Ecological Inventory of Lava Tube Caves, El Malpais National Monument, New Mexico

FINAL REPORT

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Submitted: 09 March 2011

El Malpais National Monument is a unique, caverniferous park unit in western New Mexico. This monument is riddled with lava tube caves which have received little scientific attention in regards to their bat and arthropod populations. During this two-year study, natural resource inventories were conducted at 11 caves. This work resulted in revisiting a known free-tailed bat (Tadarida brasiliensis) maternity roost and a Townsend's big-eared bat (Corynorhinus townsendii) hibernacula. The latter was first documented by the author in 2005. Additionally, at least 53 morpho-species and at least four new species representing at least 10 orders of arthropods were identified including one cave-adapted spider, two springtails, and possibly one new Carabid beetle. We also confirmed the persistence of a cave-adapted Dipluran within the deep zone of one of the caves. Cave research in El Malpais is very much in its infancy. With the likely westward advance of White-nose Syndrome (a fungal pathogen killing bats in the eastern U.S.), inventory and monitoring of the known bat hibernacula in addition to searching for additional hibernacula is of critical importance to the long-term management of bats on the monument. Additionally, conducting research to define the basic life-history requirements of both cave-adapted and newly described cave-dwelling species will enable land managers to make the best decisions concerning their management and protection.

1.0 Introduction

Cave ecosystems are among one of the most fragile ecosystems on Earth (Elliott 2000; Wynne and Pleytez 2005) due, in part, to the sensitivity of cave-dwelling organisms to human disturbance. Because many troglomorphic invertebrates are endemic to a single cave or region (Reddell 1994; Culver et al. 2000; Christman et al. 2005), and generally characterized by low population numbers (Mitchell 1970), many populations are considered imperiled (Reddell 1994; Culver et al. 2000). Most studies of cave invertebrates have been simple inventory studies, with relatively little attention paid to species richness. Despite the sensitivity of troglomorphic taxa, only a small fraction of caves in any region of the world has been assessed at an ecological system level (Culver et al. 2004).

Roosting bats (Mohr 1972; Hall 1994; Hamilton-Smith and Eberhard 2000), maternity/nursery colonies (McCracken 1989; Cockrum and Petryszyn 1991; Brown *et al.* 1993; Elliott 2000), and bat hibernacula (McCracken 1988; Humphrey 1969; Stebbings 1971; Carlson 1991; Harnish 1992; Elliott 2000) are highly sensitive to human disturbance. Additionally, bats are often considered a keystone species in cave ecosystems. When bats populate caves in large numbers, they transport significant quantities of organic material from the surface into the cave. This nutrient loading may drive entire cave ecosystems, and may support cave-adapted invertebrate species. While bats have been researched throughout most of the western United States, their use of caves remains largely under studied.

In the Southwestern U.S., the largest scale effort to assess regional cave biodiversity and endemism was a study of 24 caves in Grand Canyon-Parashant National Monument (PARA; Wynne et al., *In Prep.*). To date, three new genera and at least 15 new species of cave-dwelling invertebrates have been discovered. Of notable mention are the new genera including a Microsternodesmidae cave-limited millipede (Pratherodesmus; Shear et al. 2009), a new genus of cave cricket of the Family Rhaphidophoridae, and a new genus of bark louse (Psocoptera).

Cave ecological research in El Malpais National Monument (ELMA) will contribute to the overall understanding of southwestern U.S. cave ecology. Northup and Welborn (1997) conducted invertebrate inventories of six caves no the ELMA -- Bat, Big Skylight, Braided, Four Windows, Junction and Navajo caves. Their efforts yielded six troglobites, three trogloxenes, eight troglophiles, and numerous accidental species.

Cave-Animal Terms: Cavernicoles (cave dwelling organisms) are divided into four ecological groups (Barr 1967; Wynne and Pleytez 2005). These are, in order of their reliance upon the cave environment -- (1) *troglomorphic organisms:* (a) *troglobites* - obligatory terrestrial cave-adapted species occurring only in caves or similar subterranean habitats and (b) *stygobites* - obligatory aquatic cave-adapted organisms; (2) *trogloxenes* – taxa occurring in and requiring caves for at least a portion of their life cycle; (3) *troglophiles* – species occurring facultatively within caves and completing their life cycles there, but also occur in surface environments; and, (4) *accidental* – organisms that do not require caves, and are characterized as epigean species, but are occasionally found in caves.

2.0 Objectives

Our objectives were to: (a) identify endemic and/ or sensitive cave-adapted invertebrates; (b) develop and test a systematic sampling protocol for inventorying arthropods and vertebrates; and, (c) draw comparisons across the monument to gain inference into patterns of invertebrate species distributions, biodiversity, biogeography and endemism. This latter objective will be accomplished through my dissertation work. Ultimately, these objectives will assist NPS officials by providing some of the information necessary for developing cave resource management plans, as well as protocols to monitor how these sensitive taxa may respond to both recreational use and, in caves not used by recreationally, a climate change paradigm.

3.0 Methodology

Methods used in this work were first developed during an ecological survey of a cave in Belize (Wynne and Pleytez 2005), and field tested and refined on 24 caves on north rim Gran Canyon, and two privately-owned caves in northern Arizona (Wynne, *unpublished data*). We sampled invertebrates for four days, and searched for bats and other wildlife at each cave. Bat, Big Skylight, Braided, CDT, Four Windows, Hummingbird, Junction, Navajo, Pahoehoe, Roots Galore and Xenolith caves were inventoried during this work.

Invertebrate Sampling: We used three techniques for sampling arthropods – opportunistic collecting, time-constrained searching and baited-pitfall trapping. We sampled the entire length of each cave for cavernicolous arthropods. To reduce the risk of over collecting, one to five individuals per species were collected, which is considered adequate for positive identification (Schneider and Culver 2004).

<u>Baited pitfall traps</u>: Pitfall traps consisted of two 32 oz plastic containers placed inside on another with bait placed in the outside container, and holes punched in the base of the inside container. This design effectively attracts arthropods and keeps most arthropods separated from the bait. We buried

containers to the rim when possible and built rock ramps to the traps in other cases. Traps were baited with peanut butter (*modified from* Weinstein and Slaney 1995), and covered them with a cap rock.

Time-Constrained Direct Intuitive Searches: Time-constrained searches were conducted by searching for arthropods within a one-meter radius of each pitfall trap station. Searches were conducted for one to three minutes.

Opportunistic Collecting: We also collected any arthropods we encountered while traversing the cave.

Bat Sampling: Given the late time of year (early October), we made observations of bats using each cave. Although we were too late to survey caves for maternity and nursery use, we did scan ceilings and walls throughout the length of each cave. When bats were detected, we attempted to identify all bats to species.

Documenting Wildlife Presence: We documented the presence of all other wildlife species (scat, feathers, remains) within each cave.

4.0 Analysis

Invertebrate Taxonomic Identifications: All collected specimens will be sent off to experts for proper identification. We have discussed the proposed research with the following taxonomic experts and they have confirmed they will be willing to assist in the identifications of all materials: Drs. Rolf Aalbu (Coleoptera: Tenebrionidae), Ernest Bernard (Collembola), Theodore Cohn (Orthoptera: Rhamphidophoridae), Edward Mockford (Psocoptera), Pierre Paquin (Araneae) and William Shear (Myriapods and Opiliones).

5.0 Results

Eleven caves were inventoried during two site visits: 07-15 October 2007 and 08-15 October 2008.

Invertebrates: This work resulted in the identification of at least 53 morpho-species and at least four new species and representing at least 10 orders of arthropods (***Table 1*** and ***Appendix 1***). These include one cave-adapted Theridiid spider, two new Collembolans (*Drepanura* sp. nov.? and *Pogonognathellus* sp. nov.) and possibly one new Carabid beetle (Rhadine sp. nov.?). Additionally, a cave-adapted Dipluran (species not yet identified) was confirmed within the deep zone of Junction Cave; this species was originally indentified by Northup and Welborn (1997).

Table 1. A breakdown of Arthropod orders and number of morpho-species per Order.

Order	**# Morpho-species**
Diplura	1
Orthoptera	1
Chilopoda	2
Coleoptera	9
Collembola	5
Diptera	2
Hymenoptera	3
Hemiptera	1
Lepidoptera	4
Psocoptera	1
Total Morpho-species	**53**

Table 2. Per cave diversity of arthropods at El Malpais National Monument. Some morpho-species were detected in two or more caves.

Cave	Total
Roots Galore	18
4 Windows	14
Pahoehoe	14
Big Skylight	11
CDT	11
Bat	10
Braided	4
Hummingbird	2
Junction	2
Xenolith	1
Navajo	0

Roots Galore (n=18), 4 Windows (n=14), Pahoehoe (n=14), Big Skylight (n=11), CDT (n=11) and Bat (n=10) caves were among the most speciose caves inventoried (***Table 2***). Roots Galore and Pahoehoe caves have extensive root mats along the ceilings within their dark zones. 4 Windows and Big Skylight caves contain extensive moss gardens within the entrance. Bat Cave supports a large free-tail bat colony, and CDT cave contains numerous collapse pit entrances along the length of the lava tube. All of these factors may contribute to increased nutrient loading.

Bats: During the 2007 surveys, five *C. townsendii* were observed in the deep zone of Junction. We also observed one big brown bat (*Eptesicus fuscus;* likely torpid) roosting near the entrance.

Additionally, Bat cave continues to support a maternity/ nursery colony of free-tailed bats (*Tadarida brasiliensis*). During the 2007 work, I observed thousands of free-tailed bats roosting in the mid-section of the cave. When I returned on 14 October 2007 (to pull arthropod traps) less than 100 bats were observed.

Given our sampling window during both years (early October), we were not able to ascertain whether there were additional maternity roosts on the monument.

Other Wildlife: We observed small carnivore scat, likely ringtail (*Bassariscus astutus*), skunk (*Conepatus* sp.) and/ or raccoon (*Procyon lotor*), within Junction and Braided Caves. Skunks and raccoons have been observed preying upon bats that have fallen from the ceiling (Winkler and Adams 1972) and ringtail cats are commonly known to pick roosting bats off cave walls.

A fully articulated raccoon skeleton was observed at the back of Pahoehoe cave. This animal probably became disoriented and, unable to find its way back to the entrance, died within the cave. Packrat activity (*Neotoma* sp.) was observed in Bat and Xenolith caves. A dead gopher snake (*Pituophis catenifer*) was documented within the twilight zone of Xenolith cave. It appeared to have been killed by a tourist.

6.0 Discussion

Pahoehoe and Roots Galore caves yield the highest likelihood for supporting cave-adapted organisms that may be both new to science and a high management priority for ELMA. Both caves contain extensive root mats along the ceiling within the deep zones of both caves. Inventory work was conducted during mid-Fall rendered a relatively high number of species' detections. Conducting additional inventory work during both spring and summer would both provide insights into seasonality of arthropods occurring within these caves, as well as the likely detection of cave-adapted arthropods.

Bat cave likely supports more arthropod species than detected during the October 2007 work. This free-tailed bat roost likely supports tens of thousands of bats, which results in the deposition of significant amounts of seasonally deposited guano. Additional inventory work should be conducted during late summer once the free-tailed pups are volant and should be conducted in the evenings once the bats have left the roost to forage.

Not all arthropod species have been identified to the lowest taxonomic level possible. I am still waiting for identifications and/ or descriptions from taxonomists on several groups. This information will be incorporated into my dissertation research, and a copy of my dissertation will be provided to the Monument as a supplement to this final report.

Junction cave supports the largest known hibernaculum on the Monument. In December 2005, Wynne (*unpublished data*) counted approximately 100 *C. townsendii* hibernating in the deepest section of the cave. While only five *C. townsendii* were detected during October 2007, this does not suggest this hibernaculum is in decline. Because these observations were in mid-fall, I suggest bats were still arriving at this roost, which explains the low number of detections early in the hibernation season.

We did not detect any arthropods in Navajo cave. This is likely due to the fact that we did not resample the moss gardens at the entrance (as Northup and Welborn, 1997 did during earlier work). This cave likely contains the most significant cave ice deposit on the monument. Thus, the cave interior and deep zones are not suitable habitat for most arthropod species.

Finally, while I recognize the monument has closed all caves to both tourism and research due to the impending treat of White Nose Syndrome, there is still important scientific research that should continue. On PARA, I used a zone approach for WNS decontamination/ containment. This enabled us to conduct hibernacula inventories while following U.S. Fish and Wildlife Service WNS guidelines (USFWS 2011a, b, c). This involved designating zones based on the average known foraging radii for species likely to hibernate on PARA. I have included the protocols used as a supplement to this report (refer to ***Appendix 2***). Hopefully, this information will assist both land managers and researchers in both protecting sensitive bat species while continuing to collect data required to heighten management of sensitive cave resources.

7.0 Management Recommendations

While I recognize all caves are currently closed due to the impending westward advancement of White Nose Syndrome, this recommendation is made assuming cave visitation of tourists may resume at some point in the future.

1. **<u>Maintain closure of Junction cave during winter and year-round closure of the back portion of the cave</u>**: This cave supports a hibernaculum of *C. townsendii*, which probably contains members of the maternity roost at Braided Cave. Also, it contains a cave-adapted dipluran in the deepest part of the cave. I recommend this cave be closed during the winter to protect the hibernating bats. Permanent closure of the back of the cave is recommended to protect the diplurans and their habitat.

The additional recommendations are made to improve our understanding of cave natural resources and likely facilitate improved management practices.

1. **<u>Collect additional spider specimens at CDT cave</u>**: Arachnologist, Dr. Pierre Paquin suggests additional specimens of *Theridion* sp. nov. will be required to confirm the species is both new to science and cave adapted. Thus, additional specimens should be collected from CDT cave.

2. **<u>Conduct additional inventory work at Roots Galore and Pahoehoe caves</u>**: These two caves are the only known caves containing significant root mats, and are excellent candidates for supporting cave-adapted arthropods. Both caves appear to be warm-trapping air, and are not likely to be bat hibernacula.
3. **<u>Conduct additional arthropod inventory work at Braided cave</u>**: This cave contains the most significant cave deep zone known on the monument. Water percolates through fissures at the back of the cave resulting in a higher humidity. On PARA, I recently discovered potentially four new cave-adapted species occurring under similar environmental conditions.
4. **<u>Conduct population analysis and telemetry of Townsend's big eared bat populations on the Monument</u>**: Pierson et al. (1999) suggest this species in decline throughout its range. Obtaining data regarding population size and demographics, and identifying additional roosts will enable the monument to (a) establish a baseline population size estimates to begin monitoring this population and its two known roosts, (b) determine if the same population of *C. townsendii* is using both Braided and Junction caves, and (c) make informed decisions regarding potential cave closures and protection of this species.
5. **<u>Maintain cave closures at Bat and Braided caves:</u>** From our observations within Bat Cave, we detected no evidence of recent human activity within this cave. There was no garbage or other sign suggesting recent human visitation. Closure of this cave is likely benefiting the free-tailed bat maternity roost. Braided Cave receives some human visitation, but the remoteness of this cave and signage is likely also benefitting this colony. Seasonal closure of this cave should continue as well.
6. **<u>Conduct winter bat inventories to identify hibernacula:</u>** Additional surveys will be required at Junction cave to access the status of this roost. Once done, I suggest annual to biennial monitoring of this cave. Long-term microclimatic monitoring should be conducted in caves supporting in hibernating bats. We know little about the winter habitat requirements of year-round bat resident species. Information obtained through this work would be beneficial not only for the management of bats on El Malpais but potentially in other areas in the southwest as well. Additionally, from a management perspective, not all caves on El Malpais are suitable hibernacula roosts. Determining which caves contain hibernating bats and which are unsuitable will be instructive in potentially reopening some caves to scientific research.

8.0 Acknowledgements

Special thanks to Kayci Cook-Collins and Dana Sullivan for their guidance and continued support of this important research. Ara Kooser, Jessica Makowske, Peter Polsgrove, and Kyle Voyles provided assistance in the field. I extend much gratitude to Jeff Alford and his family at Bandera Ice Caves for providing us with a secure campsite during both site visits. Robert Delph, formerly of the Colorado Plateau Museum of Arthropod Biodiversity, provided assistance with arthropod identifications, and Rolf Aalbu, Ernie Bernard, Ed Mockford, Pierre Piquin and Bill Shear provided species level identifications for many of the specimens reported here. Fieldwork was supported through a CP-CESU agreement between El Malpais National Monument and Northern Arizona University.

9.0 Literature

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Appendix 1

Annotated List of Cavernicolous Taxa

Phylum Arthropoda
Class Arachnida
Order Araneae
Unidentified Family

Unidentified Genus and Species
Unidentified Araneae sp. 1
This unidentified Araneae species was collected in 4 Windows Cave.

Family Araneidae
Unidentified Genus and Species
Araneidae sp. 1
One juvenile specimen was collected from CDT cave. This specimen may represent a juvenile *Metellina mimetoides* because a female specimen was also confirmed. However, only one female of this species was observed. We are designating this specimen as Araneidae sp. 1. Additional material will be required to investigate this. P. Paquin identified this specimen to family.

Metellina mimetoides Chamberlin & Ivie, 1941
One adult female was identified from CDT cave. P. Paquin identified this specimen to species.

Family Linyphiidae
Unidentified Genus and Species
Linyphiidae sp. 1
One juvenile specimen was collected from CDT cave. P. Paquin identified this specimen to family level.

Unidentified Genus and Species
Linyphiidae sp. 2
One juvenile specimen was collected from Pahoehoe cave. P. Paquin identified this specimen to family level.

Lepthyphantes sp.1
Two specimens were collected from 4 Windows – both were female. P. Paquin identified these specimens to genus level.

Family Liocranidae

Unidentified Genus and Species
Liocranidae sp. 1
One juvenile specimen was collected from 4 Windows cave. P. Paquin identified this specimen to family level.

Family Nesticidae

Unidentified Genus and Species
Nesticidae sp. 1

One juvenile specimen was collected from 4 Windows cave. While it may represent *Eidmanella pallid*a, it is not possible to confirm given the age of the specimen. Thus, we are calling this detection Nesticidae sp. 1. P. Paquin identified this specimen to family.

*Eidmanella pallid*a (Emerton, 1875)
Three females were identified from Roots Galore cave. Also, two juveniles were identified to family level, Nesticidae, from Roots Galore cave. While we cannot state this definitively, we assume these two juveniles represent the same species. P. Paquin identified specimens to species and family.

Family Pholcidae
Unidentified Genus and Species
Pholcidae sp. 1
Three juvenile specimens were identified from CDT cave. P. Paquin identified these specimens to family level.

Psilochorus sp. 1
Specimens were identified from 4 Windows (2 males), Big Skylight (3 males), Hummingbird (1 male, 1 female) and Pahoehoe (1 male, 1 female) caves. P. Paquin identified these specimens to genus level.

Psilochorus sp. 2
One female specimen was collected from Bat Cave. P. Paquin designated this specimen as a different species from Psilochorus sp. 1. Additionally, one juvenile specimen was identified as "*Psilochorus*;" however, given its age, P. Paquin could not identify it beyond this level. We suggest because an adult female Psilochorus sp. 2 was identified from Bat cave, then this juvenile likely represents the same group.

Family Theridiidae
Unidentified Genus and Species
Theridiidae sp. 1
Juvenile specimens were identified from CDT (n = 3), Pahoehoe (n = 1) and Roots Galore (n = 1) caves. Currently, we cannot justify dividing these into individual species. We have no additional information to suggest this would be justified. Thus, we considered all juvenile specimens as "Theridiidae sp. 1." P. Paquin identified these specimens to family level.

Achaearanea porteri (Banks, 1896)
This species was observed in Pahoehoe and Roots Galore caves. P. Paquin identified these specimens to species.

Nesticodes rufipes (Lucas, 1846)
Three adult females were identified from Roots Galore cave. P. Paquin identified these specimens to species.

Steatoda sp. 1
One juvenile specimen was identified from Bat Cave. P. Paquin identified this specimen to genus level.

Theridion sp. nov.
One adult female was identified from CDT cave. P. Paquin suggests this may be a new species, and potentially has cave-adapted characters.

Order Opiliones
Family Sclerosomatidae

Genus Leiobunum
Leiobunum sp. 1
This harvestman was identified from 4 Windows, Bat, Big Skylight, CDT, Pahoehoe and Roots Galore caves. B. Shear (pers. com. 2009) suggests this group in western North America requires major revision. It is possible multiple species exist across the southwestern U.S., or greater North America. Given the current state of this group, we designate all harvestmen that appear "Leiobunum-like" as "Leiobunum sp."

Subclass Acari
Superorder Unknown
Unidentified Family
Unidentified Genus and Species

Acari sp. 1
One specimen was collected from Pahoehoe cave. This specimen may be cave-adapted. Additional analysis will be required to identify this specimen to a lower taxonomic level and formally discuss its potential troglomorphy.

Acari sp. 2
Two specimens were identified from 4 Windows. Additional analysis will be required to identify this specimen to a lower taxonomic level.

Acari sp. 3
Nine specimens were collected from Big Skylight cave. Additional analysis will be required to identify this specimen to a lower taxonomic level.

Acari sp. 4
One specimen was collected from Roots Galore cave. Additional analysis will be required to identify this specimen to a lower taxonomic level.

Order Chilopoda
Family Unknown
Unidentified Genus and Species

Chilopoda sp. 1
One centipede species was observed from Roots Galore cave.

Family Gosibiidae
Unidentified Genus and Species

Gosibiidae sp. 1
One specimen was collected from Pahoehoe cave. B. Shear identified this specimen to family level. Additional materials will be required to identify this centipede beyond family.

Order Coleoptera

Unidentified Family, Genus and Species
Coleoptera sp. 1
This coleopteran was collected in Bat cave. These specimens will require further study.

Coleoptera sp. 2
This coleopteran was collected in 4 Windows cave. These specimens will require further study.

Coleoptera sp. 3
This coleopteran was collected in Big Skylight cave. These specimens will require further study.

Coleoptera sp. 4
This coleopteran was collected in CDT cave. These specimens will require further study.

Coleoptera sp. 5
This coleopteran was collected in Roots Galore cave. These specimens will require further study.

Family Carabidae

Rhadine sp. nov.?
These carabid beetles were identified from Bat, Braided, CDT, Pahoehoe and Roots Galore caves. These specimens have been sent to Dr. Thomas Barr for identification, and we are awaiting confirmation on whether these specimens represent a new species. Given the lack of Rhadine research in the region, we suggest this likely represents a new species of Carabid beetle.

Family Staphalinidae
Unidentified Genus and Species

Staphalinidae sp. 1
Staphalinid beetles were identified from Bat and Roots Galore caves. These specimens will require further examination by taxonomic specialists.

Family Tenebrionidae

Unidentified Genus and Species

Tenebrionidae? sp. 1
One larvae, possibly a Tenebrionid larvae, was collected from Pahoehoe cave.

Neobaphion planipennis LeConte 1866
This species was identified from Bat Cave. R. Aalbu identified these specimens to species.

Order Collembola
Unidentified Family, Genus and Species

Collembola sp. 1
Specimens were collected from Pahoehoe and Roots Galore caves. These specimens were not identified below Order level and will require further examination.

Family Entomobryidae

Drepanura sp. nov.?
Specimens were collected from Big Skylight cave. E. Bernard indicates these specimens likely represent a new species.

Entomobrya guthriei Mills, 1931

This species was identified from Braided cave. E. Bernard identified these specimens to species.

Entomobrya zona? Christiansen and Bellinger, 1980
These species was identified from 4 Windows and Big Skylight caves. It likely represents *E. zona*. E. Bernard made this tentative species designation, but indicated the specimens aren't a "sure fit" for this species. Additional specimens will be required to confirm this.

Family Tomoceridae

Pogonognathellus sp. nov.
One and three specimens were identified from Big Skylight and 4 Windows caves, respectively. E. Bernard identified these specimens to genus level and suggests these specimens are "almost certainly undescribed." Therefore, it is listed as a new species.

Order Diploda
Family Contylidae

Austrotyla sp. 1
This specimen, identified to genus level, was collected in Big Skylight. Additional specimens will be required to identify this genus to species level identification.

Austrotyla coloradensis? (Chamberlin, 1910)
This species was identified from Roots Galore and Xenolith Caves. This is a tentative species designation due to a lack of material. Additional specimens will be required to confirm its occurrence in these caves.

Order Diplura
Family Campodeidae
Unidentified Genus and Species

Campodeidae sp. 1
This specimen was identified from Junction Cave. Currently, the author is unaware of a taxonomic specialist working with either Diplurans or the family Campodeidae who could identify these specimens to species level. This organism was first identified by Northup and Welborn (1997). This animal is cave-adapted.

Order Hemiptera
Family Fulgoridae?
Unidentified Genus and Species

Fulgoridae? sp. 1
Plant hoppers were collected from tree roots located within Pahoehoe and Roots Galore caves. These specimens have been tentatively placed within the family Fulgoridae. Additional examination of these materials, by a taxonomic expert, will be required to confirm this family designation and potentially identify these specimens to species.

Order Hymenoptera
Family Formicidae
Unidentified Genus and Species

Formicidae sp. 1

One identified ant species was collected from the entrance of Big Skylight cave. These specimens will require further study.

Family Vespidae
Unidentified Genus and Species

Vespidae sp. 1
One Vespid wasp specimen was collected from 4 Windows cave. This specimen will require further study.

Vespidae sp. 2
One Vespid wasp specimen was collected from Big Skylight cave. This specimen will require further study.

Order Lepidoptera
Unidentified Family, Genus and Species

Lepidoptera sp. 1
One unidentified Lepidoptera species was identified from Pahoehoe cave.

Lepidoptera sp. 2
One unidentified Lepidoptera species was identified from Roots Galore cave.

Family Tenididae?
Unidentified Genus and Species

Tenididae? sp. 1
One micro-lepidopteran was collected in CDT cave. Additional specimens will be required to provide a lower taxonomic identification.

Tenididae? sp. 2
Micro-lepidopteran specimens were collected from Big Skylight and Roots Galore caves. Additional work by taxonomic specialists will be required to identify these groups to a lower taxonomic identification.

Order Orthoptera
Family Rhaphidophoridae
Unidentified Species

Ceuthophilus sp. 1
At least one species of Ceuthophilus was detected in 4 Windows, Bat, Braided, CDT, Hummingbird, Junction, Pahoehoe, and Roots Galore caves.

Order Psocoptera
Family Psyllipsocidae

Psyllipsocus ramburii Selys-Longchamps, 1872
This species was identified from Bat, CDT and Roots Galore caves. E. Bernard identified these specimens to species.

Phylum Chordata

Subphylum Vertebrata
Class Reptilia
Family Colubridae

Pituophis catenifer (Blainville, 1835)
A dead gopher snake was documented within the twilight zone of Xenolith cave. This individual had numerous lacerations along the length of its body. This snake was probably killed by a tourist.

Class Mammalia
Order Chiroptera
Family Vespertilionidae

Corynorhinus townsendii Cooper 1837.
This bat has been documented hibernating in Junction cave since 2005. A maternity roost exists at Braided cave. This maternity roost has been documented both within the tunnel section of braided prior to the main section of the cave and within the twilight zone of the cave's main section (where arthropods were sampled).

Family Molossidae

Tadarida brasiliensis (I. Geoffroy, 1824)
A well-established maternity roost exists in Bat Cave. We observed bats in residence during the 2007 work.

Order Rodentia
Family Muridae

Neotoma sp. was observed in Bat and Xenolith caves.

Order Carnivora

Unknown family, genus and species. Carnivore scat was observed within the entrance of Junction Cave.

Appendix 2

WNS Decontamination SOP for Cave-Related Projects in the Southwest
Grand Canyon-Parashant National Monument
Bat Hibernacula Project (05-11 February 2011)

<u>Overview</u>: This WNS SOP has been developed to address backcountry cave research needs. Most WNS protocols assume the ability to launder clothing and other washable gear, and submerse all other equipment and ropes in a water-chemical mixture between caves.

The USFWS protocols are both ideal and preferred. However, application of these protocols is not always possible when working in the backcountry. Also, there are environmental concerns associated with improper disposal of WNS decontamination water-chemical mixtures in the field.

WNS has not been detected on the western U.S., and none of the participants in this fieldwork have been working in a WNS contaminated area. While using WNS decontamination methods is a proactive approach in the west, it is nonetheless critically important to safeguarding bat populations from the potential of human transmission of WNS.

We will inventory 12 remote for hibernating bats on Grand Canyon-Parashant National Monument and adjacent BLM-Arizona Strip lands. Although WNS is not known to occur in this region, we are applying the most practical decontamination protocols to prevent the potential spread of this fungus. We propose to use a "zone" approach in response to the impending westward advance of WNS.

This SOP provides a practical yet cautious approach to reducing the likelihood of human-to-bat transmission of *Geomyces desctructans* (the fungus that causes White-nose Syndrome).

<u>*Justification*</u>: Use of the zone approach is substantiated both through logistical constraints and the natural history of bats, other wildlife, and *G. destructans*. Dumping of large quantities of chemical products, such as quaternary ammonium compounds, may have harmful environmental effects and these activities are illegal on NPS lands. Additionally, water requirements for preparing solutions for gear immersion is impractical on Parashant where surface water is scarce, and portage capacities are limited. Also, we lack a practical means of decontaminating clothing in the field; typical decontamination entails laundering. Without this ability, team members would need to bring a change of clothing for every site, which would require 12 changes of clothes for this project.

Studies in the continental U.S. suggest many bat species frequently roost-switch throughout the year. For example, Townsend's big-eared bat (*Corynorhinus townsendii*), the most commonly monitored bat species in the western U.S., use multiple night roosts in a single night, and select different roosts for different functions - maternity, bachelor and hibernacula colonies. Radio telemetry studies suggest *C. townsendii* utilizes a home range of ~20 mile radius. Several *Myotis* species have similar sized home ranges as *C. townsendii*. Currently, the primary vector for WNS is believed to be bat-to-bat transmission. Consequently, multiple roost use by bats in a given area is likely the cause for WNS transmission between roosts in WNS-affected areas.

While unsubstantiated and unstudied, other wildlife species including coyote, porcupine, cougar and owls also have large home ranges and are known to opportunistically use caves. Thus, while wildlife use of multiple caves may be infrequent, the possibility for these species to disperse *G. destructans* between caves is a possibility.

Finally, we cannot discard the likelihood of human transmission. While human-to-bat transmission has not been demonstrated, *G. destructans* has been detected in both caving gear and in cave sediment. Furthermore, long distance dispersal of *G. destructans* from WNS-affected areas to Missouri and Oklahoma caves cannot be explained by natural bat movements and migrations. Thus, it is entirely possible humans introduced this fungus to these newly infected areas.

<u>Approach</u>: The zone approach to WNS decontamination was developed in the eastern United States in 2010 and is has been implemented for bat projects throughout the country. This approach eases the logistical burden of decontamination between every site. It is based on the discussion listed above - the primary vector

for WNS transmission is bat-to-bat contact. Thus, grouping caves into zones by geographic proximity and foraging/ roosting radii of bats, presents a practical approach to WNS decontamination.

For this project, the 12 survey sites (caves) have been grouped into four WNS decontamination zones . Caves within each zone are co-located within a 10 to 15 mile radius. Less than the foraging radii of *C. townsendii* and many *Myotis* species.

Caving Gear and Equipment

Tyvek Suits: All field personnel will wear full Tyvek suits while working in caves. This will further limit contact of clothing and elbow and knee pads with the cave environment. Tyvek suits will be reused per zone. Upon completion of a zone, suits will be properly stored in a heavy-duty plastic trash bag and ultimately disposed of.

Clothing: Four sets of clothing per team member - one set per zone. This will be done as a precaution to breeches in the Tyvek suits. If necessary and upon completion of a zone, clothing will be contained in a heavy-duty plastic trash bag along with other used gear. If no breeches occur, it may be possible to reuse some clothing between zones.

Gloves: Four pairs of gloves per team member - one pair per zone. Upon completion of a zone, gloves will be placed with other used gear and clothing in a heavy-duty plastic trash bag. Between each cave, gloves will be cleaned to the extent possible using a nylon brush.

Knee and Elbow Pads: Two sets of pads per team member. The same set of pads will be used for each cave within a designated zone. The Tyvek suit should serve as a barrier between pads and the cave environment. If necessary, between each cave, knee/elbow pads will be cleaned of dirt and sediment using a nylon brush. If a breech in the suit occurs, a zone approach to decontamination will be applied. If soaking is required, removing foam inserts from kneepads, when possible, will accelerate the drying time. The second set of pads will be available in the event of a suit breech.

Boots: One pair of “Wellington” style boots per team member. These boots are made of rubber and/or neoprene, are easy to clean, and dry quickly. Between every cave within a zone, boots will be cleaned using a nylon brush and Lysol wipes. Between zones, boots will be fully cleaned through soaking in decontamination solution. Clothespins may be used to pin the upper edge of the boot to the lip of the bucket so that decontamination solution does not enter the inside of the boots; only the outside surfaces will require decontamination.

Helmets and Lights: One helmet and one primary headlamp source per member. Between each cave, helmets and lights will be cleaned using a nylon brush and Lysol wipes. Between zones, helmets will be fully decontaminated by soaking in decontamination solution. Headlamps will not be immersed and will instead be decontaminated with Lysol wipes. If headlamps contain removable elastic head straps, the straps will soaked in solution. Backup headlamps will be stored in sealed plastic bags and kept in cave packs for emergency use. If backup headlamps are not used, decontamination will not be necessary.

Cave Packs: One PVC cave pack per person. This material is easy to clean and dries quickly. Between each cave within a zone, packs will be cleaned with a nylon brush and Lysol wipes. Between zones, packs will be fully decontaminated by soaking in decontamination solution.

Vertical Caving Gear: Some caves will require vertical access (using ropes, harnesses, descenders, ascenders, carabineers, webbing, etc.). Between caves within a zone, all gear used will be cleaned using a nylon brush and Lysol wipes, as appropriate. Between zones, vertical gear will be fully decontaminated by soaking in decontamination solution.

Survey Equipment: Four sets of survey equipment (consisting of a field notebook, clipboard, datasheets, writing utensils, and cave maps) carried by the project lead. One set will be designated for each zone and will be stored in a sealed plastic bag. Specialized items needed for surveys (e.g., cameras and distometers) will be cleaned between caves and zones using Lysol wipes. We will attempt to limit the amount of survey equipment that enters caves to minimize the amount of decontamination necessary.

Miscellaneous Gear: Additional gear will be stored in sealed plastic bags in cave packs and accessed as needed. This includes food, pee bottles, burrito bags, medical supplies, and tool kits. Any items used in caves will be properly cleaned, isolated, or disposed of, as appropriate. Water will be stored in cave packs in containers that can be easily cleaned with Lysol wipes between zones.

Special Instructions

Buddy System: Team members will work together and watch each other to make sure appropriate decontamination protocols are applied between caves and zones. With team members watching each other, this will reduce the likelihood of overlooking gear, equipment, and clothing that requires decontamination.

Procedures prior to entering caves: All gear required for entering caves, including clothing, caving gear, and survey equipment will be stored in heavy-duty plastic bags labeled by zone. Gear designated for each zone will remain isolated from other zone gear and from non-cave gear such as hiking clothes and backpacks. A staging/changing area near the cave entrance will be established to leave non-cave gear and change into cave clothes. When changing, caution will be taken to avoid contact between cave gear and hiking gear.

Placement of Packs and Gear in Caves: Field personnel will be required to be mindful when placing backpacks and gear on the ground. To the extent possible, gear will be placed on rocks or remain with each person. This will limit contact of backpacks and other equipment with the soil.

Procedures after exiting caves: When returning to the cave entrance, clothing and other personal gear will be brushed off to the extent possible. As much gear as possible will be returned to zone bags and contained prior to leaving the cave entrance area to avoid contaminating non-cave gear. When returning to the staging/changing area, care will be used to avoid contact between cave gear and hiking gear. Prior to putting on hiking clothes, wet wipes will be used on all areas of skin that were exposed in the cave (e.g., face, neck, arms). A designated trash bag will be used to contain wet wipes and other disposable items used in the cave.

Decontamination between Zones: Between cave zones, decontamination will follow the most recent version of the WNS issued by USFWS. Submersible gear will be thoroughly cleaned with brushes and soaked for a minimum of 10 minutes in a solution of Lysol IC Quaternary Disinfectant Cleaner diluted to 1:128 (one ounce concentrate per gallon of water). Scrub brushes will be decontaminated between zones and will also be soaked in the decontamination solution. For non-submersible gear (e.g., cameras, headlamps), Lysol Disinfecting Wipes will be used to wipe all surfaces.

Once a batch of decontamination solution is prepared in a 5-gallon bucket, this batch will be shared between all project members. If gear has been thoroughly cleaned of loose sediment prior to soaking, a single batch may be sufficient for decontamination of all gear for a zone change. Spent solution will remain in the bucket and covered with a tightly fastened lid. The bucket will then be placed within a plastic bag. The bucket will be securely stored in the vehicle to prevent it from tipping and spilling while driving on rough roads. Efforts will be made to reuse this solution throughout the entire expedition. If solution becomes heavily tainted by dirt, a fresh solution will be used. All chemical solutions will be properly disposed of in Saint George.

Decontamination Equipment

- 30 Tyvek suits (large) to fit over clothing, knee/elbow pads and gear
- Lysol IC Quaternary Disinfectant Cleaner – 1 1-gallon bottle
- Lysol Disinfecting Wipes (35 count) - 4 containers total; 1 per project member, plus 1

- 3 5-gallon buckets
- 3 scrub brushes, nylon-bristled - 1 per project member
- 2 boxes of large heavy duty plastic bags
- 3 boxes of wet wipes
- 1 box of clothespins