LITTLE TRIMMER PROJECT:
Instrumented Monitoring of the Underground Environment

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Introduction

This paper describes an experimental set-up to continuously monitor the underground environment in Little Trimmer Cave, Tasmania. Work at Little Trimmer is part of a project being conducted by the Tasmanian Forestry Commission to investigate the effects of logging on karst caves, and was made possible by funding from the Australian National Parks & Wildlife Service.

In its original conception the project involved monitoring hydrological and climatological parameters in a cave before and after logging to permit an assessment of impact to be made. Little Trimmer, a 200m long stream cave at Mole Creek, was selected as an ideal study site. It is situated in relatively undisturbed forest, contains active dripwater flows, and is accessibile and securable. In view of the probability of at least some damage to the cave in the course of the study, it was important that the site not be one of high conservation value.

Despite uncertainty as to the viability of logging the area, it was decided to proceed as planned on the basis that obtaining basic data on the relationship between external and underground environments was the principal aim of the project. A better understanding of karst processes in the Tasmanian context is seen as essential from a forest management perspective (Kiernan, 1984). Moreover, baseline information from Little Trimmer will provide a necessary control with which to compare data from caves in areas that have already been logged.

Instrumentation

The project relies heavily on commercially available data loggers with various monitoring attachments. Unidata Starlog 6003 and Wesdata 390 models have been employed. The Unidata loggers are able to record a large number of variables, though memory space and battery life put constraints on this in practice. Two Unidata loggers monitor three variables each, receiving inputs from tipping bucket rainfall gauges, temperature probes, and a humidity sensor. An additional four single-channel Wesdata loggers record temperatures and stream stage.

Initial performance of data loggers in the field has been encouraging. However, limitations in the use of some equipment in an underground context have become apparent. This has included the effect of very high humidities on the humidity probe, and the precipitation of calcite on the tipping mechanism of rainfall gauges used to record drip rates. It is expected that recalibration of the rainfall gauges will become necessary as a result. A slightly different problem emerged with the discovery that rats had chewed through a cable leading to the rainfall gauge. Fortunately, this appears to have been an isolated incident of sabotage.

Downloading of data loggers is accomplished in the field with a Toshiba portable computer. However, more frequent visits to the site are necessary to monitor other variables that are not being continuously recorded (see Table 1), and to collect water samples. The possibility of using an automatic water sampler to sample the cave stream at selected flow rates is being investigated.

Hydrology

The process of logging can have a considerable impact on local hydrology, thereby modifying karst processes occuring on the surface and below the ground (Kiernan, 1988). This may take the form of changing flow regimes and stream sediment loads, while deforestation and soil compaction are likely to affect biological processes in the soil that determine the chemical characteristics of percolation water. Thus obtaining an understanding of the behaviour and chemistry of water flows in the cave is a priority.

To facilitate accurate recording of stream flow, a V-notch weir and depth probe sensor were installed at a narrow point within the cave. A continuous record of dripwater flows at two points is obtained from tipping bucket rainfall gauges located beneath stalactite clusters. A large funnel directs drips into the tipping bucket at one site, while a plastic sheet suspended above the floor collects more dispersed drips at another site. The rapid deposition of carbonate on the collection apparatus is a factor that will need to be taken into consideration when interpreting the results of water analyses. Several other drips that are too slow for the tipping buckets are collected over week-long periods in small plastic bags attached to the tips of stalactites. The flow rate of one very active stalactite - up to 47 l/hour at times - is noted at the time of each visit using a funnel and measuring cylinder. Dripwater and stream samples are collected regularly and analysed for major ions.

Parameter	Method of Recording	Type of Record
Stream flow	Weir and depth probe.	Continuous
Dripwater flows	Tipping bucket rainfall gauges.	Continuous
Slow drips	Collected in plastic bags attached to stalactites.	Average over the period of collection
Fast drips	On-the-spot measurement.	Instantaneous value
Water chemistry	Manual collection of samples for lab analysis. Conductivity and pH recorded on site.	Instantaneous value
Water temperature	Temperature probe.	Continuous
Air temperatures	Temperature probes.	Continuous
Relative humidity	Humidity sensor.	Continuous
Air flows	Data from temperature probes and manual record with digital anemometer.	Mixed
Air CO_2	Draeger gas analyzer.	Instantaneous value
Soil CO_2	Miotke probe and Draeger unit.	Instantaneous value
Precipitation	Tipping bucket rainfall gauge.	Continuous

Table 1: Summary of data collection techniques at Little Trimmer. samples are collected regularly and analysed for major stations.

The stream that emerges from Little Trimmer appears to be fed primarily by percolation water. A mean value of 252ppm for total hardness is evident from weekly samples collected between July and October 1990. This approximates the mean total hardness of dripwater flows in the cave, which range in hardness from 146 to 320ppm over the same period. However, the Little Trimmer stream is too volatile to consist entirely of autogenic water. There are abrupt flood peaks in the order of 0.5 cumecs that contrast with more typical flows below 0.01 cumecs. This lends support to speculation by Kiernan (1984) that in times of flood the stream is boosted by overflow from a vadose stream system that bypasses the cave during moderate flows. If this is the case then Little Trimmer further illustrates the complexity of hydrological relationships that need to be taken into consideration in land management planning in karst areas. Analysis of water samples and water tracing during peak flows may contribute to a better understanding of how the system operates.

The two dripwater sites that are being continuously monitored with rainfall gauges have mean flow rates that are quite different. One drip site is located close to the entrance, only 7m below the surface, and is subject to large fluctuations in flow rate. The other drip is beneath some 35m of rock towards the end of the cave, and has a far more muted range of flows. Despite their differences, corresponding peaks in response to rainfall events are evident in the hydrographs of both drips.

With data on flow rates, water chemistry and surface climate, it is hoped to draw some conclusions regarding the nature of the factors influencing dripwater chemistry. These are by no means well understood. The seminal study by Pitty (1966) in the UK suggested a correlation between drip hardness, antecedent surface temperature and hence microbial activity in the soil. However, the results of related studies in this country by Jennings (1979) and Goede (1981) have been less easy to interpret.

Climatology

Variables such as temperature, the velocity and direction of air movements, humidity and CO_2 levels influence speleothem development and are decisive to the well-being of subterranean ecosystems. Cave morphology is an important determinant of rates of air exchange with the external environment and the location of microclimatic zones within caves (De Freitas et al, 1982). However, it is likely that cave climates are susceptible to activities above ground that alter the vegetation cover, soil characteristics, and water flows.

At Little Trimmer the existence of a small upper entrance is responsible for relatively vigorous air flows resulting from the "chimney effect" (Wigley & Brown, 1978). Continuous recording of air flows with conventional anemometers has not been viable due to the limitations of available instruments, logger memory capacity, and budget restrictions. Instead, monitoring this parameter has relied on temperature probes installed a short distance inside both upper and lower entrances. These record on a half-hourly basis, as does an additional temperature probe located on the surface.

Comparison of data from the three probes shows distinctive patterns that are consistent with chimney effect winds. Peaks on a plot of temperature at the upper entrance correspond to warm external temperatures, while at such times the lower entrance temperature remains unchanged. It is concluded that the temperature inside the upper entrance is responding to a warm inward draught. Conversely, decreases in temperature at the lower entrance correspond to cold external conditions, and presumably indicate a reversal of air flow direction. Some empirical support for these predictions is available from notes on the direction of air flow made during visits to the cave. A draught is particularly prominent at a constriction near the top entrance, and wind velocities of several metres per second have been measured at this point using a small digital anemometer. Observations indicate that external winds also affect air movement at times.

Contrasting the well-ventilated section of passage between the two entances, is an area of greater climatic stability deeper into the cave. Temperatures here remain essentially constant at 9.5^{0}C, though with slightly higher temperatures apparent at ceiling level. The period of record is as yet too short to detect possible seasonal variations. As might be expected, relative humidity in the more remote sections of the cave approaches 100%. This has presented problems for a Vaisala brand humidity probe being used at Little Trimmer. At such high humidities, small temperature or pressure changes are sufficient to induce condensation on the sensor, with resultant erroneous readings. The probe has now been located closer to one of the entrances where slightly less humid conditions prevail.

Biological Monitoring

One of the original selection criteria for the study site was that the cave should be relatively expendable. However, the results of biological surveying indicate that Little Trimmer contains a rich assemblage of invertebrate fauna. A total of 25 species have been recorded, including 5 troglobites and several species awaiting description. To take advantage of regular visits to the site, a simple biological monitoring program has been designed (Eberhard, 1990). This involves periodic censuses of the most common species in a variety of substrate types. Basic life history data of this sort will be useful in predicting the effects on cave ecosystems of changes to the hydrological and climatological parameters described above.

Human Impacts

The likely impact on the cave and its biological inhabitants by the researchers themselves caused concern from the outset. To reduce widespread trampling, string has been used to define paths along necessary routes and to delineate zones for the protection of important habitats. While the intention is to minimise damage, the study is an opportunity to assess the effects of intensive visitation on a cave. This involves a record of activity in the cave together with observations on the spread of dirt on flowstone floors, compaction of sediments on paths, and physical modification of calcite deposits. In addition to documenting the effect of research, this information is of interest in planning related to the recreational use of caves. The fact that the accessibility of many caves is greatly enhanced with the advent of logging roads makes this a relevant concern from a forest management viewpoint.

Summary

The use of data loggers has greatly facilitated research on the underground environment at Little Trimmer. These allow comprehensive gathering of data with relatively little effort. Problems of equipment malfunction that have hampered previous studies of this kind are likely to be reduced.

The project has focused on hydrology and climatology, both of which are crucial to karst processes and cave ecosystems. By characterising the interaction of surface and underground environments, it is envisaged that the study will contribute to a better understanding of the likely impact of forestry and other land uses on karst landscapes.

Acknowledgements

The project has been made possible by a grant to Kevin Kiernan from the Australian National Parks & Wildlife Service under the States Assistance Scheme. Andrew Causon and Terry Leary of the Rivers & Water Supply Commission, Hobart, have provided essential expertise. The assistance of Chester Shaw and Vic Fahey of the Department of Parks, Wildlife & Heritage at Mole Creek has been much appreciated. Andy Spate (N.S.W. National Parks & Wildlife Service), Stefan Eberhard (University of Tasmania), Harry Cox (Government Analyst & Chemist, Hobart), and Frank Brown (Department of Environment & Planning, Hobart) have all made valuable contributions. Rex Tuson has generously allowed free access to the study site via his Loatta property. For help in other ways we are grateful to our Forestry Commission colleagues, Mick Brown, Humphrey Elliot, Sheryl Wolfe and Mark Burrows.

References

De Freitas, C.R., Littlejohn, R.N., Clarkson, T.S. & Kristament, I.S., (1982), "Cave Climate: Assessment of Airflow and Ventilation", J. Climatol. 2: 383-397.

Eberhard, S., (1990), Little Trimmer Cave Project: Biological Monitoring Programme, Unpublished Report to the Forestry Commission, Tasmania.

Goede, A., (1981), "Variation in Hardness of Cave Drips at Two Tasmanian Sites", Helictite 19(2): 57-67.

Jennings, J.N., (1979), "Hardness Controls of Cave Drips, Murray Cave, Cooleman Plain, Kosciusko National Park", Helictite 17(1): 30-38.

Kiernan, K.K., (1984), Land Use in Karst Areas: Forestry Operations and the Mole Creek Caves, Unpublished report to the Forestry Commission and National Parks and Wildlife Service, Tasmania.

Kiernan, K.K., (1988), The Management of Soluble Rock Landscapes: An Australian Perspective, Speleo. Res. Council, Sydney.

Pitty, A.F., (1966), An Approach to the Study of Karst Water: Illustrated by Results from Pooles Cavern, Buxton, Univ. Hull Occ. Pap. Geogr. No.5.

Wigley, T.M.L., & M.C. Brown, (1976), "The Physics of Caves", pp.329-358 (in) T.D. Ford & C.H.D. Cullingford (eds), The Science of Speleology, Academic Press, London.