traffic. For each individual parameter, sampling design, field methods, data management, and analysis and reporting are discussed within the protocol. Additionally, the associated indicators and stressors for these parameters are outlined and discussed.

Indicators are trigger points that when observed should provoke managers to implement mitigating measures, as their presence hints that impact to cave resources is occurring. The indicators included in this protocol include: trash, graffiti, polishing and staining of rock surfaces, broken speleothems, compacted floors, dust accumulations, lint accumulations, footprints, and damaged resources.

Stressors are the root cause of impact to cave resources and are first evidenced by the presence of the indicators previously outlined. The stressors used in this protocol include: unmarked trails, unauthorized use, or unregulated use for undeveloped caves and overbooked tours, lack of tour trailers, specimen collecting, touching, urinating, defecating, and wandering off trails for developed caves.

Cave visitation was chosen as a parameter because it can be used as an indicator of the condition or health of a cave ecosystem once the actual numbers of visitors using a particular cave is determined. Although, the cave visitation parameter could also incorporate the other three parameters, this parameter is differentiated from the others by our intention to only address the flow of people into and through a cave and not the impacts from their visits. The cave visitation section of the protocol

This first attempt to develop cave vital signs, which was undertaken on May 1, 2003 by Mammoth Cave National Park and the Cumberland Piedmont Monitoring Network, involved a Cave Ecosystem Modeling Workshop at the Cave Research Foundation’s Hamilton Valley facility. At that workshop, cave management specialists from throughout the National Park Service identified the major threats to cave and karst resources and the vital signs that should be monitored. However, cave visitor impact was not one of the six vital signs identified. The cave vital sign protocols developed from that effort were not applicable to caves across the National Park Service, but restricted to Mammoth Cave National Park.

The second attempt to develop vital sign monitoring protocols for cave and karst resources was initiated at the Cave Vital Signs Workshop held in Lakewood, Colorado on November 18-19, 2008 under the direction of Denis Davis, then Superintendent of Timpanogos Cave National Monument. This workshop was convened because the 32 Inventory and Monitoring Networks of the National Park Service, for the most part, did not fund protocol development for cave and karst resources, except for a few individual parks, including: Mammoth Cave National Park, Oregon Caves National Monument, and Lava Beds National Monument. However, these protocols were very site specific and not applicable to all NPS units with cave and karst resources. This workshop began by revisiting the vital signs that should be monitored for cave and karst resources in the National Park Service and identifying the vital signs that were common to all caves, including both developed and undeveloped caves. As a result, cave visitor impact was added to the list and chosen as one of the vital sign protocols that would be developed. Rod Horrocks, from Wind Cave National Park, volunteered to develop this protocol. His working group included Elizabeth Hale, from Oregon Caves National Monument and Lee-Gray Boze, from Jewel Cave National Monument.

**Discussion**

The National Park Service uses vital sign monitoring to track physical, biological, and chemical elements and processes in park ecosystems. These monitoring results are used to support management decision-making and to aid park planning, research, education, and public understanding of cave and karst resources. Monitoring helps managers determine patterns of impact and to develop measures to limit or stop future impact.

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Visitor touching was chosen as a parameter because it can be used as an indicator of the condition or health of a cave ecosystem by demonstrating its presence that the mitigating procedures and management policies currently in place are insufficient to protect cave resources. The touching parameter includes both intended and unintended impact from cave visitors touching cave surfaces. Visitors' touching the walls of a cave with their bare hands is a common problem in cave management as these actions lead to staining and polishing of cave surfaces. Many management plans and policies attempt to prevent this, but it remains a nearly ubiquitous part of cave visitation. Human-cave contact causes impact in caves that is not naturally reversed and is difficult to mitigate. Touching is a complicated issue because the impact from touching cave surfaces is cumulative and is not perceptible to periodic cave visitors, as it occurs over time and at very slow rates. As a result, convincing management or managing agencies that there is a problem can often be difficult. Once the impact from touching has been allowed to accumulate, there are no tested or approved methods to mitigate that impact; so prevention or arresting that impact should be the focus. Although caves have very little carrying capacity, entirely eliminating cave entry is not a feasible management policy, in both theory and practice. Therefore management must address the symptom itself. An important management tool to prevent unnecessary touching is education and interpretation (Foster, 1989). Educating the public of the value of natural resources helps reduce damage and vandalism by allowing people to feel a sense of ownership and responsibility for the non-renewable cave resources. However, there are other measures that can and should be used in conjunction with education in developed caves, including: adding handrails or handles, installing sacrificial touching rocks, and increasing light levels. In undeveloped caves, flagging trails and enforcing glove requirement policies can reduce impact from touching.

Speleothem breakage was chosen as a parameter because it can be used as an indicator of the condition or health of a cave ecosystem by demonstrating its presence that the mitigating procedures and management policies currently in place are insufficient to protect cave resources. The speleothem breakage parameter includes both intended and unintended impacts from cave visitors breaking or collecting speleothems. Due to the nonrenewable nature of cave speleothems, at least as far as human life spans are concerned, any breakage or unauthorized collecting leaves permanent scars on a cave and can severely degrade the aesthetic quality of that cave and degrade the scientific value of its resources. Tools used to identify speleothem breakage include photomonitoring and invisible marking systems. This section of the protocol describes the monitoring tools used to determine if speleothem breakage is occurring. One of the purposes of speleothem breakage monitoring is to demonstrate to management or managing agencies that mitigating actions are required and justified. However, it is important that as soon as speleothem breakage is confirmed, mitigating measures are taken to address the issue. One should not wait to collect a preponderance of evidence before acting, as that would only lead to additional non-renewable resources being lost. Speleothem breakage monitoring goes hand in hand with speleothem inventories, which is baseline data that should be collected for every cave.

Cave visitor traffic was chosen as a parameter because it can be used as an indicator of the condition or health of a cave ecosystem by documenting the level of impact from cave visitors. The cave visitor traffic parameter includes the impact from cave visitors that is not covered by the other parameters. Tools used to quantify visitor traffic impact include photo monitoring, impact monitoring, and lint and dust monitoring. Visitor traffic impacts can diminish cave aesthetics, alter the cave ecosystem,
degrade the scientific value of cave resources, and even make traveling through a cave more hazardous. Some impacts are inevitable, some are unintentional, some result from carelessness, and others reflect what caving techniques are practiced and how groups are managed. Visitor traffic impacts include:

- Darkened, polished, discolored, and scratched rock surfaces
- Disturbed, broken, and trampled cave features, resources, and fauna
- Sediment and mineral tracking, compaction, erosion, and smearing
- Dust, lint, hair, and trash accumulation on cave surfaces and in pools
- Introduction of non-native organisms and substances to the cave environment

Summary
The cave visitor impact monitoring protocol discusses historical studies that were important in developing the monitoring procedures and the tools outlined in this protocol as well as the mitigating measures that can be implemented once impact to cave resources has been observed. Finally, it provides SOP’s that cave managers can use to conduct the monitoring outlined in this protocol.

Once the draft of the protocol is completed, the Cave Visitor Impact Protocol Working Group will work with personnel from the NPS Midwest Regional Inventory & Monitoring Group, stationed in Rapid City, South Dakota, to produce a document that can then be peer reviewed by the winter of 2013. It is hoped that the Cave Visitor Impact Vital Signs Monitoring Protocol will be finalized by the spring of 2014.

References