Bioinventory of select caves of the Markagunt Plateau, Dixie National Forest, Utah

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Introduction

Gilleland et al. (2012) visited several caves in the Dixie National Forest's Markagunt Plateau in southwestern Utah, producing maps of select caves and conducting a preliminary biological reconnaissance. As the lead biologist on that project, one of us (Taylor) found this preliminary material particularly interesting, due to the presence of several undescribed species and interesting parallels in community structure to that of Great Basin National Park, Nevada (Taylor et al. 2018). Moving to Colorado College in 2017, Taylor was better positioned to conduct further studies of the subterranean fauna of the Markagunt Plateau (**Figure 1**), which ultimately led to a return visit in August 2018 by the authors of this study, with the goal of collecting additional material of new species and conducting additional biological surveys for Dixie National Forest.

Methods

Sites were visited only once during the study, so baits and pitfall traps were not utilized. Collections were made by hand, using aspirators, plastic spoons, or paint brushes. Some taxa, including all vertebrates, vertebrate sign, vertebrate nests, and bones of vertebrates were only photo-documented, with no collections. Collected material was preserved in 95% Ethanol, stored on ice, and returned to the laboratory for further sorting and identification. Sampling emphasized terrestrial habitats, as we did not have permission to visit the one cave containing a stream. Small drip pools were present in some caves, and here aquatic (Annelida) or semiaquatic (Collembola, Mites) fauna were occasionally collected. Most materials are presently housed at Colorado College, but specimens of select taxa will be sent out to taxonomic experts for more specific identifications and these experts may retain the material or deposit it in another collection.

Cover Photo: An adult female cave cricket (Orthoptera: Rhaphidophoridae: *Ceuthophilus* sp.) has just emerged from the exoskeleton of the last nymphal instar, in the entrance zone of Our Cave, in the Dixie National Forest. Her exoskeleton will be fully hardened ("cured") within a few hours, and she will appear similar in color to the photograph found elsewhere in this report of another individual. Photo by S.J. Taylor, August 2018.

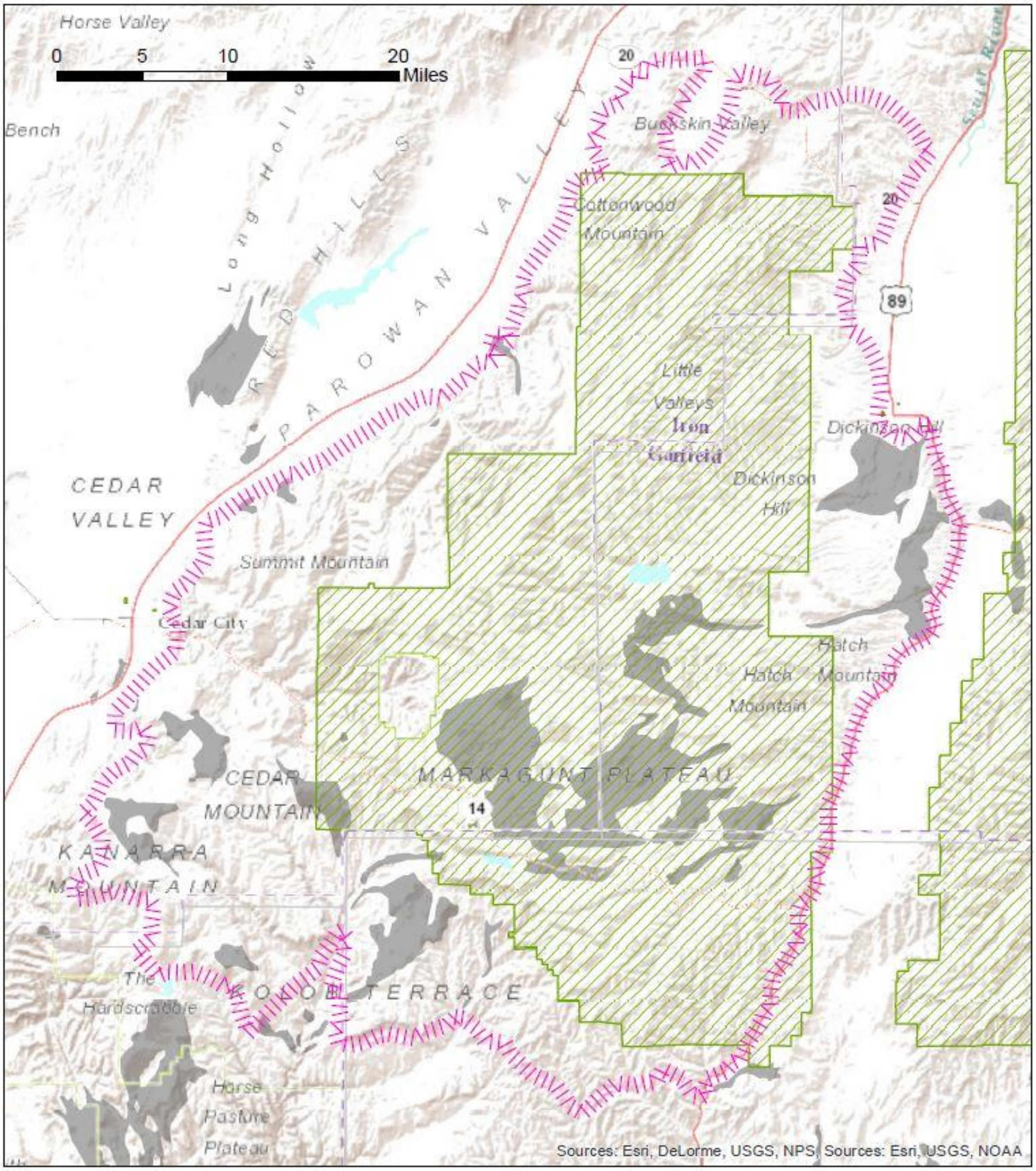


Figure 1. Markagunt Plateau (and adjacent regions) study area in southwestern Utah indicated by pink hashmark border. All sites visited were within the Dixie National Forest (green, with diagonal shading). Gray areas indicate volcanic rocks.

Results

We visited six (6) caves from 13 through 15 August, 2018 (**Table 1**). On 12 August, two of us (Taylor, Knight) relocated the entrances of several caves not bioinventoried during this project but did not enter these additonal caves. Cave locations are held in the offices of the Cedar City Range District, Dixie National Forest, Cedar City, Utah. All of the caves bioinventoried are lava tube caves except for Lar's Fork Ice Cave which is developed in limestone.

Table 1. List of sites bioinventoried during August 2018 on the Markagunt Plateau, Dixie National Forest, Utah.

Cave	**Date**	**Crew**
Aspen Sapling Cave	13 Aug 2018	Steve Taylor, Geoff Hoese, Aimee Beveridge, JoAnn Jacoby
Lost Snag Cave System, #3	13 Aug 2018	Jason Knight, Gretchen Baker, Emma Baker, Matthew Baker, Alex Knight
Lost Snag Cave System, #9	13 Aug 2018	Steve Taylor, Geoff Hoese, Aimee Beveridge, Jason Knight, Gretchen Baker, JoAnn Jacoby, Emma Baker, Matthew Baker, Alex Knight
Lars Fork Ice Cave	14 Aug 2018	Steve Taylor, Geoff Hoese, Aimee Beveridge, Gretchen Baker, Emma Baker, Mathew Baker, JoAnn Jacoby
Our Cave	15 Aug 2018	Steve Taylor, Geoff Hoese, Aimee Beveridge
Mammoth Cave	15 Aug 2018	Steve Taylor, Geoff Hoese, Aimee Beveridge,

Plants and Fungi

We observed Aspen trees (Order Malpighiales: Family Salicaceae: *Populus tremuloides* Michx.) growing in at least two cave entrances (Lar's Fork Ice Cave, **Figure 2**; Aspen Sapling Cave) as well as grasses, mosses, ferns and other herbaceous vegetation in the entrance zones of caves. In the twilight zone, some mosses and algae were observed (**Figure 3**). Dark zone flora was restricted to sprouting seeds (which die in the absence of light), roots of trees and other plants penetrating into the cave through cracks in the ceiling (**Figure 4**), walls, and floors of the caves, and occasional fungi growing on decomposing litter, animal scat (**Figure 5**), roots hanging down into the cave (**Figure 4**), and other organic substrates.

Figure 2. Aspens, *Populus tremuloides*, growing in the entrance pit of Lar's Fork Ice Cave, Dixie National Forest, Utah.

Figure 3. Mosses growing on breakdown in the twilight zone of Lost Snag Cave #9, Dixie National Forest, Utah.

Figure 4. Tree roots penetrating into lava tube cave passage through a crack in the ceiling, Our Cave, Dixie National Forest, Utah. Note occasional fungal growth present on the roots.

Figure 5. The fruiting body of a fungus, growing off of mammal feces in Our Cave, Dixie National Forest, Utah. Note scattered colonies (white flecks) of fungi and other microbes on soil behind the fungus (especially near top of photo).

Invertebrates

A summary of invertebrates recorded from caves of the Markagunt Plateau (Dixie National Forest, Utah) during this study is provided in **Table 2**.

Mollusca: Gastropoda

At least two species of snails were recorded from this study. One is a species with discoid shell morphology (**Figure 6**, **Figure 7A**), and the other is a pupilliform species (**Figure 7B**).

Figure 6. A snail from Lar's Fork Ice Cave with a discoid shell morphology. This appears to be a mature individual.

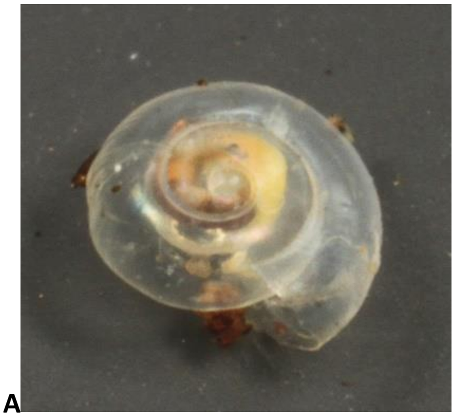
A  B 

Figure 7. Two gastropods collected from Lar's Fork Ice Cave. **A**) a discoid snail, perhaps an immature of the species depicted in **Figure 6**; **B**) a small snail with a pupilliform shell morphology.

Annelida

Though earthworms are no doubt present in the rich hummus found in the entrances of several caves, none were recorded. We did find a series of individuals of an aquatic oligochaete in a small drip pool deep within Our Cave (**Figure 8**).

Figure 8. An aquatic oligochaete from Our Cave.

Table 2. List of invertebrate taxa by cave based on August 2018 bioinventory of select caves. Efforts in Mammoth Cave were cursory at best, our focus there was upon bats.

Phylum	Class	Order	Family	Genus	Common Name	Aspen Sapling Cave	Lost Snag #3	Lost Snag #9	Lar's Fork Ice Cave	Our Cave	Mammoth Cave
Mollusca											
	Gastropoda										
					snail A				x		
					snail B				x		
					snail C				x		
Annelida											
	Clitellata										
					aquatic worm					x	
Arthropoda											
	Arachnida										
		Araneae			spiders, mixed	x	x	x	x	x	
	Arachnida: Acari: Parasitiformes										
		Mesostigmata									
			Parasitidae		mite A		x	x	x		
	Arachnida: Acari										
					mite B	x					
					mite C	x					
					mite D				x		
					mite E				x	x	
					mite F					x	
					mite G					x	
	Arachnida										
		Pseudoscorpiones									
			Neobisiidae: Microcreagrinae								
				cf Cryptocreagris n.sp.							
					cave pseudoscorpion		x	x			
	Chilopoda										
		Lithobiomorpha									
			Lithobiidae								
					stone centepedes	x	x	x		x	

Phylum	Class	Order	Family	Genus	Common Name	Aspen Sapling Cave	Lost Snag #3	Lost Snag #9	Lar's Fork Ice Cave	Our Cave	Mammoth Cave
	Diplopoda										
		Chordeumatida									
			cf Conotylidae?								
				cf *Idagona* n. sp.							
					cave millipede		x	x			
	Collembola										
		Poduromorpha									
			Tullbergidae								
					elongate springtails					x	
		Entomobryomorpha									
					springtail A		x		x		
			Tomoceridae								
				cf Pogognathellus sp.							
					springtail B		x	x	x		
			cf. Sinellidae?								
					springtail C			x		x	
			Undetermined								
					springtail D			x	x		
			Isotomidae								
					springtail E					x	
		Symphypleona									
			Arrhopalitidae								
				Pygmarrhopalites sp.							
					globular springtails					x	
	Diplura										
		Diplura: Rhabdura									
			Campodeidae								
					dipluran					x	
	Insecta										
		Hemiptera: Auchenorrhyncha									
			Cicadellidae								
					leafhopper			x			
		Hemiptera: Sternorrhyncha: Aphidomorpha									
			Adelgidae								
					adelgids					x	

Phylum	Class	Order	Family	Genus	Common Name	Aspen Sapling Cave	Lost Snag #3	Lost Snag #9	Lar's Fork Ice Cave	Our Cave	Mammoth Cave
		Orthoptera									
			Rhaphidoporidae								
				Ceuthophilus sp.							
					cave crickets	x		x	x	x	
		Psocoptera									
					bark louse	x					
		Coleoptera									
			Carabidae								
					ground beetles					x	x
			Leiodidae								
					round fungus beetles			x			
			Anobiidae: Ptininae								
					Spider Beetles		x		x		
			Staphylinidae								
					rove beetle A	x					
			Undetermined								
					beetle larva A			x			
					beetle larva B					x	
		Diptera									
			Trichoceridae								
					winter crane flies	x	x		x		
			Mycetophilidae								
					fungus gnats		x				
			Sciaridae								
					dark-winged fungus gnats		x	x	x	x	
			Cecidomyiidae								
					gall midges					x	
			Phoridae								
					humpbacked flies				x		
			Undetermined								
					fly - undetermined A					x	

Phylum	Class	Order	Family	Genus	Common Name	Aspen Sapling Cave	Lost Snag #3	Lost Snag #9	Lar's Fork Ice Cave	Our Cave	Mammoth Cave
		Lepidoptera									
			Nymphalidae								
				Nymphalis californica (Boisduval, 1852)							
					California tortoiseshell				x		
		Hymenoptera									
			Formicidae								
					ant A	x					
					ant B	x					
					ant C				x	x	
			Tiphiidae								
					Tiphiid wasps					x	
			Vespidae: Eumeninae								
					potter and mason wasps					x	
			Undetermined								
					wasp - undetermined A					x	
					wasp - undetermined B					x	
					wasp - undetermined C	x					

Arachnida: Acari

Mites were frequently encountered in all cave zones. These animals were quite varied (**Figure 9**), including some species that are likely predators (**Figure 9B**) as well as parasites (**Figure 9G**). Others may scavenge dead plant, animal, and fungal material. Some groups of mites include cave-adapted species, e.g., Zacharda et al. (2010).

Arachnida: Araneae

A variety of spiders were found during this study, and they occupied all caves zones. Some taxa, including members of the Nesticidae (**Figure 10A**), may have some degree of cave adaptation, while others are clearly accidentals, typically found in the entrance and twilight zones of the caves.

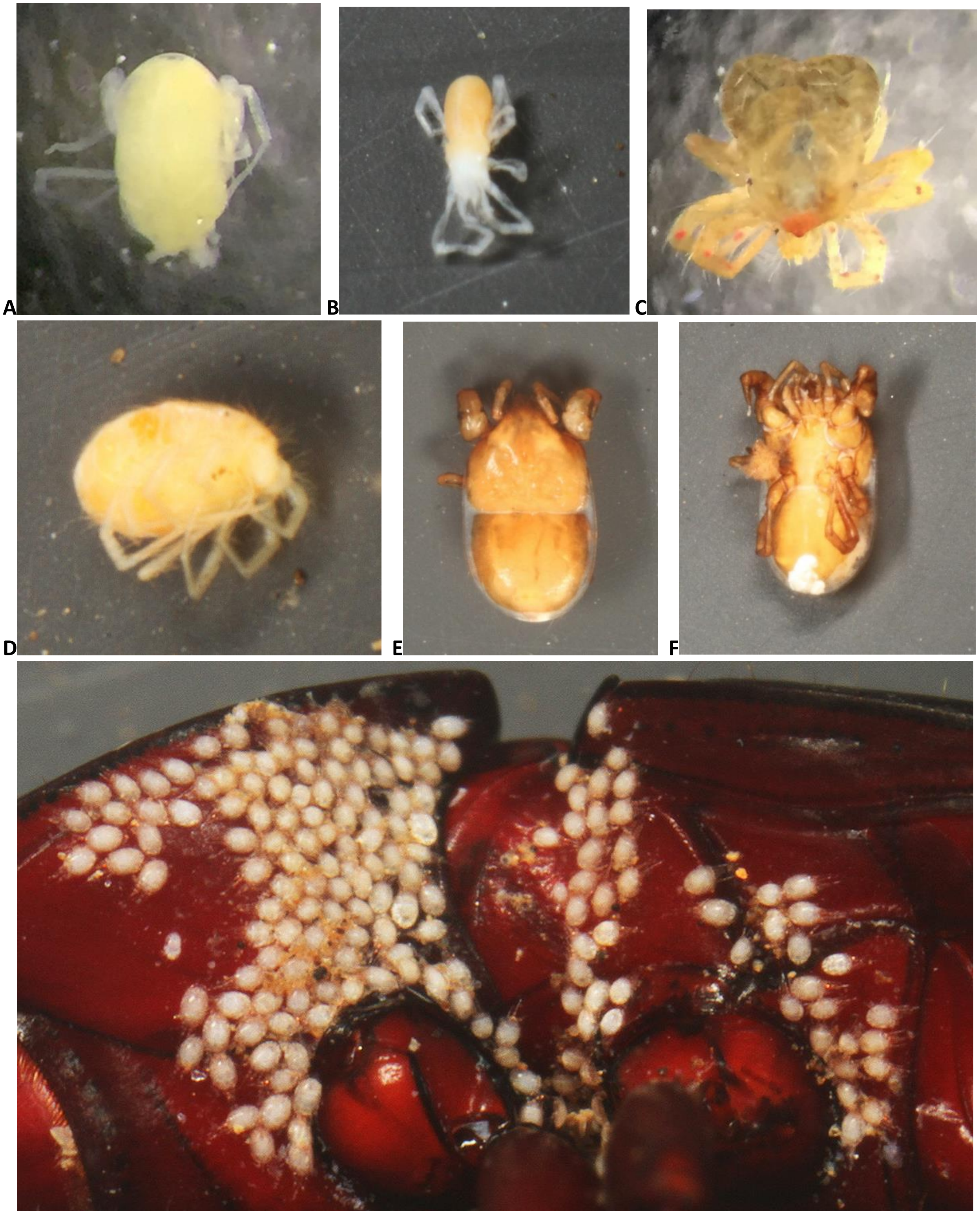
Arachnida: Pseudoscorpiones

One species of pseudoscorpion was encountered (**Figure 11**), and it occurred in several caves. This species appears to be an undescribed *Cryptocreagris* (Neobissidae: Microcreagrinae) possibly related to another Microcreagrinae known from caves in Great Basin National Park (Taylor et al., 2008).

Symphyla

A single individual of the myriopod class Symphyla was observed (**Figure 12**) in Lar's Fork Ice Cave, but it was not collected. These animals are occasionally encountered in caves of western North America (e.g., Taylor et al., 2008) and are likely edaphobites that occur incidentally in caves. This specimen is like in the family Scutigerellidae, possibly belonging to the genus *Hanseniella*.

Figure 12. A Symphylan, photographed in Lar's Fork Ice Cave.



A B C D E F G

Figure 9. A selection of mites collected from caves of the Markagunt Plateau. **A**) Aspen Sapling Cave; **B**) Lost Snag #3 Cave (Parasitiformes: Mesostigmata: Parasitidae); **C**) Aspen Sapling Cave; **D**) Our Cave; **E**) Lar's Fork Ice Cave, dorsal view; **F**) Lar's Fork Ice Cave, ventral view; and **G**) Our Cave, ectoparasitice upon a ground beetle (Carabidae).

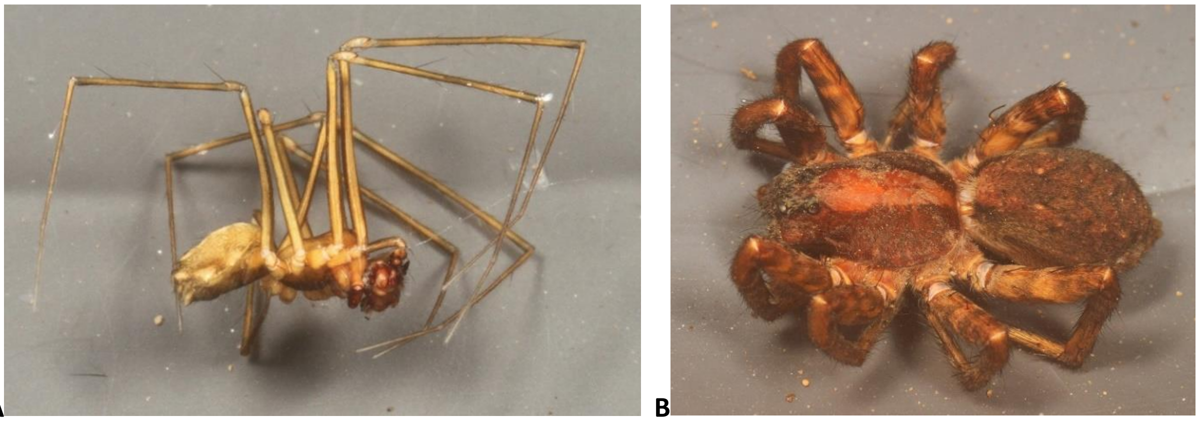


Figure 10. Spiders collected from the caves of the Markagunt Plateau. **A**) an adult male, probably family Nesticidae, from Lost Snag #3 Cave; **B**) a wolf spider (Lycosidae) from Lar's Fork Ice Cave.

Figure 11. *Cryptocreagris* n.sp. a Microcreagrine pseudoscorpion. **F**ield photographs from **A**) Lost Snag #9 Cave and **B**) Lost Snag #3 Cave. **C**) Laboratory photo of a specimen from Lost Snag #9 Cave.

Chilopoda

Stone centipedes (**Figure 12**) were frequently encountered, being recorded from four of the caves (Aspen Sapling Cave, Lost Snag #3 Cave, Lost Snag #9 Cave, and Our Cave). The we most commonly found in entrance and twilight zones, where they are predators, likely hunting for various invertebrates in the relatively rich organic material found in these cave zones.

Figure 12. A stone centipede (Chilopoda: Lithobiomorpha: Lithobiidae) from Lost Snag #3 Cave.

Diplopoda

The cave millipede (**Figure 13**) recorded from the Lost Snag Cave System (Lost Snag #3 Cave, Lost Snag #9 Cave) appears to be a new species of *Idagona* (Chordeumatida: Conotylidae), a millipede genus which thus far contains three described species: *Idagona lehmanensis* Shear 2007 from limestone caves in Great Basin National Park (Nevada), *Idagona westcotti* Buckett & Gardner 1967 from lava tube caves in Idaho, and *Idagona jasperi* Shear 2007 known from high altitude caves in northern Utah (Shear, 2007).

Figure 13. A cave millipede from Lost Snag #3 Cave.

Hexapoda: Collembola

We found a diverse assemblage of springtails in the caves of the Markagunt Plateau (**Figure 14**). Several of these (**Figure 14 D-F**) are likely cave obligate species, whereas others (**Figure 14 A-B**) may be accidental or opportunistic inhabitants of the entrance and twilight zones of caves. This rich collection of springtails holds promise of containing one or more species new to science, and these have already been shipped to a taxonomic expert (Dr. Aron Katz, University of Illinois) for further study.

Hexapoda: Insecta

The remaining invertebrates reported are all insects. Some of these are regular cave inhabitants, while others are accidental or incidental in caves.

Orthoptera: Rhaphidophoridae

Cave crickets of the genus *Ceuthophilus* (**Figure 15**, cover photo) are common inhabitants of caves in the Markagunt Plateau. We observed them singly or in loose clusters at most of the caves, with clusters comprised of mixed groups of adults and nymphs. These crickets typically roost in caves, animal dens, and other sheltered areas during the daytime, and disperse out across the forest floor at night, foraging upon plant material and scavenging off of dead animals (Taylor et al. 2005).

Hemiptera

A leaf hopper from Lost Snag #9 Cave (**Figure 16A**) is likely an accidental, but Adelgidae (Sternorrhyncha: Aphidomorpha) from Our Cave (**Figure 16B**) seem likely to be associated with tree roots hanging down into the cave passages. The adelgids were extremely small (early instar nymphs), and were found on the surface film of small drip pools on the cave floor.

Psocoptera

A single collection of Psocoptera from Aspen Sapling Cave (**Figure 17**) probably represents an accidental, surface species, although Psocoptera with well-developed eyes have been described from material collected in several caves in the Western Hemisphere (e.g., Mockford 2009, 2011).

Coleoptera

Various beetles (**Figure 18**) collected during this study represent a range of associations with the cave environment, from putatively cave-limited species (e.g., round fungus beetles: Leiodidae, **Figure 18C**), to mammal nest associates such as spider beetles (Anobidae: Ptininae; **Figure 18D**), to accidental or incidental species such as ground beetles (Carbidae; **Figure 18B, F**). The round fungus beetles (Leiodidae) are of particular interest, as several US species are associated with caves (Peck & Newton, 2017), including Western species (e.g., Peck, 1973, 1980; Peck & Wynne, 2013).

Figure 14. Select springtails (Collembola) collected from caves on the Markagunt Plateau. Entomobrymorpha, perhaps genus Pogognathellus, from **A**) Lost Snag #3 Cave, and **B**) Lar's Fork Ice Cave. In addition to the color difference, note the marked difference in shape of the prothorax. **C**) Entomobryomorpha from Lar's Fork Ice Cave; **D**) Isotomidae (Entomobryomorpha) from Our Cave. Two springtails from the surface of small drip pools on the floor of Our Cave: **E**) Tullbergidae (Poduromorpha); **F**) Arrhopalitidae (Symphypleona).

Figure 15. A cave cricket, *Ceuthophilus* sp. (Orthoptera: Rhaphidophoridae) roosting on the ceiling of Aspen Sapling Cave.

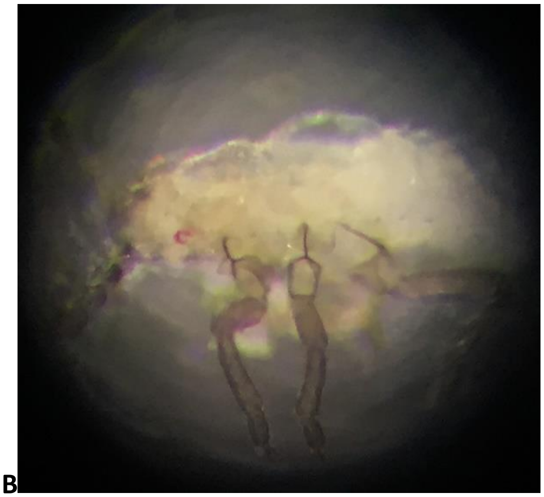
A  B 

Figure 16. Hemiptera from caves on the Markagunt Plateau. A) Cicadellidae; B) Adelgidae.

Figure 17. Psocoptera from Aspen Sapling Cave.

Figure 18. Beetles from caves on the Markagunt Plateau, Dixie National Forest, Utah. **A**) an unidentified beetle larva from Lost Snag #9 Cave; **B**) a ground beetle (Carabidae), heavily infested with mites, from Our Cave; **C**) Leiodidae from Lost Snag #3 Cave; **D**) a spider beetle (Anobiidae: Ptininae) from Lost Snag #3 Cave; **E**) rove beetle (Staphylinidae) from Aspen Sapling Cave; **F**) a ground beetle (Carabidae).

Diptera

Several families of flies (**Figure 19**) were recorded from the caves. Adult Trichoceridae, known as winter crane flies (**Figure 19A**), were commonly encountered in cave entrances and twilight zones of caves where their larvae likely feed upon decaying vegetation. Only one humpbacked fly (Phoridae) was collected (**Figure 19B**) but this group is hyperdiverse, with several species known from North American caves (e.g., Disney, 1994; Disney & Campbell, 2010; Disney et al., 2011), and it is plausible that this represents a new species. Dark-winged fungus gnats (Sciaridae) were collected from the dark zone of several caves (**Figure 19C**) and this represents another group where it is not unusual to discover new species in North American caves (e.g., Vilkamaa et al. 2011).

Lepidoptera

We expected to find a few moths in the caves, but none were detected. A nymphalid butterfly found roosting in the entrance of Lar's Fork Ice Cave (**Figure 20**) is related to a species found to facultatively utilize caves as roosts in Nevada (Taylor et al. 2009).

Hymenoptera

Ants (Formicidae) were frequently encountered in the entrance zones of caves (**Figure 21A**) where they likely are foraging in the relatively rich organic debris of this zone. Several species of ants have been associated with caves in the western United States (Cokendolpher et al., 2009; Pape, 2016) but none are considered cave-limited species (Tinaut & Lopez, 2001). A variety of wasps were recorded (**Figure 21B-F**) mostly from the entrance and twilight zones; none appear to have any special association with caves.

Figure 19. Select flies (Diptera) from caves of the Markagunt Plateau. **A**) Trichoceridae from Aspen Sapling Cave; **B**) Phoridae from Lar's Fork Ice Cave; **C**) Sciaridae from Lar's Fork Ice Cave.

Figure 20. A California tortoiseshell, *Nymphalis californica* (Boisduval, 1852) roosting in the entrance of Lar's Fork Ice Cave.

Figure 21. Select Hymenoptera from caves on the Markagunt Plateau. **A**) an ant (Formicidae) from Aspen Sapling Cave; **B**) an unidentified wasp, probably parasitic, from Aspen Sapling Cave; **C**) a tiphiid wasp (Tiphiidae) from Our Cave, an accidental; **D**) Vespidae: Eumeninae (potter and mason wasps) from Our Cave, an accidental; **E**) an undetermined wasp from Our Cave, likely accidental; **F**) an unidentified wasp, probably parasitic, from Our Cave.

Vertebrates

A wide variety of vertebrates likely used caves and other subterranean voids — such as spaces among breakdown, talus, and lava fields — as temporary shelters, dens, and other primary habitat. Additionally, caves may function as traps, where wildlife not typically associated with subterranean environments may fall or wash into caves. The bodies of these accidental species provide critical nutrients to the fragile, nutrient poor subterranean ecosystem. Those vertebrates which may routinely utilize this habitat also contribute to the subterranean ecosystem by bringing in woody and herbaceous debris (e.g., for nests and dens, or from the remains of feeding on cones and fruits) and by depositing feces and other organic materials that can support other subterranean life.

Amphibians

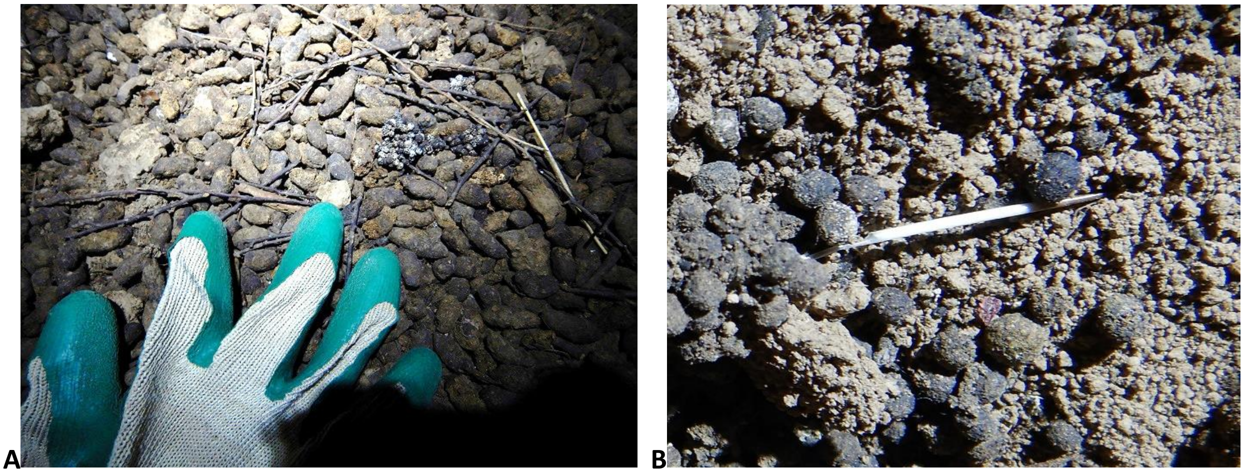
The only amphibian recorded during our survey was a tiger salamander in Our Cave (**Figure 22**). Cave entrance zones provide protected, often relatively moist conditions with a rich accumulation of invertebrate prey. This species is likely relatively common but infrequently encountered in lava flows on the Markagunt Plateau. As these animals need water for eggs and young, their presence suggests water is sometimes present in the general vicinity.

Figure 22. A tiger salamander, *Ambystoma tigrinum* (Caudata: Ambystomatidae) in the entrance zone of Our Cave.

Mammals

The presence of the North American porcupine, *Erethizon dorsatum* (Linnaeus, 1758) (Rodentia: Erethizontidae) was documented on the basis of latrine sites (**Figure 23A**) and stray quills (**Figure 23B**).

Bats (Chiroptera: Vespertilionidae) occurring or possibly occurring on the Markagunt Plateau all belong to the family Vespertilionidae, with approximately 14 species which may utilize habitats in this area (**Table 3**). All 14 of these bats are listed as species of "Least Concern" on the IUCN Red List of Threatened Species (http://www.iucnredlist.org/ , accessed 22 Aug 2018). Specific information on the bat fauna of the Dixie National Forest is available from various agency reports (Day and Peterson, 1999; Jackson and Herder, 1997; Lengas, 1994). We observed scattered light bat guano in many of the caves visited, with marked accumulations only present in Mammoth Cave (**Figure 24A**). The only bats seen during our bioinventory were a large colony of *Myotis evotis* (H. Allen, 1864), the western long-eared Myotis, in Mammoth Cave. This colony was in three clusters (**Figure 24B**), within 1.5 m of one another, in a recessed ceiling channel. The timing of our visit, and the fact that the bats were clustered in a colony, indicates that this is a maternity colony, as males and non-pregnant females roost singly (Adams, 2003). We were able to make a conservative minimum count of bats in two of the three clusters using photographs — counts were 39 in one cluster, 22 in another, with the third cluster being similar in size (but not counted, due to lack of photo). Thus, the maternity colony includes more than 70 bats (count includes a few pups). Positive identification was facilitated by the presence of a single recently deceased individual found on the ground (**Figure 24C**), allowing for photography and later study of key characters. A cave cricket (Orthoptera: Rhaphidophoridae: *Ceuthophilus* sp.), a ground beetle (Coleoptera: Carabidae), and an unidentified smaller beetle (Coleoptera) were observed feeding on the fresh carcass (arrows, **Figure 24C**). In Utah, *M. evotis* has been recorded across a broad range of habitats — including forests dominated by Ponderosa, Spruce, and Fir. They occur at a broad range of elevations, ranging up to at least 9,500 ft (Shuster, 1957; Mollhagen and Bogan, 1997). This species feeds on various insects, gleaning insects off of tree bark and preying upon flying insects, and they are adapted to feeding in habitats with relatively dense vegetation (Adams, 2003). Thus far, *M. evotis* has not been observed exhibiting symptoms of White Nose Syndrome (WNS), nor have any individuals been found to be positive for the causative agent of WNS, the fungus *Pseudogymnoascus destructans* (Blehert & Gargas) Minnis & D.L. Lindner (Ascomycota: Pseudeurotiaceae; **Table 1**). However, many cave-roosting bats which hibernate – including many of the western *Myotis* species, are certainly vulnerable to WNS. As WNS continues to show, in general, a classic pattern of epidemiological spread (**Figure 25**), it is likely that bat-to-bat contact will continue to function as the primary means of the continued western spread of this deadly disease. Thus, we can expect bat mortality in Utah populations within the next few years.



A **B**

Figure 23. Typical sign of North American porcupine (*Erethizon dorsatum*) from Aspen Sapling Cave. **A**) feces (glove for scale); **B**) quill.

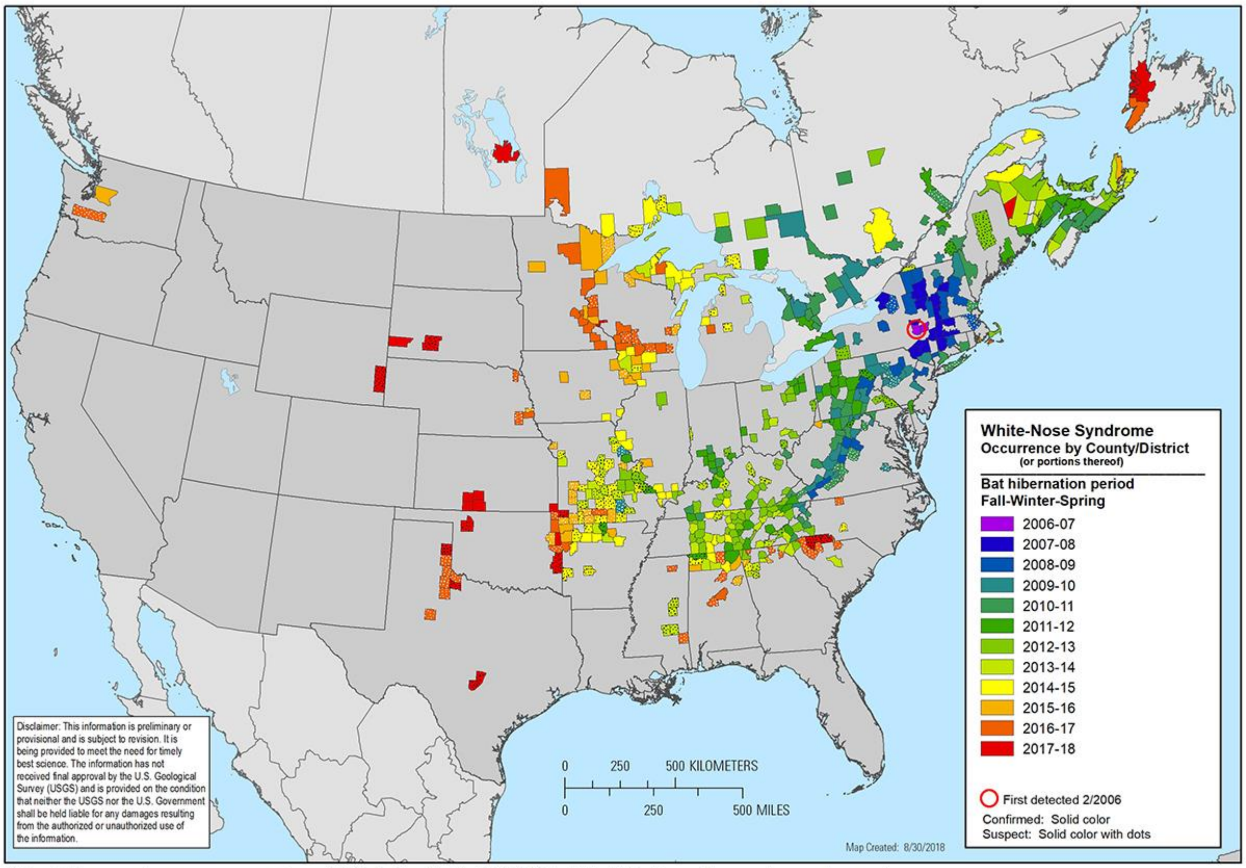
Table 3. Bats likely or possibly occurring on the Markagunt Plateau, Utah, based on distributions as given in Adams (2003). ***Obs*** = observed during this study; ***Cnf*** = species confirmed to have diagnostic symptoms of white-nose syndrome detected (source: https://www.whitenosesyndrome.org/static-page/bats-affected-by-wns accessed 19 Aug 2018); ***Pd*** = species and subspecies on which *Pseudogymnoascus destructans* has been detected, but no diagnostic sign of white-nose syndrome has been documented (source: https://www.whitenosesyndrome.org/static-page/bats-affected-by-wns accessed 19 Aug 2018); ***WSC*** = Wildlife Species of Concern (State of Utah, Department of Natural Resources, Division of Wildlife Resources; 1 November 2017 list); and ***T2*** – On the Utah Species of Concern List as a Tier II species (Sutter et al., 2005).

Species or Subspecies	**Common Name**
Antrozonus pallidus pallidus (LeConte, 1856)	pallid bat
Corynorhinus townsendii Cooper, 1837	Townsend's big-eared bat – ***Pd, WSC, T2***
Eptesicus fuscus pallidus Young, 1908	big brown bat – ***Cnf*** (in *E. f. fuscus*)
Euderma maculatum (J.A. Allen, 1891)	spotted batt – ***T2***
Idionycteris phyllotis (G.M. Allen, 1916)	Allen's big-eared bat – ***WSC, T2***
Lasionycteris noctivagans (Le Conte, 1831)	silver-haired bat – ***Pd***
Lasiurus blossevilli (Lesson & Garnot, 1826)	western red bat – ***WSC, T2***
Lasiurus cinereus (Palisot de Beauvois, 1796)	hoary bat
Myotis ciliolabrum (Merriam, 1886)	western small-footed Myotis – ***Pd***
Myotis evotis (H. Allen, 1864)	western long-eared Myotis – ***Obs***
Myotis thysanodes Miller, 1897	fringed Myotis – ***WSC, T2***
Myotis volans (H. Allen, 1866)	long-legged Myotis – ***Cnf***
Pipistrellus hesperus (H. Allen, 1864)	western pipistrelle
Tadarida brasillensis (I. Geoffroy, 1824)	Brazilian free-tailed bat – ***Pd***

A B

C

Figure 24. *Myotis evotis*, western long-eared Myotis, in Mammoth Cave, Markagunt Plateau, Dixie National Forest. **A**) Bat guano from *M. evotis* in Mammoth Cave. Varying ages of guano indicate more prolonged site occupancy; **B**) part of the maternity colony of *M. evotis* in Mammoth Cave, a pup is visible riding upon its mother on the left side of the image. **C**) Recently deceased *M. evotis* on the floor of Mammoth Cave. Arrows point to an unidentified small beetle (left; Coleoptera) and a ground beetle (right; Coloeptera: Carabidae). The ground beetle was feeding on the exposed flesh just prior to the photograph. Photographs by S.J. Taylor August 2018.



Citation: White-nose syndrome occurrence map - by year (2018). Data Last Updated: 8/30/2018. Available at: https://www.whitenosesyndrome.org/resources/map.

Figure 25. The spread of WNS, a deadly disease of hibernating bats, across the conterminous United States and Canada, as of 30 August 2018.

Recommendations

Most caves in the Dixie National Forest on the Markagunt Plateau receive very little visitation. However, four cave systems receive heavy visitation: Mammoth Cave, Bower's Cave, Duck Creek Ice Cave, and Ice Cave. All of three of these are easy to find via road signage and associated parking areas. It is important that the general public have opportunities to experience and appreciate cave environments, so keeping these sites at least seasonally accessible to the public has significant value. Nonetheless, removing some road signage would likely reduce human impacts—those who are unaware that there are caves on the Dixie would be less likely to encounter them. Similarly, staff and volunteers at the visitors center across the highway from the Duck Creek Campground should not reveal locations, or even the existence of, caves other than the three listed above. Offering up cave information when it is not requested only serves to increase negative human impacts to the caves. Parking areas should continue to be maintained for these sites, and parking lot signage provides an opportunity for enhanced education of the general public, an opportunity that could be further expanded upon. For safety, the wooden ladder at the entrance to Bower's Cave should be replaced with a heavy metal ladder secured in the cave using metal pins (as implemented in professionally built cave gates in this Forest). We examined cave gates at Mammoth Cave and Our Cave, and found them to fully meet modern standards for cave gate construction. The gate at Our Cave should continue to be obscured/hidden to minimize likelihood of discovery. Occasional visits to this entrance are warranted to ensure the gate has not been vandalized/breached — here, it may be appropriate to schedule such visits on a regular basis, taking care to not create a trail or standard parking spot that might reveal the cave location. An occasional drive-by of the parking areas for the Lost Snag system & for Lars Fork Ice Cave are also warranted, to ensure these caves continue to receive little visitation. We understand that protocols for cave rescue are already in place, and these should be reviewed every few years to ensure protocols and contact phone numbers are up-to-date. Consultation with the National Cave Rescue Commission (NCRC) in rescue-related reviews and other activities should be considered essential. Presently, Gretchen Baker (NPS, Great Basin National Park, Nevada) should be the primary point of contact in NCRC.

As WNS spreads across North America, few, if any, management actions have been identified that show significant promise in limiting the spread of this disease. Nevertheless, resource management actions are most effective when informed by solid data. We recommend annual or biennial winter visits to all of the caves on the Dixie National Forest, to obtain counts of hibernating bats, by species, and to monitor for signs of WNS. This work should be carried out by small team led by an experienced bat biologist, in consultation with the Utah state lead for winter bat surveys. Additionally, stationary monitoring points and driving transects across the Dixie NF during the summer, both utilizing modern ultrasound detectors and appropriate software for file analysis, would be most valuable in identifying areas of elevated bat activity, by species. This work should be carried out by biologists with experience working with bat acoustics. Numerous factors affect the effectiveness of acoustic monitoring for bats – and carefully designed fieldwork, along with professional vetting of subset of accumulated call-libraries, can result in a highly informative dataset that can help guide various management decisions related for forest activities of all kinds. USFS's strategy regarding WNS (Amelon et al., 2012) is to focus on "how can we minimize exposure of uninfected animals to the pathogen, maximize survival of bats that are exposed to the pathogen and minimizing the survival and fitness of the pathogen." USFS is also partner in a nation-wide multi-agency approach to managing WNS (WNS-Plan, 2011), with current information on implementation, decontamination guidelines, and other information available at: https://www.whitenosesyndrome.org/ (accessed 21 Aug 2018).

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