Beneath the Forest

Volume 5, Issue 1 Spring 2012

"Beneath the Forest" is a biannual newsletter published by the Forest Service of the U.S. Department of Agriculture.

Edited by Johanna L. Kovarik, Minerals and Geology Management Centralized National Operations

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Cave and Karst Calendar of Events

Karst Field Studies Courses

June 4 - 23, 2012

Locations in KY, MO, and NM

www.karstfieldstudies.com

National Speleological Society Convention

June 25 - 29, 2012

Lewisburg, West Virginia

http://www.nss2012.com

Orientation to Cave Rescue

June 6 and 7, 2012

Oregon Caves National Monument

http://www.caves.org/commission/ncrc/national/OCRs/Orientation%20to%20Cave%20Rescue,%20ORCA,%202012.pdf

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Geological Society of America

November 4 - 7, 2012

Charlotte, NC

http://www.geosociety.org/meetings/2012

Editor's Notes:

Our issue of "Beneath the Forest" is a special one in spring 2012. With two slightly longer articles, the issue focuses on the area that most recently hosted the National Cave and Karst Management Symposium.

Larry Spangler of the U.S. Geological Survey has provided us with an excellent overview of the hydrogeology of the Uinta-Wasatch-Cache as a treat for the geologists in the crowd of Beneath the Forest subscribers. And, for those interested in something just a little bit different, Wendell Nope has written a very entertaining article about the work that he and Richard Lamb are conducting in Ricks Spring through cave diving.

I'd like to thank all the contributors for this issue as well as Melody Holm for assistance, support, and editing. Thanks go to Sonja Beavers in the national Office of Communication for assistance with creating the external version of this newsletter. The original issue was published internally in May 2012. Our next issue will be the fall issue. Articles for the Fall 2012 issue are due on October 1, 2012, in order for the issue to be out in November 2012. Please encourage resource managers, cavers, karst scientists, and other speleological enthusiasts who do work on your forest to submit articles for the next exciting issue!

Johanna Kovarik, Editor

Cover art: Ricks Spring entrance on the Uinta-Wasatch-Cache, November 2011. Image: J. Kovarik.

Contributors and entities represented in this issue:

Wendell Nope
Uinta-Wasatch-Cache National Forest

Lawrence Spangler
U.S. Geological Survey

Cynthia Sandeno
Monongahela National Forest

Ricks Spring is located at MM477 on Hwy 89 in Logan Canyon, about 17 miles outside Logan, Utah. The spring boils up from the rear of this open cavern, flowing from 0 to 75 cubic feet per second. depending on the time of year and the previous winter snowpack. Image: W. Nope

Utah's First Diveable Underwater Cave System

Wendell Nope
Volunteer
Uinta-Wasatch-Cache National Forest

When one thinks of karst springs, Florida automatically comes to mind. Yet, an extensive karst system also exists in the limestone and dolomite geology of Logan Canyon, UT. The U.S. Geological Survey (USGS) and the Forest Service have conducted extensive dye drainage studies in this region. The USGS and Forest Service have identified numerous springs and sumps have been identified, but to-date none of them have ever been found to be sizeable enough for underwater caving. I wouldn't expect anyone reading this article to know who I am. So, I would like to introduce myself. I currently reside in Salt Lake City, UT, and I am a State Police Officer, working as a trainer at the Utah Police Academy.

I also have a collateral assignment as the trainer of the Utah Department of Public Safety Dive Team. It was in that assignment that I developed a curiosity about cave diving. After completing my National Speleological Society Cave Diving Section (NSS-CDS) Cave Diver certification, I realized that I won't make it to Florida very often to dive the Devil's System, Peacock, Little River, etc. My only option seemed to be to find a wet cave in Utah to enjoy my passion. Everyone I spoke to told me that there were no wet caves in Utah. I just couldn't believe it. This article reveals the result of a year's worth of interview after interview, checking out sites, the disappointment of failure after failure, even the criticism of nay-sayers, and, then, the extreme elation of being more than rewarded for all the time and effort.

As a preface, there are many hundreds of dry caves in Utah. In fact, the discovery of the Main Drain Cave in Logan Canyon has received national attention as being one of the deepest dry caves in the United States. Downward exploration has stopped in Main Drain because it has reached a terminal sump at a depth of 1,227 feet (which may become another story later on). However, wet or totally submerged caves are rare. An interview one day in March 2007 with USGS hydrologist Larry Spangler produced a lead. Spangler has researched Logan Canyon drainage for years, and some of his work may be seen at the following Web page: http://water.usgs.gov/ogw/karst/kigconference/les_delineation.htm. Spangler is an accomplished dry caver. He is active in the local NSS Grotto and has put in many hundreds of hours underground. Spangler stated that once, when the water table was far below normal, he had been able to see into the opening of Ricks Spring as it flowed out of the rock. He felt a diver might be able to get in there if some of the blockage was removed from the mouth of the spring.

(Cave dive continues on page 4)

(Cave dive continued from page 3)

After further discussion, we decided to go and determine the status of the entrance and the outflow. The photo below says it all. Spangler, Richard Lamb (a local cave diver), and I then went to Ricks Spring. The water flowing out of this spring is crystal clear. It's also cold—on the first visit it was 43 degrees Fahrenheit. After several hours of clearing baseball to basketball-size rocks out of the throat at a depth of 14 feet there was enough clearance to enter the cavern zone. When I made it through the very first time, I looked around with awe, realizing that I was looking at something that no human being had ever seen before. Each subsequent dive has produced that same feeling as we have pushed further into the system. On this first effort, we laid only 200 feet of line. It wasn't because of a lack of interest to go farther, but rather, the presence of numerous side passages in the first 200 feet. There are five off-shoot passages: two back-mount (meaning tanks are worn on the diver's back), one side-mount, and three no-mount (meaning the tanks are pushed ahead of the diver).

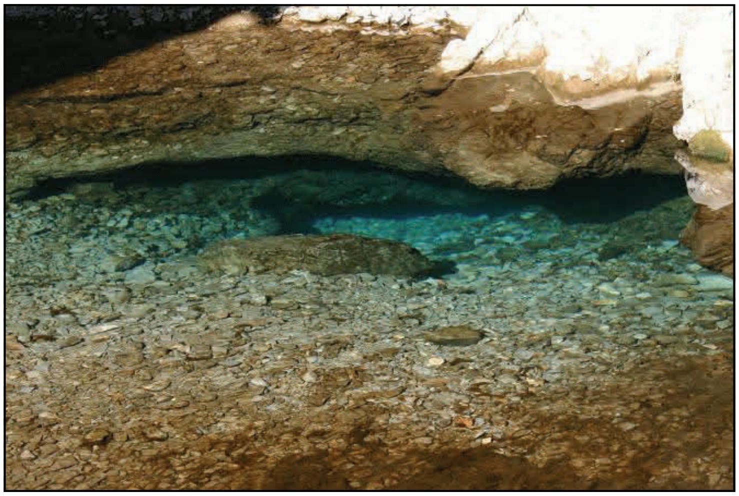
The water clarity in the main and side passages remained crystal clear throughout the penetration phase of the dives that day. There was next to no silt on the rock floor and walls of the main passageway due to a rather strong flow. We had agreed with Spangler to penetrate only 200 feet and, then, report our findings to him. One thing that no amount of training can prepare a cave diver for is the heavy percolation (dislodged ancient silt) that a virgin cave may produce. After tying off the exploration line on the "first push," Lamb and I turned the dive. As soon as we began the exit, our lights shined into what appeared to be a snowstorm white-out. Visibility went from more than 100 feet to 1 foot as soon as we headed into the downstream flow. I had a flash thought that we might have stirred up the bottom on the way in, but I knew better—something was more dangerous about this silt-out.

This is the view from inside the spring, looking out. When the sun is at a certain point in the sky, sunlight shining in creates this other-worldly view which is almost indescribable as the diver approaches the exit after exploring. Image: W. Nope

Training kicked in, and we initiated an emergency exit procedure called "Bump & Go," in which we maintain physical contact with each other as we exit. As we got to the primary tie-off point in the cavern zone, we made a 3-minute stop. Our maximum depth had been 70 feet, and no decompression stop was necessary. In that short time, the percolation dissipated, being blown out of the cave entrance by the waterflow. We were once again in crystal-clear water. We exited safely and, as we surfaced, Spangler was standing right there, almost waist-deep in the frigid water, with a grin from ear-to-ear and 20 questions.

Spangler has one of the bubbliest personalities I have ever known. He grilled us on the geology, passageways, waterflow, and several other hydrology-type issues. I felt like he was as excited as we were to make this unique find. Spangler then explained to us that the ability to go upstream in this cave system had enormous impact on an issue that he had been researching for years now—the Ricks Spring water source. Some years ago, the Forest Service placed dye in the Logan River above Ricks Spring.

(Cave Dive continues on page 5)



The entrance opens up to a cavern just beyond the initial restriction. The main passage gets bigger as it goes. This is how the spring looks most of the year, but boils up to 24" during the snowmelt season (see boil atwww.wendellnope.com/ricks2010boil.wmv). Image: W. Nope

(Cave dive continued rom page 4)

When the dye showed up in the spring, a declaration was made that this was not a true spring, but, rather, an underground diversion of the river. To me, this is not an issue, but I'm only a diver and not a hydrologist. The assertion has been made that Ricks Spring begins at a point where the fault line crosses the river and ends at the point where it reaches the boil itself.

Larry Spangler has done dye tests of his own and found that dye placed in a high mountain glacial lake named Tony Grove (more than 5 miles away and 2,000 feet higher in elevation) also exited out through Ricks Spring. If Ricks Spring is only an underground diversion of the river, it may end at about a 1,500 foot distance, as that is where the fault intersects the Logan River. Spangler 's research suggests there is a confluence at some point where the Tony Grove drainage and the fault-diverted Logan River water combine and flow to Ricks Spring. This is hopefully the case, since this would mean a cave system with both unique qualities and possibly a tremendous distance. Finding the confluence would be as exciting as the initial discovery of the cave system.

While on a later dive, Richard Lamb's son Thomas Lamb discovered the exact point at which the river water intrudes into the main passageway, so we learned that both the USGS and the Forest Service are correct. On the second push, another local cave diver named Randy Thornton joined Lamb and me. We pushed the distance out to 500 feet, finding even more passages along the way. At about the 250-foot point, the geology of the main passage changes from a fault-line type tunnel to a bore-hole configuration. In this new section, there are few places to grab hand-holds, so kicking is the only option. The amount of flow along this 250-foot stretch will certainly be a limiting factor for the distance that we'll be able to penetrate in future exploratory dives. What a great problem to have, considering our greatest problem previous to this was not having a cave in Utah to dive in at all!

A couple weeks later, Richard Lamb and I returned for another couple more dives. We laid new line from 500 to 800 feet. The geology along this section changes from a bore-hole back to a fault-line configuration. There was not much flow on this dive, and the only reason we stopped at 800 feet was that we came to a large air pocket, big enough to either stand up or sit down. We both immediately realized this might be used as a location for future extended penetrations involving stage bottles or even just resting. On our next dive, we collected an air sample to test for content. Although the air is indeed breathable, the oxygen content in this small airspace may be diminished by multiple divers within a short timeframe. By the third push, we had named several side-passages and geology features. About 75 feet from the cave entrance is the Rabbit Hole Tunnel, which is a horse-shoe configuration and leads back to the main passage. At about 140 feet is the Eye Socket Tunnel, which has two side-by-side openings and a column in-between. As you might imagine, the openings seem somewhat like eye sockets on a skull.

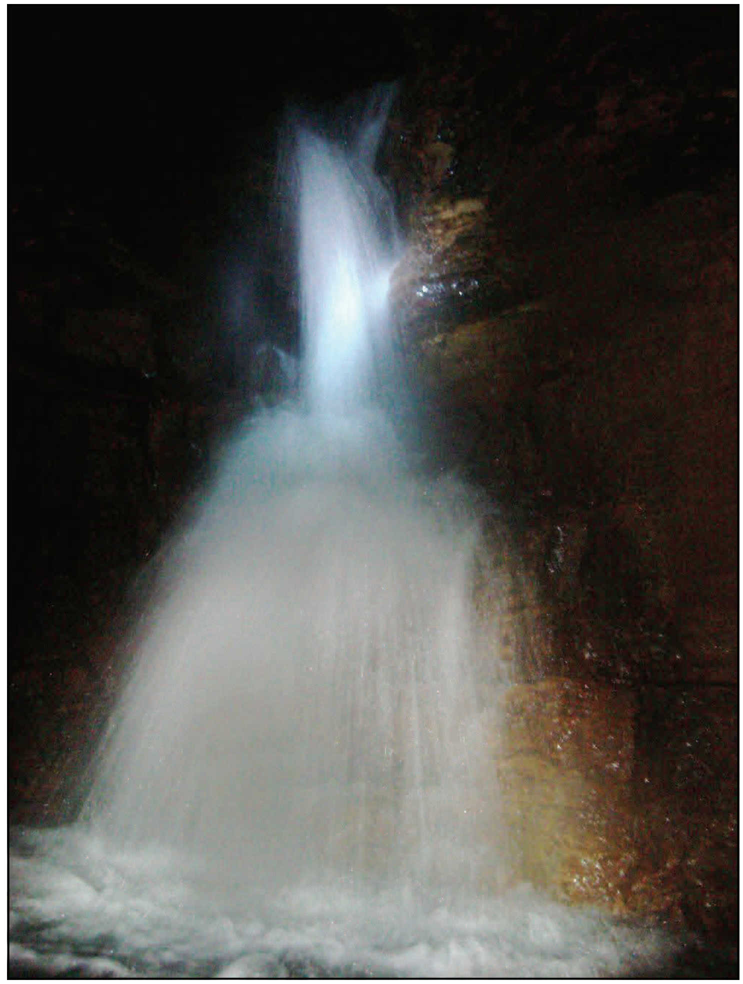
(Cave dive continues on page 6)

(Cave dive continued from page 5)

This is a side-mount tunnel that is, as yet, unexplored, but appears to open up into a room after a distance of about 30 feet. Back in the main passage, just about 150 feet from the entrance, is the Honey Hole—a cork-screw shaft that starts at 30 feet depth and descends to 70 feet. Past this shaft is the Slippery Slide Tunnel (bore-hole configuration), so named for the lack of Pull & Glide points. Beyond this, the main passage changes back from bore-hole to fault-line configuration. At about 750 feet, one encounters the Tibby's Table Obstruction, which is a 4-foot by 6-foot by 6-inch slab jammed into the tunnel such that it somewhat bisects the passageway at about a 60-degree angle. Large back-mount divers may find this obstruction challenging, even impassible, as was the case with one diver on a subsequent exploration dive.

As of this writing, very few cave divers have penetrated Ricks Spring. The Rocky Mountain region does not have a high population of cave divers compared to Florida and other parts of the country. The numbers are rapidly growing now that there is somewhere in Utah to dive. Also, the existence of the Ricks Spring underwater cave system has not been widely publicized nationwide. Lastly, Jennefer Parker of the local Forest Service office monitors diving in the cave on a dive-by-dive basis because the cave system is still in the exploration phase and not, completely, a recreational site as yet.

On August 12, 2007, Lamb and I returned to video the main passage up to the airspace. Using a discount video camera setup (second-hand housing and four Light Cannon flashlights), I was successful in acquiring reasonably decent footage. It has now been edited such that the video fits on a regular CD. A special segment shows Lamb as he maneuvers through the Tibby's Table obstruction. Photos of Tibby's Table and the air space were taken and the best quality image is included herein. This video may presently be seen at http://www.wendellnope.com/ricks20091010.wmv.



Upon penetrating 2,200 feet, the diver surfaces into a pool at the base of this incredible 28' waterfall aptly named Vestal Falls. It looks like something out of a Disney movie. To add to this amazing sight is the knowledge that less than a dozen people in the world have witnessed this sight in person. Image: W. Nope

There are more fascinating aspects of this cave's geology. The Slippery Slide Tunnel has a slight upward angle. During almost the entire time in this tunnel, we could see our breathing exhaust bubbles race ahead along the ceiling. Initially, this caused percolation to cloud the way, but by now this has lessened. Also, the Slippery Slide Tunnel ends at a large chamber, at least large for this cave system.

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(Cave dive continued from page 6)

Top Image: **Beautiful features decorate the second dry cave, near Vestal Falls. This is indicative that this area has been relatively stable, in spite of seismic activity that is experienced often in this region of the State of Utah.** Bottom Image: **This restriction is found at the 2300 foot point and will require an hour or so of moving rocks to pass through. The passageway seems to continue far beyond this point and will be explored summer/fall 2012. Images: W. Nope**

Each dive so far has produced considerable percolation as we enter this chamber, so its detailed characteristics are as yet unknown. At the far end of the air pocket, we can see the passage continuing. The opening has the appearance of a gaping maw, as it is viewed from the beginning of the air pocket.

Yet, upon arriving at the opening, it becomes obvious that the passage makes a turn such that this is only an optical illusion. The main passage continues on in a horizontal and vertical serpentine fashion until a second air pocket is encountered. This airspace is much larger than the first and has some incredibly beautiful geology in the ceiling. Ever-present moisture on the ceiling gives this airspace the appearance of glistening layers of rock strata. It is an awe-inspiring sight.

Continuing on and after a distance of just over 100 feet, a third airspace appears. This is even larger and has a dome-like configuration. It also reveals strata layers that are similar to giant growth rings of a tree. Again, the sight is breathtaking. This airspace has a small sandy beach that might provide a temporary staging spot, if an urgent pause in the dive was necessary. There is also a visual deception in this airspace—our eyes are attracted to the fascinating beach and beautiful dome. If we didn't for a cave passage continuing on from here, we might not have spotted it easily. As we came into this dome-room, our eyes were drawn to the left and upward. The underwater passage actually continues to the right and downward. When we finally spotted it, it was incredible. We have named this unique geology "Jim Wyatt's Elbow." The passage now opens up into a large and wide Florida-type underwater cave passage. Silt covers the floor, and the water is a brilliant cobalt-blue. The water appears different than the first 800 feet or so, causing me to wonder if we have passed another confluence of intrusion water and snowmelt drainage. When I first saw this sight, I literally gasped in my regulator. It is truly breathtaking, compared to the passage up to this point, which is comprised of very slightly brown-tinted water.

(Cave dive continued on page 8)

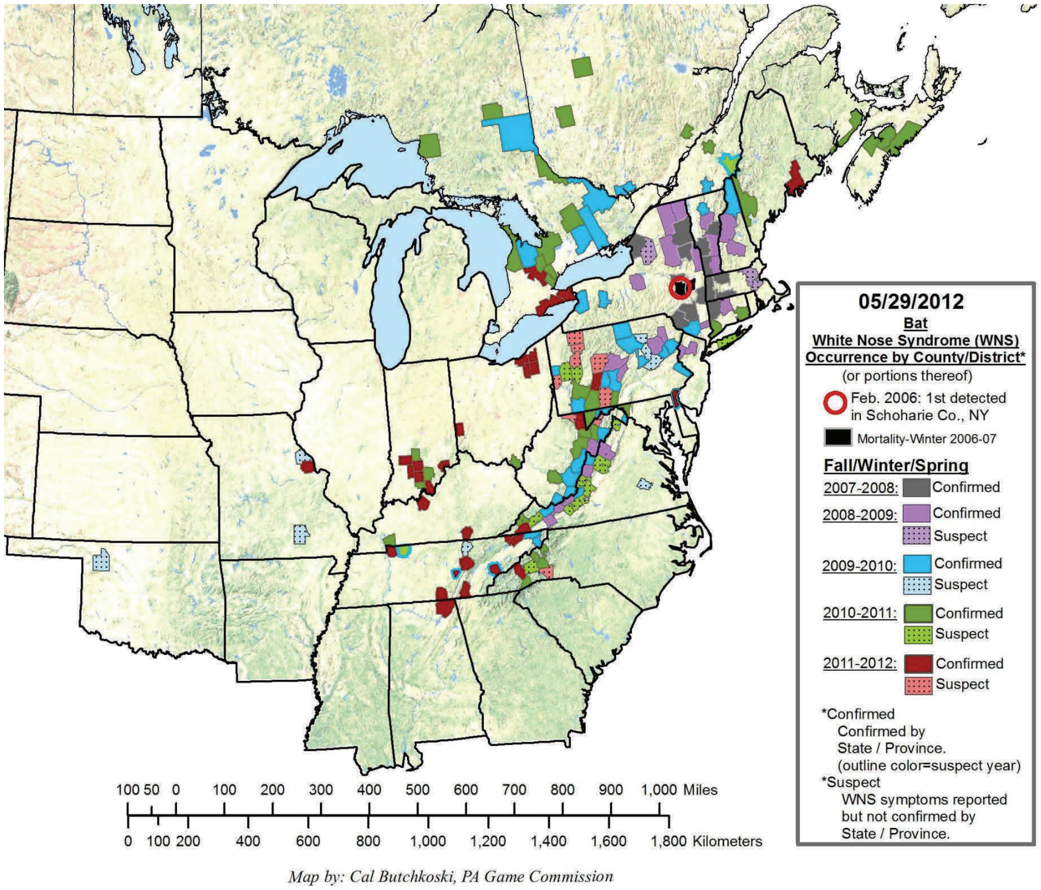
Richard Lamb (left), Thomas Lamb (top), and Wendell Nope (right) have made the initial exploration and cartography. Richard & Wendell discovered the cave system, but Thomas is credited for discovering the "River Intrusion Tunnel" passageway that is the convergence of the two spring water sources, Tony Grove Lake and the Logan River. Image: W. Nope

(Cave dive continued from page 7)

Jim Wyatt's Elbow now leaves the dome-room, slopes sharply downward, and somewhat levels off for another (horizontal) 150 feet to an even more stunning sight. As the passage gradually becomes more shallow, another airspace seems apparent due to reflections of the surface bouncing light back to us. The surprise sets in as soon as our heads breach—this is not just another airspace but actually the opening to a huge dry chamber. The water passage turns into a stream running through this dry cave. On this first visit, we couldn't see the other end of the cave, even with our 10 Watt High Intensity Diode (HID) lights. A subsequent dive revealed the cave to be about 250 feet long, 30 to 50 feet wide, and at least 50 feet high. There is even a beautiful cascading waterfall. On our first dive to this point, Lamb and I were so stunned by the view that we just stared. Our conclusion was to return later with digital and video cameras to document the discovery. We tied off the exploration reel and started the exit procedure. As we headed out, I shook my head in disbelief at what we had found.

Beyond the dry cave, the stream heads back underground into a larger underwater passageway. It continues for another 1,000 feet and opens up into a second large dry chamber. Directly above our heads as we breach is a stunningly beautiful 28-foot waterfall we named Vestal Falls. It is indeed worthy of its name. From this pool area, we had to search for the continuation of the passageway. It continues a short distance and then pinches off at a major restriction. Golf ball- to brick-sized stones choke off this restriction and will require considerable effort to clear out to make this restriction passable.

It is a genuine privilege to find the first diveable underwater cave in Utah. The 2,300 feet of easy-access passageway exceeds all of our wildest dreams. Finally, the sumps engender a true explorer attitude. I can hardly imagine what else Ricks Spring Cave holds for us as we explore the cobalt-blue water passage that continues beyond the 2,300-foot penetration point. But, everyone need only standby for a few months—that will likely be another article. ▪



White-nose Syndrome spread map current as of May 2012, courtesy USFWS

National White-Nose Syndrome Updates and BatsLIVE

Cynthia Sandeno
National Cave and Karst Coordinator
US Forest Service

The U.S. Fish and Wildlife Service, working with State and Federal agency partners, has released new National WNS Decontamination Protocols. These protocols were approved on March 15, 2012, and include the use of submersion in hot water (effective at sustained temperatures of greater than or equal to 122 degrees Fahrenheit for 20 minutes) as a disinfectant. Detailed protocols are available at http://www.fws.gov/whitenosesyndrome/. These protocols are periodically updated, so check the Web site often. The Forest Service will be issuing an addendum that will apply to decontamination for WNS on all Forest Service lands in the next few months.

Over the past few weeks there has been a lot of discussion about using these disinfectant products safely. More than anything, if you are a Forest Service employee, you need to make sure that you are familiar with the disinfectant chemicals that you are using and what the label requires (uses and disposal). The current WNS protocol establishes a preference for hot water methods of decontamination. If however, you use antimicrobial pesticides, always follow label directions for use and disposal.

By their nature, many pesticides may pose some risk to humans, animals, or the environment because they are designed to kill or otherwise adversely affect living organisms.

(WNS continued on page 10)

(WNS continued from page 9)

At the same time, pesticides are often useful because of their ability to control disease-causing organisms, insects, weeds, or other pests. The pesticide label is your guide to using pesticides safely and effectively. It contains pertinent information that you should read and understand before you use a pesticide product, including information on proper personal protective equipment. Do not use any pesticide outside of its registered label. For more information, please visit http://www.epa.gov/pesticides/label/. For proposed outdoor uses of antimicrobial pesticides, consult your local Forest Service pesticide use coordinator concerning pesticide use proposal requirements. When using quaternary ammonium or bleach products—Complete a Job Hazard Analysis that addresses the use, handling, and disposal of these products.

Read and follow label directions, wear appropriate personal protective equipment (such as goggles, face shield, protective gloves, and protective clothing), and ensure adequate ventilation. Because each State may have different regulations concerning the disposal of decontamination solutions and rinse water, always dispose of these items where they will be processed in a municipal water treatment facility. Never dispose solutions or rinse water on the ground, in groundwater, in outhouses, or down simple wastewater systems, such as at campgrounds or rural recreational vehicle dumps. We can't protect caves and bats if we don't protect ourselves.

WNS has continued to spread over the last several months and has been confirmed in several new counties in the Eastern United States. The disease has been confirmed west of the Mississippi River in Lincoln County, MO. This is one county south of the Pike County site where the Geomyces destructans fungus was detected 2 years ago.

Although we still continue to know very little about the disease, a few new studies have provided important findings. The appropriately named fungus *Geomyces destructans* has been found to be the cause of WNS in bats, according to research published in the journal *Nature.*

A study by U.S. Geological Survey (USGS) scientists and partners, conducted at the USGS National Wildlife Health Center in Madison, WI, provides the first direct evidence that the fungus *G. destructans* causes WNS.

In addition, a new study by Warnecke et al. (2012) strongly suggests that *G. destructans* was introduced from Europe. The article states that "accidental introduction of *G. destructans* from Europe is responsible for the WNS-related mass mortality of bats in North America. Our data suggest that the absence of mortality observed among European bats infected with *G. destructans* reflects different physiological and behavioral responses of European versus North American bats rather than a heightened pathogenicity of (the North American strain of) *G. destructans*. This finding also supports the hypothesis that *G. destructans* may have impacted European bat populations in the past and that bats in Europe have coevolved resistance to (e.g., via immune system responses), or tolerance of (e.g., via behavioral adaptations), infection with *G. destructans*." The full article is available at http://www.willisbatlab.org/uploads/8/0/0/6/8006753/warnecke_et_al._2012_pnas.pdf.

BatsLIVE: A Distance Learning Adventure

The Forest Service has developed a partnership of Federal and State land management agencies, educational institutions, and nongovernmental organizations to plan, implement, and evaluate a comprehensive bat outreach and education project—BatsLIVE.

(WNS Continued on page 11)

Divers surface in Rick's Spring. Image: J. Kovarik

(WNS continued from page 10)

This project will reach a diversity of key audiences–children and their educators, land management professionals, and interested general publics. BatsLIVE will emphasize the ecological significance of bats and their dependence on cave and karst ecosystems and will build awareness, understanding, and appreciation of bats and the conservation challenges they face. Outreach techniques will include both innovative distance learning methodologies and technologies (such as Web sites, Web casts and Webinars) and more traditional outreach techniques such as field trips and presentations, publications, and educational materials.

Please join us for this exciting, free education program developed for children in the 4th through 8th grades and their educators. Visit our Website at http://batslive.pwnet.org/ for more information.

Events include:

A **free live Webcast** from Bracken Bat Cave in Texas on **September 18, 2012, from 7 to 8:30 p.m. (ET)**. With more than 22 million Mexican free-tailed bats living in the cave from March through October, Bracken holds one of the largest concentrations of mammals on Earth

A **live Webinar** on **October 11, 2012, from 7 to 8:30 p.m. (ET)** entitled "Cave and Karst—The World Beneath Our Feet." Presenters include Cynthia Sandeno, National Cave and Karst Coordinator for the Forest Service; Carol Zokaites, Chief of Environmental Education for Virginia State Parks; and Dr. Rick Toomey, Director of the Mammoth Cave International Center for Science and Learning. ▪

Karst Hydrogeology of the Bear River Range in the vicinity of Logan Canyon in the Uinta-Wasatch-Cache NF, Northern Utah

Larry Spangler
U.S. Geological Survey
Salt Lake City, Utah

Introduction

Alpine karst terrains in Utah are developed primarily in high altitude areas where abundant precipitation and fractured carbonate rocks are present. A high percentage of the land area in these alpine terrains is managed by the Forest Service and includes the Bear River Range in northern Utah and extending into southeastern Idaho (fig. 1) (Wasatch-Cache National Forest), the flanks of the Uinta Mountains in northeastern Utah (Ashley and Wasatch-Cache National Forests), and localized areas within the Wasatch Range (Wasatch-Cache and Uinta National Forests). Alpine karst terrains also are present in the southwestern part of the state on the Markagunt Plateau, on lands within Dixie National Forest. In addition, karst features, particularly caves, are present in many of the mountain ranges that lie within the Basin and Range physiographic province, which includes the western one-third of the state. Most of these lands are administered by the Bureau of Land Management. This article focuses on karst development in the Bear River Range in the vicinity of the Logan River, in northern Utah.

The Bear River Range is bisected by the Logan River, which flows westward through a 20-mile long deep canyon (fig. 1). In the Logan Canyon area, altitude ranges from about 5,000 feet along the river to almost 10,000 feet on Mt. Naomi, the highest point in the range. Mean annual precipitation at Tony Grove Lake (8,000 feet) is about 50 inches, which occurs primarily in the form of snow from October to March. Karst features in this alpine region include large springs, sinking or losing streams, caves and pits, sinkholes (dolines), large closed basins, blind valleys, dolomite pavement, and karren (surficial karst landforms). Karst development likely occurred during interglacial periods during the Pleistocene age, punctuated by several periods of glaciation (Wilson, 1976). Although many karst features have probably formed or been enhanced since the last glaciation (15,000 years B.P.), fluvioglacial deposits in caves, speleothem age-dating, solution breccias, and anomalous cave entrance locations indicate that cave development was significantly more extensive in the past.

Geology

The Bear River Range consists of a thick sequence (as much as 8,000 feet) of mostly carbonate (limestone and dolostone) rocks overlying Precambrian to Cambrian-age quartzites (fig. 2) (Dover, 1987, 1995). In the Logan Canyon area, the carbonate rocks range in age from Cambrian to Mississippian and include the Blomington Formation (1,000 + feet) of Cambrian age; the Garden City Formation (1,400 to 2,000 feet) and Fish Haven Dolomite (350 feet) of Ordovician age; the Laketown Dolomite (1,500 to 2,000 feet) of Silurian age; the Water Canyon Formation (425 to 600 feet), Hyrum Dolomite (850 feet), and Beirdneau Formation (1,000 feet) of Devonian age; and the Lodgepole Limestone (750 feet) of Mississippian age (Dover, 1987). All of the formations compose the upper part of a large regional structure, termed the Logan Peak syncline (figs. 1 and 2).

(Karst continued on page 14)

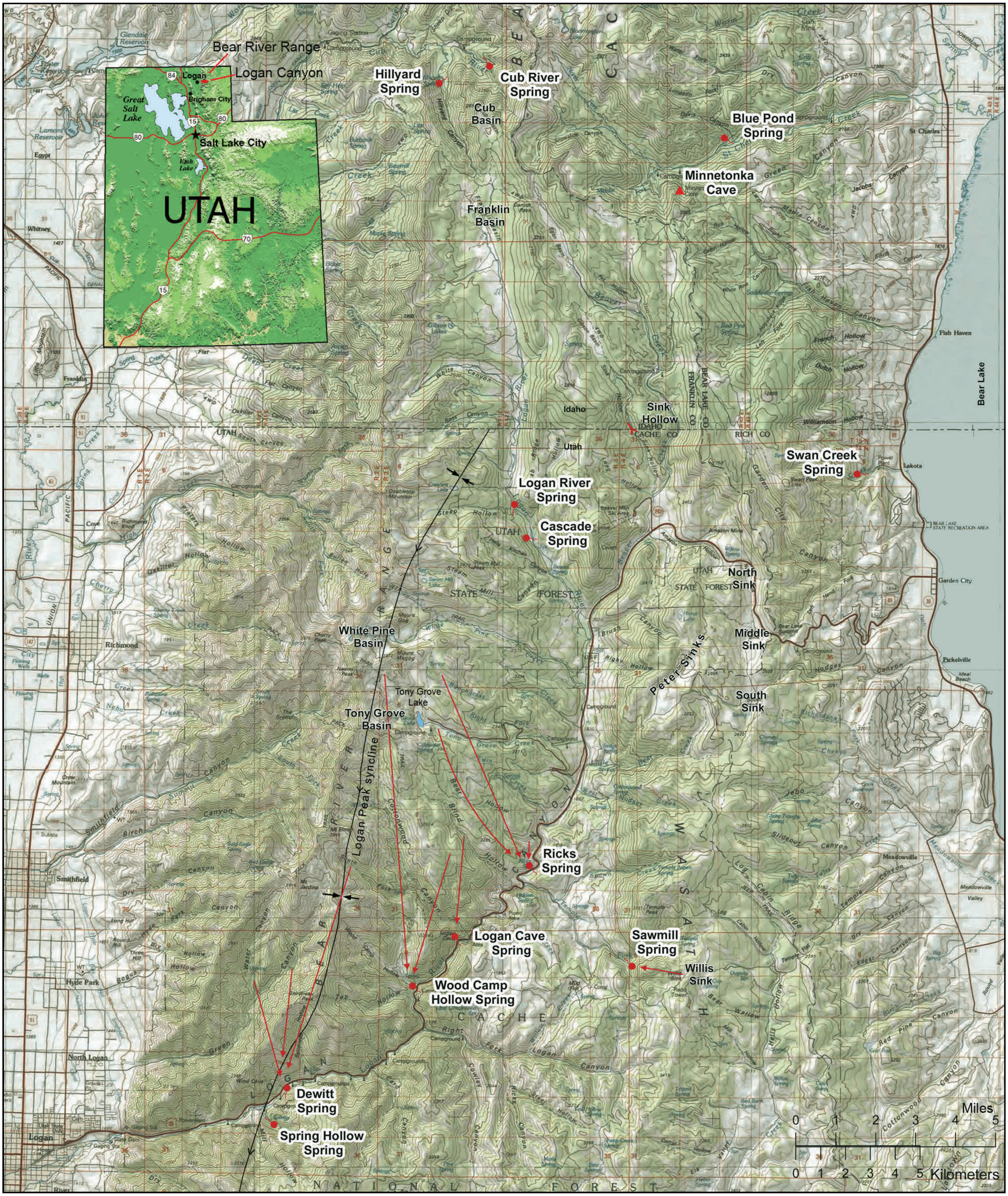


Figure 1. Location of major springs and other significant karst features in the northern part of the Bear River Range, and general direction of groundwater flow (red arrows) based on results of dye tracing. Image: L. Spangler

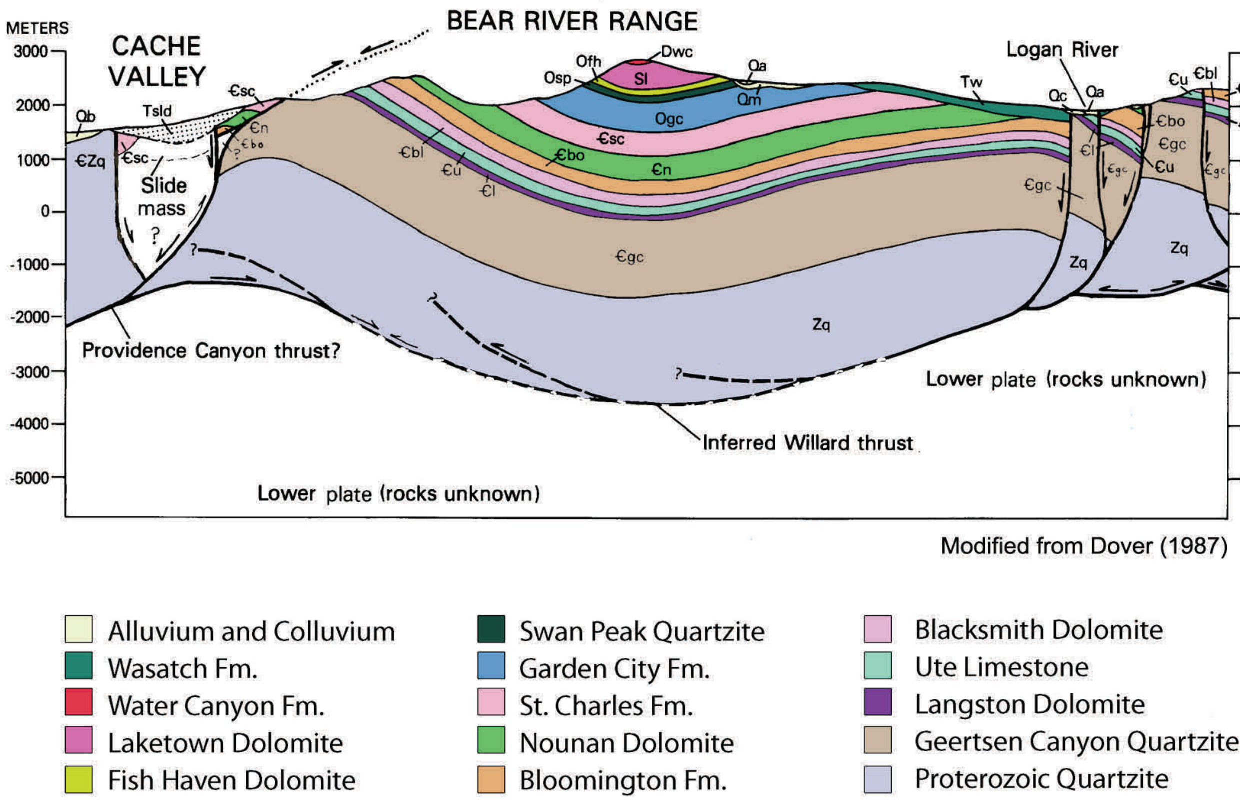


Figure 2. Cross section through the Logan Peak syncline north of the Logan River, showing principal geologic units.

(Karst continued from page 12)

The syncline plunges to the southwest at about 15 degrees with rocks on the west limb dipping at a considerably steeper angle (as much as 60 degrees) than those on the east limb. This structural feature and associated fractures influence the movement of groundwater and thus, cave development, throughout much of the region (Spangler, 2001). Southeast of the Logan River and east of the outcrop area of the Logan Peak syncline, the carbonate rocks are largely mantled by the Tertiary-age Wasatch Formation, a conglomeratic, silty, marly unit that is highly faulted and locally cavernous.

Hydrogeology

North and west of the Logan River, the principal karst groundwater flow systems (aquifers) are developed primarily within the Garden City Formation (cherty limestone), the Fish Haven and Laketown Dolomites, and the Water Canyon Formation (Dover, 1987). Although all of the carbonate units are capable of transmitting water along dissolution-enhanced fractures, faults, and bedding planes, groundwater flow systems within these units appear to be stratigraphically separated. In particular, the Swan Peak Quartzite appears to be a barrier to downward movement of water from the Fish Haven Dolomite to the Garden City Formation (fig. 2) and influences the direction of groundwater movement.

Recharge and Discharge

Recharge to the karst aquifer(s) takes place primarily by snowmelt runoff through sinkholes and pits in high-altitude glaciated basins, as infiltration to the underlying carbonate rocks through fluvioglacial deposits in stream drainages, and as diffuse infiltration along ridges and valley slopes. Water entering sinkholes and other closed basins moves vertically downward along solution-enlarged fractures to principal conduits that channel water to large springs.

(Karst continued on page 15)

(Karst continued from page 14)

Pits range in depth from less than 100 to at least 300 feet, but some of these have been occluded by fluvioglacial materials consisting primarily of quartzite boulders. Pits are particularly numerous in the Tony Grove and White Pine Basins (fig. 1). Fluvioglacial deposits also form a veneer over the carbonate bedrock in stream drainages. These deposits are very permeable however, and streams typically lose all flow over short distances. Because most streams in these alpine drainages are fed by snowmelt runoff, they tend to be seasonal. Diffuse infiltration from snowmelt along ridges and valley slopes provides an additional component of recharge to the aquifer(s). Although concentrated recharge through sinkholes is significant, diffuse infiltration probably is a more substantial component of recharge, contributing to long-term storage in the aquifer(s) and maintaining base flow of the springs.

Discharge from the karst aquifer(s) is primarily from second and third magnitude (Meinzer, 1927) springs along the Logan River, which is the principal base level stream for groundwater discharge in this part of the Bear River Range. Three second magnitude (average discharge between 10 and 100 cubic feet per second (cfs)) and three third magnitude (average discharge between 1 and 10 cfs) springs along with several smaller springs, discharge along the north and west sides of the river and include, from downstream to upstream, Dewitt, Wood Camp Hollow, Logan Cave, Ricks, Cascade, and Logan River Springs (fig. 1). Two large springs (Spring Hollow and Sawmill) also discharge along the south side of the river. Discharge of the larger springs is highly variable and can range from less than 1 cfs (449 gallons/minute) during base (low) flow to more than 50 cfs during peak flow (Mundorff, 1971). Springs respond primarily to snowmelt runoff, resulting in peak discharge from late spring to early summer and base flow during the winter months(fig. 3).

Groundwater Basins

Dewitt Spring discharges from the Water Canyon Formation along the floodplain of the Logan River and serves as a public supply for the city of Logan, about 7 miles to the west. Discharge of the spring generally ranges from about 10 to 35 cfs (fig. 3). Results of dye tracing to Dewitt Spring from as far as 7 miles and 2,900 feet higher than the spring, indicate a groundwater basin generally fanning out from northwest to northeast of the spring that largely coincides with the areal extent (outcrop area) of the Logan Peak syncline. Groundwater movement is probably down dip along the west and east limbs of the syncline toward the axis and subsequently southwest to the spring, which is located along the axis of the syncline where the Logan River breaches the structure (fig. 1).

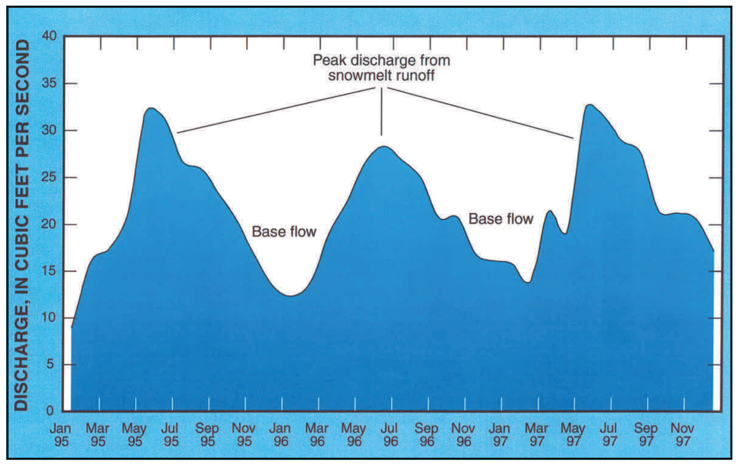


Figure 3. Hydrograph of Dewitt Spring and typical seasonal response of an alpine karst spring to snowmelt runoff.

Wood Camp Hollow Spring discharges from two adjacent outlets in the Laketown Dolomite. Discharge of the spring ranges from about 5 to at least 50 cfs, but is difficult to measure at peak flow because the Logan River partially impounds free flow from the spring.

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Wood Camp Hollow Spring at peak flow. I: L. Spangler

Wood Camp Hollow Spring near base (low) flow. I: L. Spangler

Results of dye tracing to Wood Camp Hollow Spring indicate a groundwater basin generally north of the spring with recharge originating from as much as 3,800 feet higher than the spring. Discharge from the spring largely originates from the Tony Grove and White Pine Basins, about 7 to 8 miles to the north (fig. 1), and which contain some of the deepest caves in the state, including Main Drain, the deepest in Utah. The stream in Nielsons Cave, second deepest cave in the Bear River Range at 880 feet, also has been dye traced to the spring.

The Tony Grove and White Pine Basins, glacial cirques that have been solutionally modified and deepened, are situated along the axis of the Logan Peak syncline at an altitude of about 9,000 feet (fig. 1). The basins are floored by the Laketown Dolomite, a highly karstic unit that hosts dozens of pits and sinks. Dye tracing in these basins has shown that precipitation moves vertically downward through the dolomite and along the east limb of the Logan Peak syncline to discharge at Wood Camp Hollow Spring, more than 3,000 feet lower. At least part of this water courses through Main Drain Cave, located in the southern part of the Tony Grove Basin, on its way to the spring.

Initially discovered in 2000 and named Deception Pit, a high-level lead discovered in 2004 led the way on to the rest of the cave, which was eventually bottomed at 1,227 feet, making it one of the deepest caves in the country. Continued exploration in the lower levels of the cave over the last several years has brought the total survey to about 2 miles. Since 2003, the Tony Grove Cave Survey project has inventoried more than 100 significant karst features (caves, pits, sinks) in the Tony Grove and White Pine Basins.

Logan Cave Spring discharges from the upper part of the Garden City Formation. Water from the spring normally discharges from talus below the entrance to the cave, but during spring runoff, also discharges directly from the cave, which serves as an overflow route. Discharge of the spring normally ranges from less than 1 to about 10 cfs. Results of dye tracing to Logan Cave Spring indicate a recharge area generally north-northeast of the spring and at a lower altitude than the recharge areas for the other springs (fig. 1). As a result, peak flow of Logan Cave Spring generally occurs earlier than that of the other springs. Logan Cave is one of only a few horizontal stream caves in the Bear River Range.

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White Pine Basin is developed in the Laketown Dolomite, which hosts numerous pits and sinks. I: L. Spangler

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The cave can be traversed for almost 4,300 feet on three levels. Much of the cave is developed along northeast-trending joint(s), particularly the upper levels, with secondary development along northwest-trending joint(s). Most of the cave consists of a high narrow canyon with no tributary passages. At low flow, the main passage in the cave is dry and can be followed for approximately 500 feet before the stream is encountered. This stream passage can then be followed for an additional 1,500 feet before ending in a sump. Two dry upper levels also can be accessed near the end of the main level. Logan Cave was gated in the 1990s in response to protection and restoration of the endangered Townsend's Big-eared bat.

Ricks Spring discharges from four outlets in the Garden City Formation along a normal fault, which is dramatically exposed in the main alcove. Discharge of the spring ranges from less than 1 to a reported 75 cfs (Mundorff, 1971). During spring snowmelt, most water discharges from the alcove; during winter base flow, no flow occurs from the alcove and only a standing pool is left behind. Results of dye tracing to Ricks Spring indicate a groundwater basin that extends more than 5 miles to the northwest in the Tony Grove Lake area, and 2,600 feet higher than the spring (fig. 1). In addition, investigations by the U.S. Forest Service during the 1970s indicate that part of the flow to Ricks Spring originates directly from the Logan River upstream of the spring. Groundwater movement in the Ricks Spring basin appears to be confined within the Garden City Formation, possibly along northwest-trending joints.

The submerged conduit into Ricks Spring was first accessed by a team of Utah cave divers in 2007.

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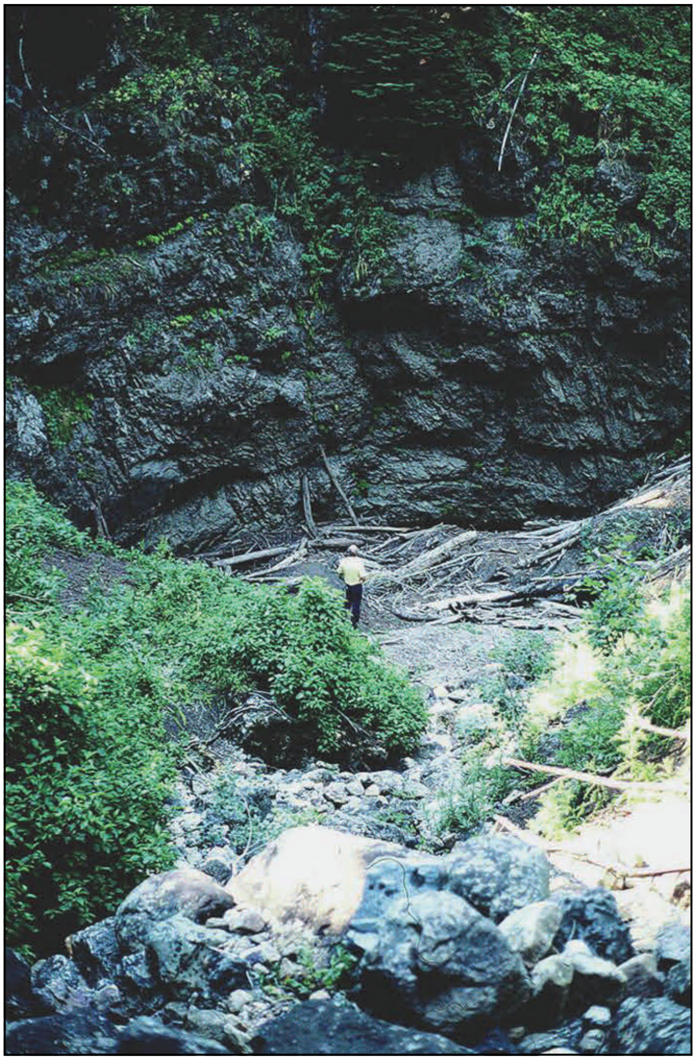

Sink hollow valley is a deep blind valley located on the Utah-Idaho state line. I: L. Spangler

Logan Cave Spring discharges from the entrance during snowmelt runoff. I: L. Spangler

(Karst continued from page 17)

Since that time, a number of dives have pushed the known length of the underwater cave to about 2,300 feet. Along the way, several air-filled rooms were encountered, one of which contains a spectacular waterfall. Exploration of this cave has shown that groundwater descends to a depth of 70 feet below the spring outlet, and thus, below the level of the adjacent Logan River, before rising from the alcove. In addition, a passage was located that possibly represents input from the Logan River.

On the basis of dye-tracer studies conducted since 1990 (Spangler, 2001), recharge areas for Dewitt, Wood Camp Hollow, and Ricks Springs are estimated to be between 7 and 20 square miles. Results of these dye tests indicate that groundwater basins for these springs appear to be areally and stratigraphically separated, and surface-water drainage basins do not coincide with the groundwater basins. Water from losing streams typically moves beneath ridges from one surface-water basin or watershed to discharge areas in adjacent surface-water basins.

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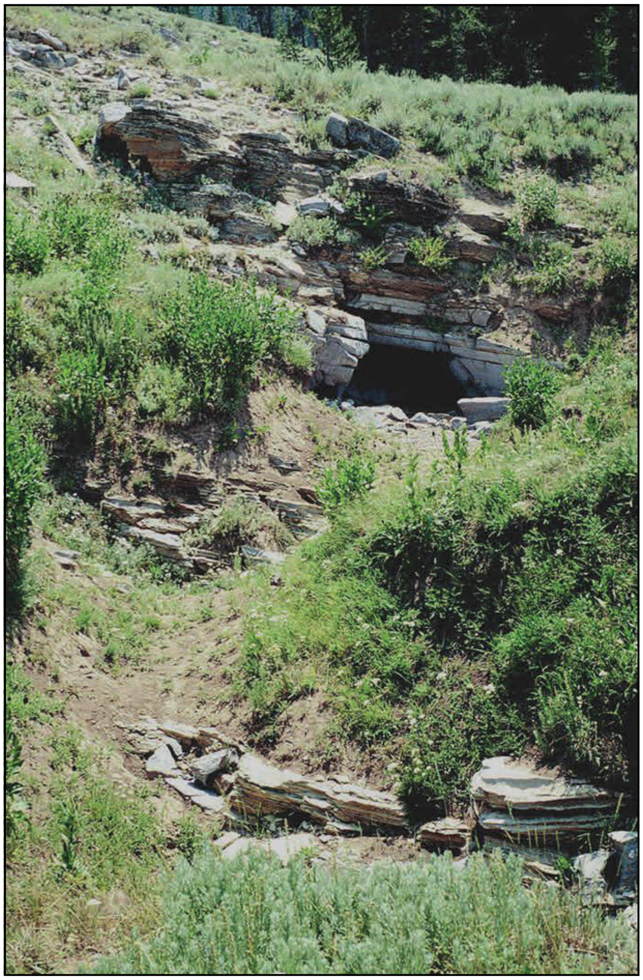

Ephemeral stream drainage terminates in cave in Franklin Basin. I: L. Spangler

Furthermore, losing streams in the upstream and downstream parts of the same surface drainage can be diverted to springs in different groundwater basins. Results of dye tracing from these losing streams also indicate groundwater travel times of 1 to 4 weeks, from distances as far as 8 miles. However, because the method used for dye recovery employs passive (cumulative) techniques, groundwater travel times are considered maximum and in most cases, are probably substantially less.

Other Areas

Karst flow systems and their associated landforms also are present in many other areas of the Bear River Range, particularly that part of the range which extends north into southeastern Idaho (fig. 1), as indicated by large springs, sinkhole basins characterized by internal drainage, blind valleys, as well as caves and losing streams. Minnetonka Cave, situated in the eastern part of the range, is one of only a few commercial tour caves in the United States that is operated by the U.S. Forest Service and is one of the longer horizontal caves in the Bear River Range, with more than a mile of large, dry passage. In the Cub Basin and Franklin Basin areas, groundwater probably moves north to Cub River and (or) Hillyard Springs (fig. 1), which form the headwaters of the Cub River, rather than south toward the Logan River. Swan Creek Spring, one of the two largest karst springs in Utah with a measured peak flow exceeding 300 cfs, discharges from the eastern flank of the range into Bear Lake. The recharge area for this spring is not well known but likely incorporates areas of sinkhole development west and southwest of the spring, including North, Middle, and South Sinks, and possibly Peter Sinks (fig. 1). These sinks represent solution basins that have formed along faults (grabens), the largest of which is more than a mile across. Middle Sink has the dubious distinction of having some of the coldest temperatures ever recorded in Utah. Because of the high altitude and closed basin that acts as a cold air trap, temperatures as low as -54^{0}F have been recorded. In summary, some of the best developed alpine karst in the western United States occurs in the Bear River Range of northern Utah and southeastern Idaho, and the potential for deep cave systems remains high. ▪

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(Karst Continued on page 20)

News from another Forest: Upper Bastian Spring , Schell Creek Range, Humboldt-Toiyabe National Forest. At high flow in 2011, this spring and Lower Bastian Spring together flowed at 25 cubic feet per second. I: J. Gurrieri

(Karst Continued from page 19)

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