

Library

Fire Impact Study
El Malpais National Monument
New Mexico

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1 Introduction

1.1 Products and Effects of Fire

Fire plays important roles in ecosystems and can be a force in releasing nutrients that are tied up in plants and litter. Many studies have examined the impact of fire on above ground flora and fauna, but a search of the BIOSIS database back to 1969 revealed no studies that examined the effects of fire on caves or lava tubes. Only one study of fire in volcanic areas (other than the fire during volcanic eruptions) was found (Johnson and Smathers[7]). The effects of fire on vegetation, mammals, and birds are reviewed by Wright and Bailey[14]. The effects of prescribed burns and wildfires on invertebrates are discussed by Bellido[2]; Force[4]; Hansen[5]; Majer[9]; and Sgardelis and Margaris[11].

To study the effects of fire on lava tubes we start with an understanding of the products of fire and the known effects on surface biota, in particular the invertebrates present in soil and litter. The major products of fire are airborne particulates, carbon monoxide, hydrocarbons, (Wright and Bailey[14]) and water, carbon dioxide, and heat. Fire produces an increase in air and soil temperature, lowers the relative humidity over time close to the ground due to loss of insulating vegetation and litter, blackens the ground which produces increased solar absorbances, and kills some invertebrates outright (Majer[9]).

The degree of the increase in temperature, the length of time the increase is in effect, and the depth to which the temperature increase penetrates the soil are key factors in assessing the impact of fire on invertebrates. The elevated temperature is not long lasting as illustrated in Figure 1.1; the temperature falls off sharply over time. This temperature curve also applies to below soil temperatures, which Wright and Bailey[14] review. Majer[9] notes that a prescribed burn in a jarrah (eucalyptus) forest in Western Australia resulted in a temperature of 38° C down to 22-75mm, 45° C down to 10-57mm and 66° C down to 5-12mm. These temperatures resulted in a partial ashing of the litter.

The degree to which invertebrates are affected by fire is influenced by the degree to which resources on which they feed (plants, litter, etc.) are destroyed. Other factors which influence the impact on invertebrates include the destruction of structural diversity of their environment, which leads to a

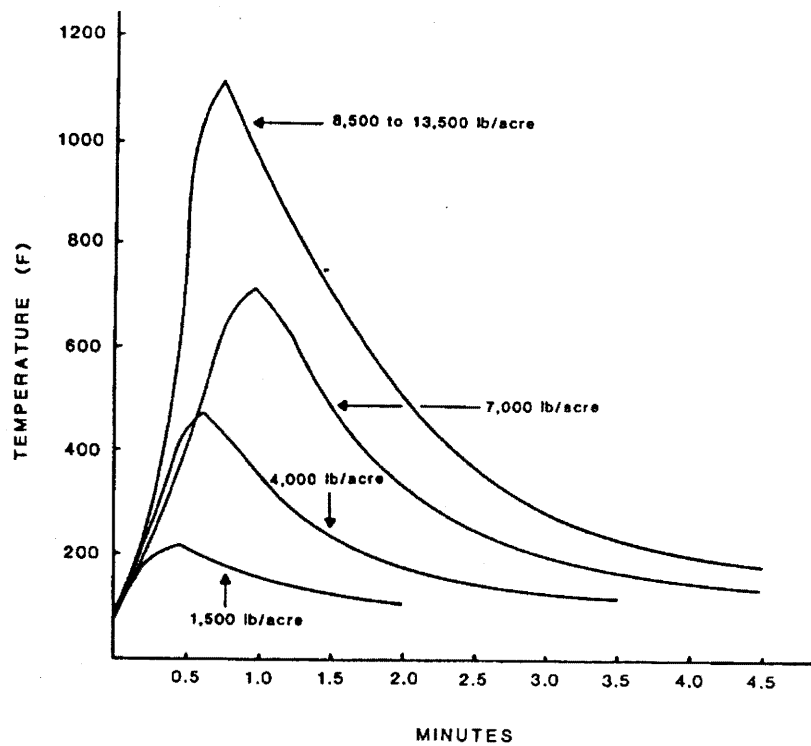


Figure 1.1: Time-temperature curves at the soil surface during prescribed grass fires for four amounts of fine fuel. At the time of burning, air temperature, relative humidity, and wind were 21°C to 27°C, 20 to 40 percent, and 13-24 km/h. (from [14])

a decline in invertebrate abundance, diversity, and densities (Sgardelis and Margaritis[11]. Differences in mortality of soil and litter fauna are influenced by the intensity of the fire (Bellido[2]) and the season in which the burn occurs. During the rainy season there are more arthropods active on the surface to be killed than during dry or cold times when arthropods are further down in the soil (Sgardelis and Margaritis[11]).

Fire has immediate effects (mortality and survivorship) on invertebrates and long terms effects (recolonization from taxa that survive the fire and the immigration of fauna from surrounding areas). The immediate effect of fire may be an increase in diversity and richness followed by a decline of species richness, diversity, and abundance (Force[4]). Overall, some studies show no differences between burned and unburned plots (e.g. Abbott[1]), while other studies say that the arthropod fauna was destroyed (Touyama, Nakagoshi, and Takahashi[12]). Looking at which particular taxa survive fires begins to reveal differences among different studies and habitats.

Studies vary in their determination of which taxa survive the best, but Buck[3], Force[4], Hansen[5], and Sgardelis and Margaritis[11] are in general agreement that ants (Formicidae), Collembola, and various ground beetles (Staphylinidae and carabidae) survive well.

Some fauna may escape the fire by being under rocks on the ground surface. Litter survives with them in this refugia and enhances their continued survival until other litter is generated (Sgardelis and Margaritis[11]). Over time, recovery of invertebrate fauna is tied to the recovery of the plants and hence the litter in which many invertebrates live and on which they may feed. Recolonization occurs from surrounding areas (Sgardelis and Margaritis[11] and Touyama, Nakagoshi, and Takahashi[12]). Sgardelis and Margaritis[11] and Abbott[1] show three to four years are necessary for recovery of invertebrate fauna.

The knowledge gleaned from these studies provides us with guidelines for the parameters to be studied during and immediately following the fire, and allows us to predict which groups in which we expect to see survivorship. We will also set lines of pitfall traps in the entrances of the lava tubes during the fire to see if the tubes are used as refugia from the fire.

1.2 Description of Lava Tubes

The experimental lava tube, Lava Wall (also known as Peel Bark), and the control lava tube, Frozen Mat, are located about 34°57'15"N and 108°06'30"W. Bob and Debbie Buecher mapped these lava tubes on 25-26 September 1993 and the maps will be available for the final report.

Lava Wall is the smaller of the two lava tubes. It has a large wide entrance about 4.5-6m wide, and gets narrower and lower as you go into the cave. The cave turns into a low muddy crawl just past the hygrothermograph, continuing for more than 15m. The crawl shows evidence of repeated flooding and organic input, and a slight breeze is detectable, implying a second entrance. Unfortunately, the cave got too low to continue to the other entrance. Checking the surface, it is likely that the second entrance is in breakdown in a low sink about 30m west of the cave. Unlike Frozen Mat, this cave is relatively level once you are inside the entrance. Lava Wall gets much more light in the entrance making the entrance community very important.

Frozen Mat is the larger cave and consists of two rooms and a passage. The small (less than 1 meter square) entrance leads into a breakdown room. This entrance room is about 7m by 9m. Over a large breakdown pile, approximately to the east, is the room, 6-7.5m wide and at least 18m long containing an ice sheet about 6m wide by 4.5-6m long covered with up to 2.5cm of water. The ice is about 3m-4.5m below the entrance and about 10.5-12m from the entrance. The room extends no more than about 3m beyond the ice.

On the left side of the entrance room in Frozen Mat is a low passage going to the left for at least 9m. We detected no airflow through this passage and it appeared to pinch out. This passage contains numerous bat bones.

2 Goals and Objectives

To study the impact of a prescribed burn on a lava tube, we have the following objectives to be conducted pre- and post-burn, in the treatment lava tube (Lava Wall) and the control lava tube (Frozen Mat):

- Monitor temperature continuously at appropriate sites in the sink, ceiling, and floor areas of the tubes.
- Monitor humidity continuously at one site in each lava tube.

- Measure carbon monoxide and carbon dioxide levels in the air in the lava tubes.
- Measure the dissolved solids, conductivity, and pH of standing water (in Lava Wall Cave only drips have been available).
- Measure particulate levels.
- Determine the species composition, diversity, and richness of the arthropod fauna in the lava tubes, sink, and immediate area surrounding the sink.

3 Temperature and Humidity

One of the major components of fire is temperature. To see if the temperature of the fire affects the cave, we need to know and to be able to predict what is normal for the cave and hence identify any abnormal temperatures during the burn.

3.1 Materials and Methods

Onset Computer HoboTM dataloggers recorded temperatures and relative humidity in the two caves. These dataloggers were chosen for their low-cost, small size (1.5cm x 3.3cm x 4.3cm), and flexibility. Table 3.1 details their specifications. The temperature dataloggers have a 1.8m cable between the datalogger and the temperature probe allowing the datalogger to be placed nearby in a safe, convenient location. For the Lava Wall sink, this distance is extended by a cable 3m longer.

Datalogger	Range	Best Resolution
Sink temperature	-37° C to +46° C	0.26° C
Cave temperature	-5° C to +37° C	0.16° C
Relative humidity	0 to 100%	0.5%

Table 3.1: Specifications for Onset Hobo dataloggers used.

Figures 3.2 shows the approximate locations of the dataloggers in Lava Wall. The sink temperatures are recorded to provide a base from which to

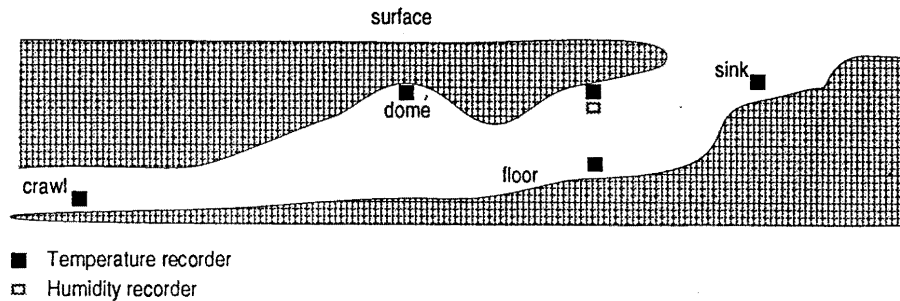


Figure 3.2: Approximate locations of dataloggers shown in a cross-section of Lava Wall Cave.

try to predict the internal temperatures. The reasons for choosing the other locations are as follows:

- Floor and ceiling temperature measurements in the twilight zone record any breathing in and out the entrance.
- The dome is a location where the distance to the surface is minimized, and hence may be more likely to feel the effects of the fire.
- The crawl is a low area where the temperature should remain stable. If hot air from the fire blows through the cave, this datalogger will record it.

Frozen Mat Cave has dataloggers located in areas detailed by Figure 3.3. It does not have any additional openings, so the floor and ceiling temperature measurements in the twilight zone record the cave breathing in and out the entrance. The ice sheet in the back will keep the temperature nearly constant as long as it remains a major portion of the floor in the back of the cave.

A cave breathing in will send warm air along the ceiling (when the outside temperature is higher than the cave temperature), and cooler air along the floor of the cave (when the outside temperature is cooler than the cave temperature). Breathing out will appear in the temperature log as air the temperature of the deeper cave appearing at the entrance.

The dataloggers are capable of storing 1800 observations before the data needs to be downloaded. The interval between samples was chosen to maximize the observations recorded between the trips when the data could be

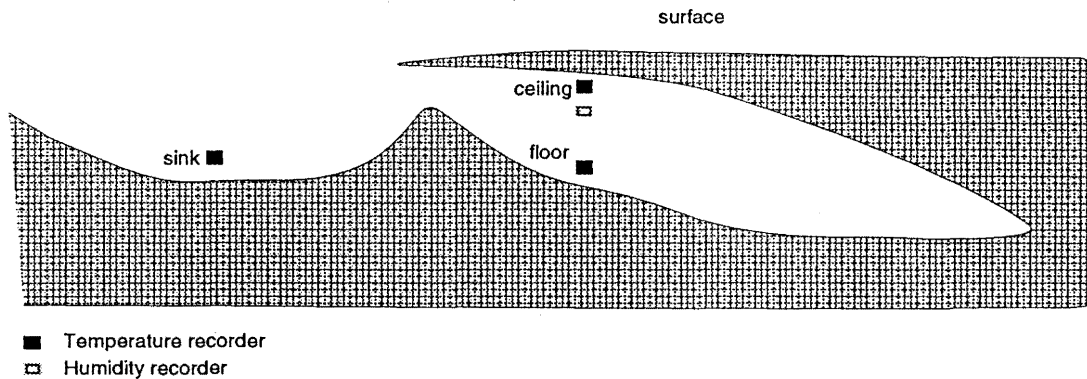


Figure 3.3: Approximate locations of dataloggers shown in a cross-section of Frozen Mat Cave.

downloaded. Therefore, the time interval between downloadings ranged from one week when we were visiting the site often, to three months in the winter (normal weather patterns prevent access to the caves during winter).

3.2 Results

Starting outside, the temperatures in the sinks for both tubes are presented in Figure 3.4; the daily variations in temperature are evident. Frozen Mat shows a wider variation in temperature than Lava Wall, probably due to two differences:

- Lava Wall has more and thicker vegetation in the sink than Frozen Mat.
- The sinks have different geometries; Lava Wall has a steeper-walled smaller sink than Frozen Mat.

Besides the diurnal variations, the graph also shows the effect of cloudy days. A front moved through and the skies were overcast or mostly cloudy on day 311.

3.2.1 Lava Wall

By definition, direct solar radiation, a major force in the temperature swings between day and night, does not reach into the twilight zone. The graph in

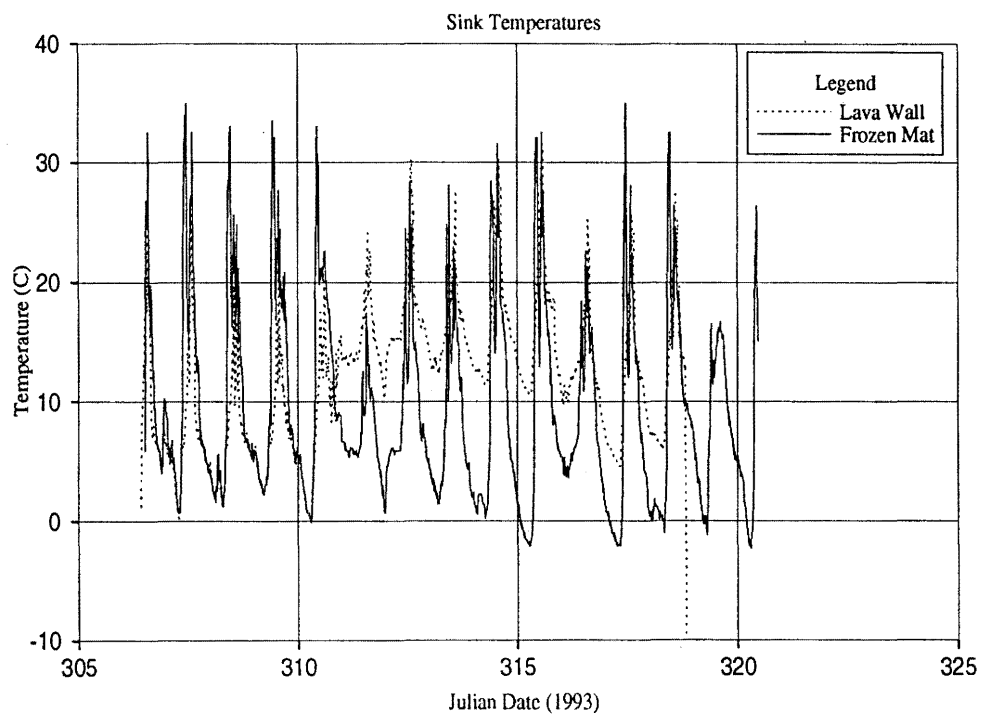


Figure 3.4: Temperatures recorded in the sinks.

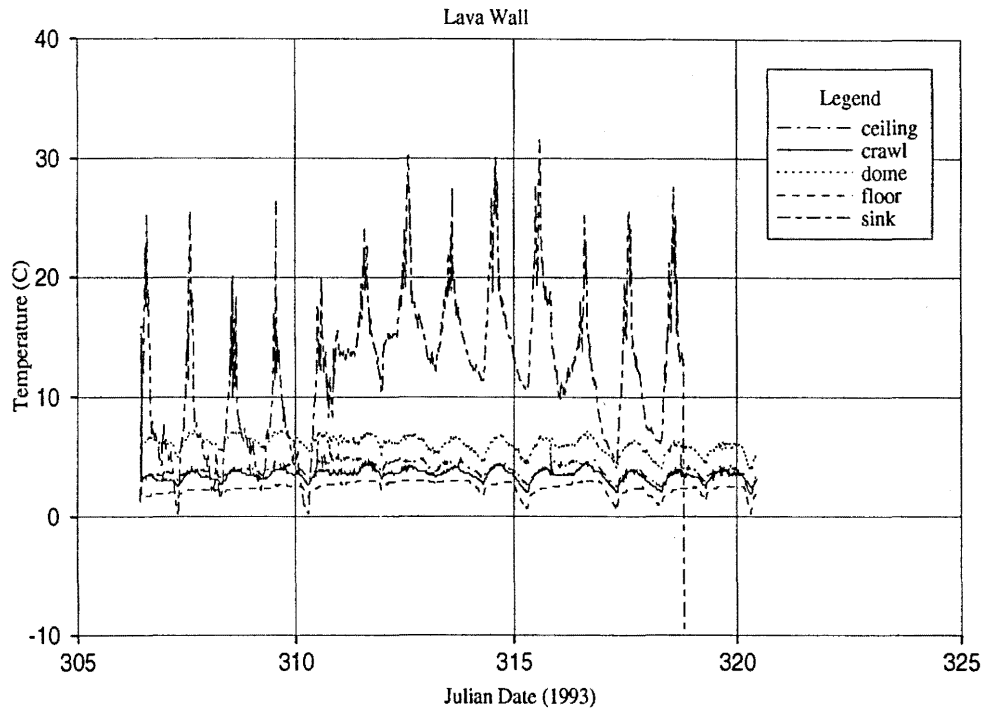


Figure 3.5: Temperatures recorded in Lava Wall.

Figure 3.5 shows that the temperature swings between day and night are less the deeper into the cave the measurement was taken.

The temperature at the ceiling is higher than the temperature on the floor, an expected difference, showing the air is thermally stratified in the twilight zone of the cave.

Figure 3.6 shows the relative humidity in the twilight zone compared with the temperature out in the sink. The expected relationship between temperature and humidity is that as the temperature goes up during the day, the relative humidity should go down, rising again after dark. This pattern is not what the datalogger recorded, indicating either a problem with the datalogger or an unusual process taking place.

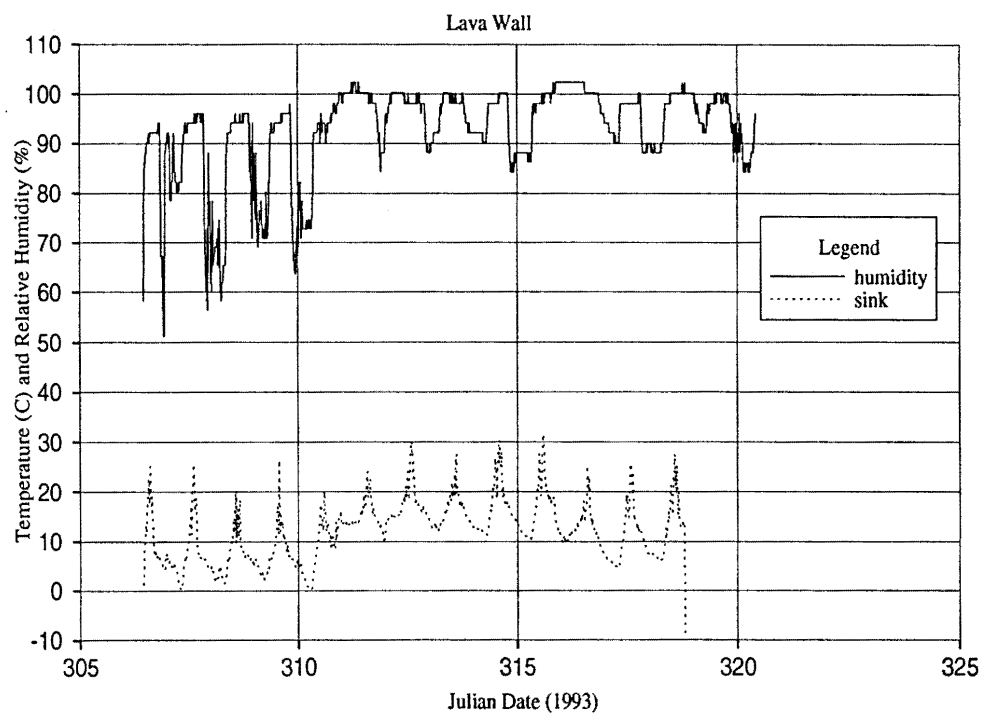


Figure 3.6: Relative Humidity (%) and sink temperature at Lava Wall.

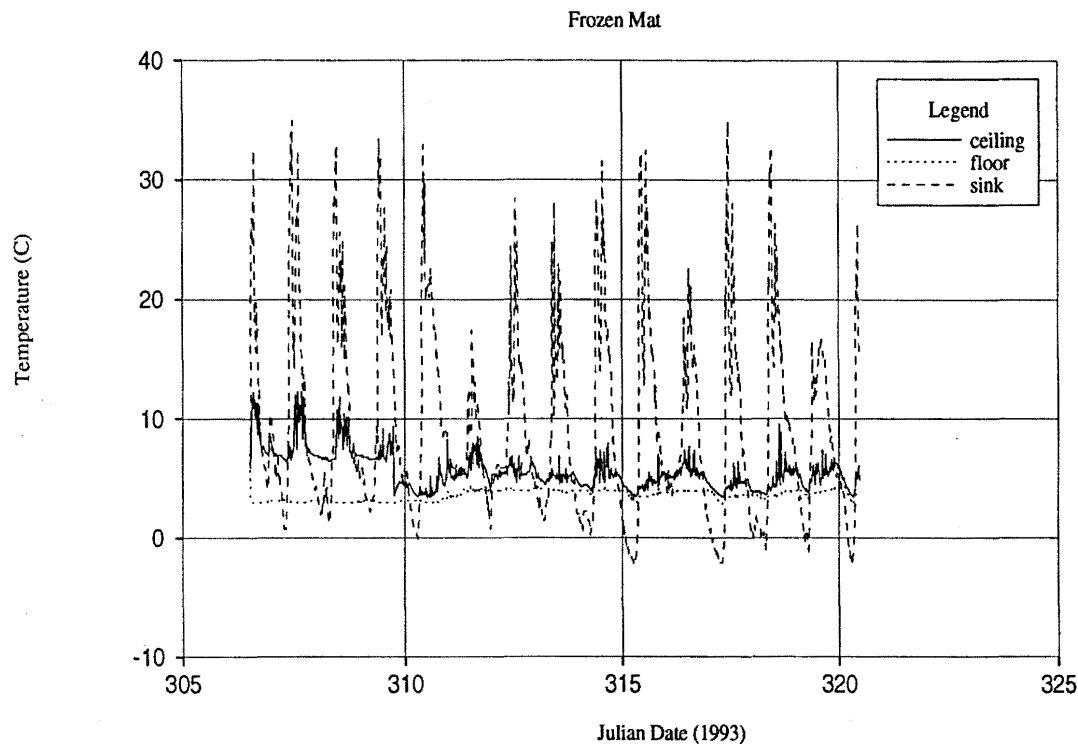


Figure 3.7: Temperatures measured in Frozen Mat.

3.2.2 Frozen Mat

The graph in Figure 3.7 shows the temperatures recorded in Frozen Mat. Because it does not have a second entrance, we did not place probes further back in the cave; the only airflow would be the cave breathing in and out as pressure changes outside, and the ice sheet in the back will keep temperatures near it constant as long as it remains mostly frozen.

Figure 3.7 also shows the difference that about 0.75m makes in the temperature of the air. Between days 309 and 310, the probe fell from the ceiling and hung in the air about 0.75m below the ceiling. The temperature was about 2° C cooler in this lower position.

Frozen Mat breathes during the day, as evidenced by the sharp temperature swings of about 2°C. This variation is due to the warmer outside air entering and exiting the cave as the wind blowing across the entrance changes

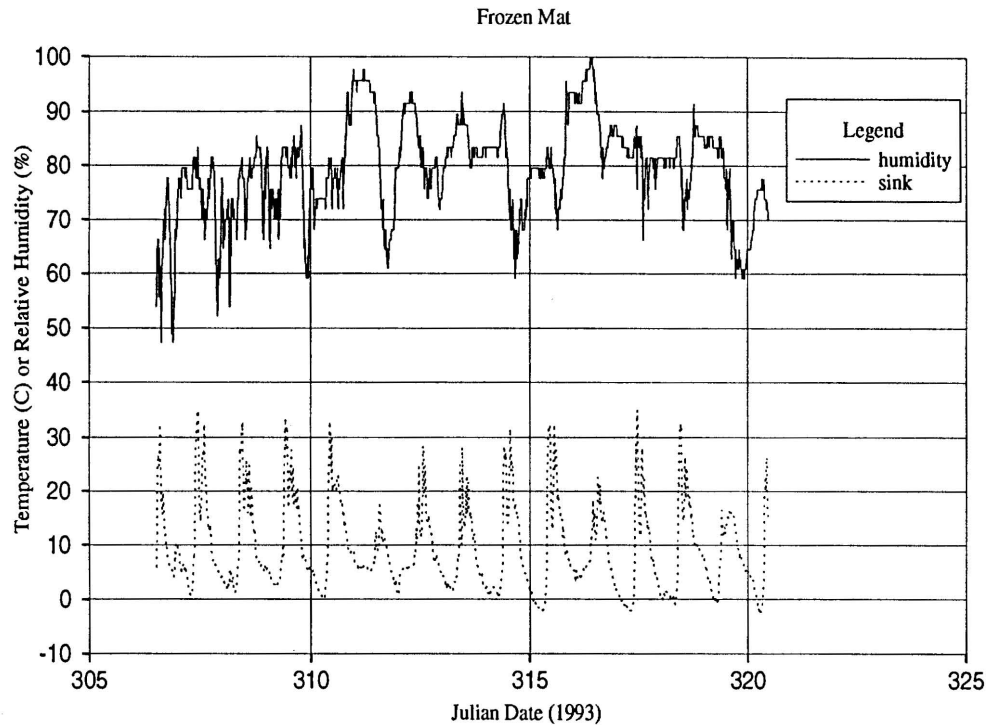


Figure 3.8: Frozen Mat relative humidity and sink temperature.

the pressure in the cave (wind blowing across an opening will lower the pressure in the cavity). The air moving in and out during the breathing is warm air since the floor temperature stays nearly constant. During the winter, we would expect to see cooler entering along the floor.

The graph in Figure 3.8 shows the relative humidity measured at the twilight zone and the sink temperature. The relative humidity follows the expected diurnal variations.

3.3 Discussion

3.3.1 Problems

Recording temperatures was not without incident. At Lava Wall Cave, a rodent of some sort chewed on several cables. We noticed the first one when

graphing the temperature in the sink; the removal of the temperature probe by the critter caused the temperature reading to drop to temperatures inconsistent with the Frozen Mat Cave sink. When we investigated the erroneous readings, we discovered the missing cable. On the next trip, we discovered the rodent had severed two other cables. As a result of these problems, the sink probe was encased in PVC pipe, the floor probes were withdrawn into the plastic containers protecting the dataloggers, and the ceiling and dome dataloggers were moved to the ceilings rather than being on the floor as before. As a result of these changes, the reaction time of many of the thermistors will be slower than before.

Another matter still needing investigation is the relative humidity in Lava Wall. If the problem is not the datalogger, then we need to investigate to see what is causing the different behavior of the humidity.

3.3.2 A Comparison of the Two Caves

Initially, Frozen Mat was to be a control cave for Lava Wall. While these two caves are similar, Lava Wall has two entrances and Frozen Mat only has one. This difference means that the airflow is dissimilar, evident in the graphs in Figures 3.5 and 3.7; Frozen Mat breathes a great deal while Lava Wall is more stable. An additional factor in the breathing difference is due to the different sizes of openings; Frozen Mat's entrance is about 1 m² while Lava Wall's is many times larger.

Because of the difference in how the caves react to their environment, it is good that the burn was postponed. We have the necessary time to gather the data to use Lava Wall as its own control.

3.3.3 Future Plans

As heat diffuses into an object, it follows the equation of heat diffusion found in textbooks on partial differential equations:

$$DT_{xx} = T_t,$$

where x is the distance from the entrance or surface and t is time since the heat was applied to the outside of the cave, and D is a constant relating to how fast heat diffuses into lava. Initially, we will assume that the forcing function (the sun heating the surface) for this equation is a sine function,

not completely correct, but sufficient for a first order approximation. Doing the math, we end up with a model for the temperature in the cave of:

$$T(x, t) = Ae^{-x\sqrt{\frac{\omega}{2D}}} \cos[x\sqrt{\frac{\omega}{2D}} - \omega t],$$

where D , x , and t are as before, ω is the period of the forcing function (24 hours), and A is the amplitude of the forcing function (the difference between the maximum and minimum daily temperatures).

We will take this model, which is based on the physics of heat transfer, and compare it to the data to see how well it fits. If the data fits the model reasonably well, the next step is to more accurately model the daily temperature swing, and use it as the forcing function for the first equation.

Once we have six months of data, we will look at the average daily temperature and see if a seasonal variation is evident.

When the burn actually occurs, the soil should have “Tempil cards” placed at regular depths from the surface down to the lava. These cards contain pellets that melt at a specific temperature, allowing the determination of the maximum temperature reached at that depth in the soil. If these cards are placed above the dome and crawl in Lava Wall, we can see how deep the effects of the fire are, and whether or not we would expect to see any change in the cave below.

4 CO₂ and CO

4.1 Materials and Methods

Dräger tubes are sealed glass tubes containing a substance which absorbs CO₂ and changes color. These tubes are calibrated for a specific volume of air to pass through the tube, supplied by a hand-operated pump. The percentage of CO₂ in the air is read by the distance the color exists in the tube after the air has passed through the tube. In theory it all works well. However, the color does not have a sharp line, but gradually fades out, making determination of the exact depth of the color difficult.

No CO measurements have been taken yet.

Location	% CO ₂
Outside Lava Wall	0.014
Lava Wall twilight zone	0.012
Lava Wall near hygromograph	0.014
Frozen Mat northeast corner of entrance room	0.01
Frozen Mat near large ice sheet	0.01

Table 4.2: CO₂ percentages of air at various locations in Lava Wall and Frozen Mat.

4.2 Results

Table 4.2 lists the CO₂ percentages recorded.

4.3 Discussion

Due to the difficulty reading the Dräger tubes, the error is probably as big as the differences noted, since the light available affects the ability to read the tube. Literature searches have indicated that CO is a more notable byproduct of fire due to its toxicity, so in the future we will investigate CO.

5 Water Chemistry

5.1 Materials and Methods

25ml of water was collected from each cave. Since Lava Wall had no standing water, this water came from drips in the dome, collected by holding a sterile vial next to them. In Frozen Mat, the water was taken into a sterile syringe from beside the ice sheet in the back room of the cave. The caves were sampled 9/25/93 and 10/2/93, and Simon Santillanes at the City of Albuquerque analyzed the samples.

5.2 Results

The results of Santillanes' analysis are presented in Tables 5.3 and 5.4.

Sample location	pH	Temperature °C	Conductivity uS/cm	Total Solids dg/L
Lava Wall	5.4	24	19.82	< 1
Frozen Mat	6.0	24	111.00	1

Table 5.3: Water quality results for sample collected on 9/25/93.

Sample location	pH	Temperature °C	Conductivity uS/cm	Total Solids dg/L
Lava Wall	5.4	24.16	16.00	1
Frozen Mat	5.8	23.60	109.30	1

Table 5.4: Water quality results for sample collected on 10/2/93.

5.3 Discussion

The pH of the water is somewhat acidic probably due to the pine needles in the soil above the cave.

Santillanes provided the following notes about the first sample:

Total solids, for this type of sample, is usually measured in mg/L instead of dg/L. However, with the limited amount of sample, the detection limit had to be raised.

The Frozen Mat sample had a small colloid of dirt that burst upon releasing the sample from the syringe. This may be the reason for the marked differences in total solids and conductivity between the two samples. Another possible reason for the difference in conductivity may be the high surface tension noticed in this sample. There was not enough sample to perform a duplicate test with. Another sample could be recollected for comparison purposes in order to confirm or refute this data so that a true baseline might be achieved.

Santillanes provided the following notes about the second sample:

Total solids, for this type of sample, is usually measured in mg/L instead of dg/L. However, with the limited amount of sample, the detection limit had to be raised.

We will continue to collect water and send it out for analysis and continue after the burn as well to see if any changes occur.

6 Particulates

6.1 Materials and Methods

Particulate traps, consisting of white sticky shelf paper approximately 0.09m^2 were placed in each of the caves, at the back of the twilight zone on 10/2/93. 24 hours and 2 weeks later, the traps were collected and covered with clear plastic wrap.

6.2 Results

The particles counted on the two-week samples were: The two week particulate counts are:

Lava Wall	331
Frozen Mat	1584

6.3 Discussion

This method of particulate investigation is time-consuming and error-prone. We are investigating a replacement particulate study.

7 Invertebrates

7.1 Materials and Methods

To inventory the terrestrial invertebrates present in the lava tubes and in the immediate vicinity of the two sinks, we used a combination of the following techniques:

Visual Inspection One of the primary techniques to observe and sample the invertebrate fauna is visual inspection of habitats using an OptiVisor (a magnifier). We examined organic material in the lava tubes

(leaf litter, wood, guano, feces, roots, etc.) as well as different substrates (soil, under rocks, cracks, crevices). Each cave was examined for invertebrates in August, September, and October.

Pitfall Trapping Another technique for sampling the invertebrate fauna is pitfall trapping, which uses small plastic cups (we used 16oz and 10oz) with funnel shaped inserts (used only on the 16oz cups). These are buried in the substrate up to the rim and were unbaited. The surface was sampled using two sets of twelve pitfall traps, one in the control plot near Frozen Mat and the other in the proposed burn plot near Lava Wall. All pitfall traps were set for a period of 24 hours in August 28-29, September 25-26 and October 2-3, 1993. The pitfall traps were also run from October 18 to 24. All pitfall samples were returned to OSU for arthropod extraction and identification.

Extraction of Soil Invertebrates The most efficient technique to sample invertebrates, especially the very small taxa ($< 5\text{mm}$) is to extract them from the organic matter and soil in which they live. The two primary methods of extracting invertebrates from these habitats are: Berlese [10] and flotation (Hart and Fain [6], Kethley [8], and Walter *et al.* [13]). The advantage of flotation over Berlese is you do not need a large sample and it is much more efficient than Berlese, however, flotation will not work for the guano of insectivorous vertebrates. For the El Malpais soil fauna, we elected to use heptane flotation of litter samples collected from under vegetation in both sinks, under shrubs near the sink, and from soil in open areas surrounding the sink. Extraction was performed at The Ohio State University (OSU).

7.2 Results

Tables 7.5, 7.6 and 7.7 show the preliminary results of pitfall trapping. The identifications provided in this report are preliminary, and these lists will grow as more taxa are identified. More complete identifications and analysis of invertebrate fauna will be provided in the final report.

The pitfall traps were flooded on two occasions, August 28-29 and October 19. The flooding resulted in little or no usable information in August and therefore we used a longer trapping period (5 days) in October.

The pitfall data from September and October suggests the Acari (mites), are the dominant arthropod group with 17 families (Tables 7.5, 7.6). The Collembola (springtails) and Araneae (spiders) are a distant second and third with three to four families each. The pitfall data also imply the surface area around Frozen Mat Cave has fewer species than the area around Lava Wall Cave. This difference could be due to the limited number of samples collected, but is probably related to differences in vegetation and soils.

The two sinks are different (Table 7.7). The Frozen Mat sink had fewer species than Lava Wall sink. This reduction in species may result from one or more of the following:

- The Frozen Mat sink is partially shaded by large ponderosa pines (*Pinus ponderosa*) depending on the season and time of day, and has a small juniper growing in the bottom of the sink; the Lava Wall Cave sink is not shaded.
- Most of the Frozen Mat sink is covered with a thick mat of pine needles and is much drier on the surface.
- The Lava Wall sink has several small shrubs (*Ribes* sp.) growing in it which shade the surface and provide soil and leaf litter.
- The Lava Wall sink has steeper sides and a smaller diameter.
- The Lava Wall sink has moss growing on the rocks and soil, implying a higher moisture content.

The cave fauna in each cave is limited (Table 7.8). The lack of invertebrates may be due to the low temperatures and lack of moisture throughout the two caves or may be an artifact of the limited field work to date. The data collected to date are too sparse to reach any conclusions.

8 Conclusions

It is extremely fortunate that the burn did not occur in the fall of 1993. The caves are complex and time is required to learn the normal parameters (temperature, humidity, particulates, water chemistry, CO₂, and CO) for the caves in order to determine what effect the fire will have. Much variance

	Burn Plot Control Plot	
Myriapoda		
Diplopoda (millipedes)		
undetermined material	X	X
Chilopoda (centipedes)		
undetermined material	X	X
Insecta (insects)		
Collembola (springtails)		
Sminthuridae	X	-
Entomobryidae	X	X
Poduridae	X	X
Coleoptera (beetles)		
Staphylinidae	X	-
Siphonaptera (fleas)		
undetermined material	X	-
Homoptera (leaf & plant hoppers)		
undetermined material	X	X
Hemiptera (true bugs)		
undetermined material	X	X
Hymenoptera (bees, wasps and ants)		
Formicidae	X	X
undetermined material	X	X
Orthoptera (grasshoppers & crickets)		
Rhaphidophoridae		
<i>Ceuthophilus</i> sp.	X	X
undetermined material	X	X
Lepidoptera (moths & butterflies)		
undetermined material	X	X
Thysanoptera (thrips)		
undetermined material	X	-

Table 7.5: Preliminary Comparison of Surface Collected Invertebrates in the Lava Wall and Frozen Mat Cave area (part 1).

	Burn Plot Control Plot	
Arachnida (arachnids)		
Araneae (spiders)		
undetermined material	X	X
Acari (mites)		
Acariformes		
Prostigmata		
Adamystidae	X	X
Anystidae		
<i>Chausseria</i> sp.	X	X
Bdellidae	X	X
Cunaxidae	X	-
Eupodidae		
<i>Eupodes</i> sp.	X	X
<i>Linapodes</i> sp.	X	-
Erythraeidae		
<i>Augustsonella</i> sp.	X	X
<i>Erythraeidae</i> sp.	X	X
<i>Lasioerythraeidae</i> sp.	X	X
<i>Balaustium</i> sp.	X	X
<i>Leptus</i> sp.	X	X
Microtrombidiidae	X	X
Nanorchestidae	X	X
Pygmephoridae	X	X
Rhagidiidae	X	-
Smarididae		
<i>Fessonia</i> sp.	X	-
Tydedidae	X	X
Tetranychidae	X	-
Trombidiidae		
<i>Allothrombium</i> sp.	X	X
Oribatida		
undetermined material	X	X
Parasitiformes		
Mesostigmata		
Laelapidae	X	X

Table 7.6: Preliminary Comparison of Surface Collected Invertebrates in the Lava Wall and Frozen Mat Cave area (part 2).

	Lava Wall	Frozen Mat
Insecta		
Collembola (springtails)		
Sminthuridae	X	-
Entomobryidae	X	X
Poduridae	X	X
Coleoptera (beetles)		
Staphylinidae	X	-
Hymenoptera (bees, wasps & ants)		
Formicidae	X	X
Orthoptera (grasshoppers & crickets)		
Rhaphidophoridae		
<i>Ceuthophilus</i> sp.	X	X
Arachnida (arachnids)		
Araneae (spiders)		
undetermined material	X	X
Acari (Mites)		
Acariformes		
Prostigmata		
Anystidae		
<i>Chausseria</i> sp.	X	X
Bdellidae	X	-
Eupodidae		
<i>Eupodes</i> sp.	X	X
<i>Linapodes</i> sp.	X	-
Erythraeidae		
<i>Balaustium</i> sp.	X	-
<i>Leptus</i> sp.	X	-
Nanorchestidae	X	X
Neothrombiidae		
<i>Ceuthothrombium</i> sp.	X	-
Rhagidiidae	X	-
Tydedidae	X	X
Trombidiidae		
<i>Allothrombium</i> sp.	X	-
Oribatida		
undetermined taxa	X	X
Parasitiformes		
Mesostigmata		
Laelapidae	X	-

Table 7.7: Preliminary Comparison of Invertebrates from the Lava Wall and Frozen Mat Sinks.

	Lava Wall	Frozen Mat
Insecta		
Collembola (springtails)		
Entomobryidae	X	-
Orthoptera (grasshoppers & crickets)		
Rhaphidophoridae		
<i>Ceuthophilus</i> sp.	X	-
Lepidoptera (moths & butterflies)		
undetermined material	-	X
Arachnida (arachnids)		
Araneae (spiders)		
undetermined material	X	X
Acari (Mites)		
Acariformes		
Prostigmata		
Bdellidae	X	-
Eupodidae		
<i>Eupodes</i> sp.	X	-
Rhagidiidae	X	-

Table 7.8: Preliminary Comparison of Invertebrates from the Lava Wall and Frozen Mat Caves.

occurs in the invertebrate fauna and additional time will allow us to do more sampling prior to the burn. These additional preburn data will allow better evaluation of the effects the fire will have on the fauna.

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