Cave and Karst Management in Australasia XVIII

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Margaret River, Western Australia, 2009

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2009

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Photo Rauleigh Webb

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Contents

Papers

Cave Management In The Leeuwin–Naturaliste, An Accident Of History

Anne Wood

Caves Manager Dept Environment and Conservation, Blackwood District

Abstract

The main purpose of this brief paper is to provide an outline of the various bodies involved with management of caves and karst in the Leeuwin-Naturaliste area.

From 1901 to 1910 the Caves Board was responsible for overseeing the management of show caves in the SW of Western Australia. In 1911 State Hotels, a body having an association with tourism, was given this responsibility, heralding an era of management and infrastructure decline. In 1958 management of Yallingup Cave (now Ngilgi) passed to the Busselton Tourist Bureau, and management of Lake, Mammoth and Moondyne passed to the Augusta Margaret River Tourist Bureau. Most of the limestone and karst features in this region are within the Leeuwin-Naturaliste National Park (LNNP), which is made up of 36 separate reserves originally gazetted between 1902 and 2004.

In the present day the Department of Environment and Conservation manages the Leeuwin-Naturaliste National Park. Two of the caves within the park, Calgardup and Giants, are open to the public and entry to all others in the LNNP is controlled via the Cave and Abseil Permit System. Under the permit system, about ten sites are classified as 'Adventure Caves' and the rest as 'Restricted Access'.

The two tourism associations continue to manage the better known show caves. Geographe Bay Tourism Association manages Ngilgi Cave. The Augusta Margaret River Tourism Association manages Lake, Mammoth, Jewel and Moondyne Caves.

Introduction

The main purpose of this brief paper is to provide an outline of the various bodies involved with the management of caves and karst in the South West Capes area. The area under discussion is the karst area found on the Leeuwin-Naturaliste Ridge, from Cape Naturaliste in the north to Cape Leeuwin in the south.

In 1901 the Caves Board, a committee to protect and administer the South West Caves was formed. Dr John Winthrop Hackett, a man of great influence and one of the founders of the University of Western Australia was the main driving force behind the formation of the Caves Board. Col. Ernest Albert Le Souef, who was responsible for the establishment of the Perth Zoo at the request of the WA Govt, was another notable member of the Caves Board. From 1901 to 1910 the Caves Board was responsible for overseeing the management of show caves in the SW of Western Australia. Steps & gates were installed in many caves, including Yallingup Cave (now Ngilgi), Northcote Grotto, Milligans Cave, Blackboy Hollow Cave, Wallcliffe Cave, Witchcliffe Cave, Calgardup Cave, Mammoth Cave, Lake Cave, Bride Cave, Giants Cave, Golgotha Cave, Deepdene Cave, and Moondyne Cave. The earliest reserves in the Leeuwin-Naturaliste area were set aside in 1902 for the purpose of "protection and preservation of caves and flora and for health and pleasure resort". In 1911 the Caves Board was dissolved.

Responsibility for the management of the caves reserves eventually passed to the State Hotels Department, a body having an association with tourism. However State Hotels had no interest in the management of the reserves, only in the management of hotels, including Caves House at Yallingup. The period of State Hotels management was marked by neglect and infrastructure decline.

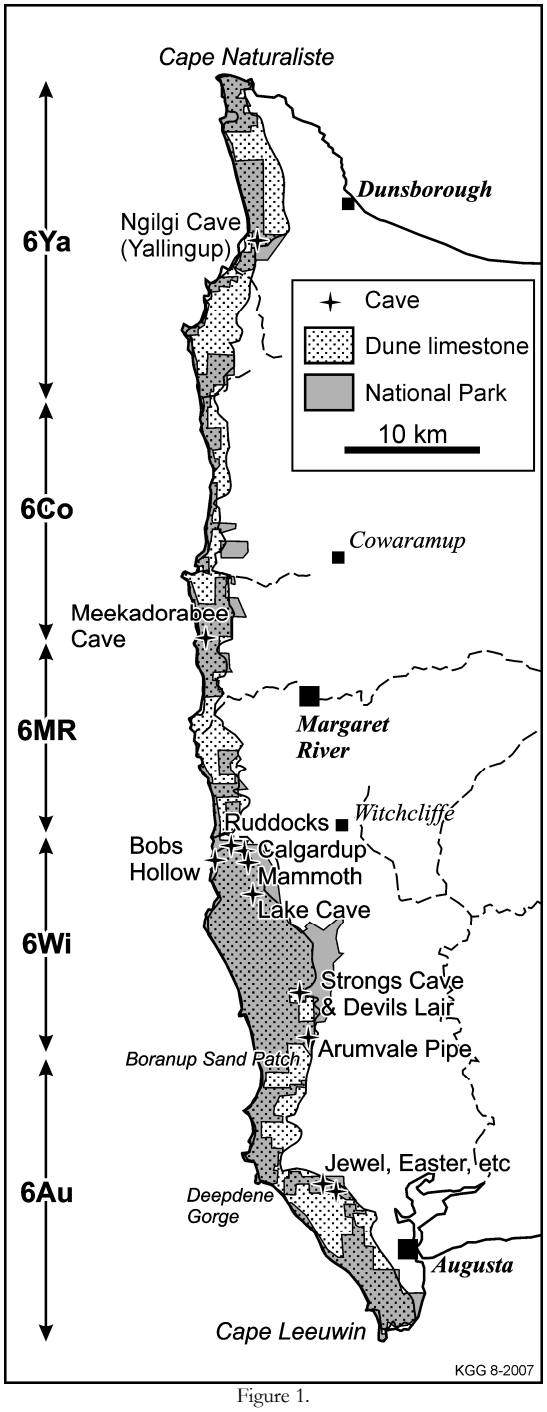


Figure 1.

In 1958 the Augusta Margaret River Tourist Bureau took out leases of four 40 acre blocks surrounding Mammoth, Lake, Deepdene and Moondyne Caves from State Hotels. The State Hotels Department ceased to exist in 1960, leaving the management of Yallingup Cave with the Busselton Tourist Bureau and the management of Mammoth, Lake, Moondyne and the recently opened Jewel Cave with the Augusta Margaret River Tourist Bureau.

Since 1902 when the first reserves were set aside there have been many additions and now most of the limestone and karst features in this region are within the Leeuwin-Naturaliste National Park (LNNP), which is made up of 36 separate reserves originally gazetted between 1902 and 2004. Figure 1 shows the area of limestone and the area of national park.

In the present day the Department of Environment and Conservation (DEC) manages the Leeuwin-Naturaliste National Park. Two of the caves within the park, Calgardup and Giants, are open to the public. Both these caves are self-guided by the light of a hand held or helmet mounted light. Calgardup Cave is no more difficult to access than a typical show cave as it is fitted out with boardwalks and stairs. Giants Cave is a little more adventurous with some rock scrambling and vertical ladders to negotiate. Entry to all other caves in the LNNP is controlled via the Cave and Abseil Permit System. Under the permit system, about ten sites are classified as "Adventure Caves" and the rest as "Restricted Access". An accredited leader is needed to book a permit. The main users of adventure caves are school groups and commercial tour operators. There are well over 100 caves within the LNNP and many other karst features.

The two tourism associations continue to manage the better known show caves. Geographe Bay Tourism Association (formerly Busselton Tourist Bureau) manages Ngilgi Cave (formerly Yallingup Cave). The Augusta Margaret River Tourism Association manages Lake, Mammoth, Jewel and Moondyne Caves. These show caves are within national park, but on separate locations vested in each of the two tourism associations. Figure 2 shows the national park coloured green, including some of the better known DEC managed sites such as Calgardup, Giants, Bride, and Golgotha Caves. The locations of the sites managed by the two tourism associations are also indicated on figure 2.

There are some caves and karst areas not included in those discussed above. The Shire of Augusta Margaret River has some reserves containing karst features. The most notable of these is Wallcliffe Cave on the southern bank of the Margaret River, not far from the coast. There are also a few caves found on private property, particularly in the northern part of the Leeuwin-Naturaliste ridge where the national park is quite patchy and does not include large areas of karst.

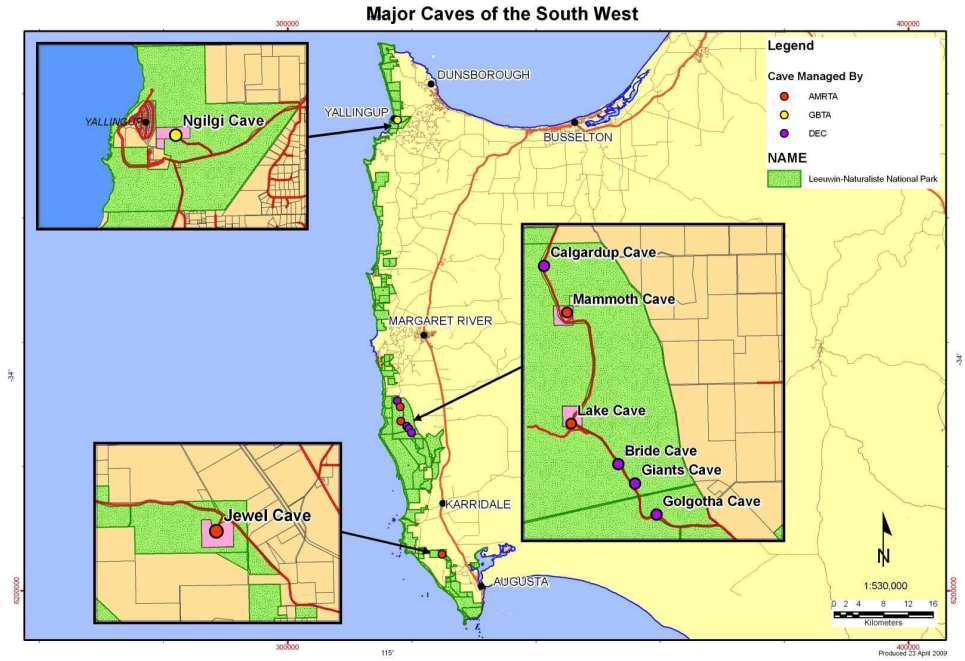

Major Caves of the South West
Legend
Cave Managed By
AMRTA
GBTA
DEC
NAME
Leeuwin-Naturaliste National Park
DUNSBOROUGH
YALLINGUP
BUSSELTON
Ngilgi Cave
Calgardup Cave
Mammoth Cave
MARGARET RIVER
Lake Cave
Bride Cave
Giants Cave
Golgotha Cave
KARRIDALE
Jewel Cave
AUGUSTA
1:530,000
Kilometers

Figure 2.

Thematic Interpretation – adding value to your tours and variety to your day

Sasa Kennedy

Abstract

To many visitors one cave tour is much like another; the same can be said of many guides.

This paper looks at how karst managers can effectively utilise the principles of thematic interpretation to give their tours a point of difference, raise the standard of guiding at their site and improve job satisfaction for their guiding staff.

In addition the paper will show how by using effective thematic interpretation management can convey a message which will encourage visitors to support them in their conservation endeavours.

The paper will clarify the difference between a guided tour and an interpretive tour; explain the use of themes; give practical examples of interpretive techniques; suggest cost-effective ways to build staff skills and interest; and show how thematic tours can assist you in on-selling your product.

Introduction

To many visitors one cave tour is much like another; the same can be said of many guides. This paper looks at how karst managers can effectively utilise the principles of thematic interpretation to give their tours a point of difference, raise the standard of guiding at their site and improve job satisfaction for their guiding staff. In addition the paper will show how by using effective thematic interpretation management can convey a message which will encourage visitors to support them in their conservation endeavours.

The paper will clarify the difference between a guided tour and an interpretive tour; explain the use of themes; give practical examples of interpretive techniques; suggest cost-effective ways to build staff skills and interest; and show how thematic tours can assist you in on-selling your product.

On most cave tours as the guide leads the group through the cave they may talk about how the cave and crystal decorations formed; they will point out and name various formations and talk about how the cave was discovered. In my experience many guides believe the visitors cannot understand, or are not really interested in, the geology, so it is covered in a cursory manner.

A truly interpretive tour is different in that the guide seeks to involve the visitors in the tour and make the site significant to them by developing their understanding of it; the information conveyed is site specific and client specific. The result is that the visitor leaves with a clearer understanding of the site and a memorable message about the site.

To really understand the difference between a guided tour and an interpretive tour it is helpful to go back to the Oxford Dictionary, where interpretation is defined as:

- The act of interpreting
- Proper explanation, hence signification and meaning
- The action of translating

It is the second and third definitions which are useful; explanations must be clear enough that the significance and meaning is conveyed and to do this well we must put ourselves in the role of translator. We must take the language of the cave and put in into words that the visitor can understand. To do this effectively the interpreter must do three things:

- Understand the initial language to be translated
- Use effective translation techniques
- Understand the language being translated to

Language consists of both vocabulary and grammar. When we use scientific and other cave terminology without explaining the meaning of these words we are merely showing off and creating barriers to visitor understanding. When jargon is used the meaning must be explained. This means that the interpreter must themselves have a clear

understanding of the terminology, not always the case when they have picked it up by following other guides on their tours, without additional training and sources of information being available. If we learn a language by listening to a native speaker we will pick up any misunderstandings and mispronunciations they have; likewise if we learn about caves by following only one or two guides.

When we are taught a language we are also taught about the culture that spawned the language. The culture of caves is largely to do with history and science.

Typically guides initially learn of the history of their caves by listening to other guides and management and by reading booklets and other material produced to be sold as souvenirs. Interested guides will also search out early visitor guide books. It is important that access is given to original sources, not just guide books but recounts by early visitors of their experiences and any records that are available, such as records of improvements to infrastructure. Some time spent delving through the records at the local or State Library may prove most interesting. Primary sources are best, but even secondary sources may contain gems of information that have been lost over time.

Local historical societies can provide invaluable information on characters who have played a part in the history of various cave systems. Jenolan Caves is blessed with its own historical society – Jenolan Caves Historical & Preservation Society (JCHAPS) – which many of the guides are active members of. Jenolan also boasts its very own Chat Room on the web, where many questions are raised, discussions held and information aired. While this is a truly outstanding position to be in history wise, local history societies can be found in most areas and should be encouraged to develop files on local cave history. Many people contribute to the history of each system, not just those who made the important discoveries.

The other major facet of cave culture is cave science. Again, this is generally learnt, in the first instance at least, by following guides on their tours and asking questions in the lunch room. This all too often leads to a generic version of cave science being presented during tours, which takes little account of the audience or of the specifics that set a particular cave apart from all others. Hardly surprising then that many visitors think that once they've seen one cave there is nothing more to discover.

If you are in the lucky position of having scientists, cavers or surveyors interested in studying your cave system encourage them; if there is a lack of interest, make it known that you welcome those who wish to contribute to knowledge of your system. Invite researchers and surveyors to share their findings, maps and knowledge with your staff; try to arrange for guides to be actively involved with any scientific studies taking place in your system. If nothing else it will give them time to look at the cave from a different perspective, without the distraction of keeping an eye on visitors. More likely they will gain a deeper understanding of what they are translating for your visitors.

If at all possible arrange some formal training in cave science for your guides.

Include discussions of current happenings in your cave tours. Visitors love up to date information; it increases their sense of involvement and makes the tour more personal.

The science and history of your karst system is unique; it should not sound just like the science and history of a system in another country.

With a deeper understanding of a cave the messages that the cave conveys become more obvious. These are what we need to communicate to our visitors. Each tour will benefit from having a central theme. A theme is not merely a topic; it is a message that gives your tour coherence. A theme is written as a statement – it can, therefore, be debated. A theme is a message; it may be an environmental message, but could just as easily be an idea that will help to link together the many facets of the tour.

A theme such as:- *A journey through the River Cave is a journey through time* helps to link geological time and historical time into the one story. *From little things big things grow* borrows from the name of a popular song (by Kev Carmody) and will help keep the message in peoples' minds for longer by linking it with a tune they may well be familiar with. It relates

to all facets of the Lucas tour – the formation of the limestone; the formation of the caves and decorations; the discoveries that branched out from one seemingly insignificant crack in the floor; the legal protection of Jenolan and other cave systems; the light shows we can enjoy today from the candlelit tours of the past.

In order to convey a message, we rely on both the sender and the receiver. Your guides are each a unique combination of personal qualities and foibles, experiences and interests. Encourage them to pursue their interests in the cave world and, where appropriate, to share their personal cave stories with your visitors. The aim is not to develop egocentric guides, but to create more personal interpretation for your visitors; to hear stories first hand gives them a real feeling of being close to the action and encourages interaction between guide and visitor.

However, guides each have their own unique weaknesses as well. Even experienced guides can benefit from some formal training in interpretive theory and techniques, even if only to remind them of the range of options available to assist them in getting their message across. Formal training in cave geology can also clarify the very complex science involved in cave development.

Your visitors, too, are each unique. To tailor the translation to them your guides need to get to know them; to understand their lingo and a little of their culture. Chatting to individuals at the meeting place and between interpretive stops will prove invaluable in ensuring that the tour meets the needs of these specific visitors. Factors to consider are where they are from, how long they are staying, what their interests are, what other caves/sites they have visited and why they have come to your site.

There are many techniques which may be utilized to ensure the translation is clear and interesting to your visitors. Some techniques are optional, a few are essential. To begin with the guide should not just be enthusiastic about the cave, but should openly share that enthusiasm. This requires some energy output! The guide must also be knowledgeable on their topic. It is great to acknowledge and utilise the knowledge and experiences of your visitors, but it is not a good look when they have a better understanding of the site than the guide.

Be site specific: discuss what you are observing now, not the shawl you will see later in the tour or the discovery hole that was passed on the way in; talk about how this cave was formed, not how caves in general are formed. While being site specific, it is also important to provide some context:- *When these caves were discovered they were still sending convicts to New South Wales.*

The use of props may be appropriate. Pictures of the early explorers or visitors are useful, as humans are very visual critters and like to relate to other people. A piece of crystal to pass around will dispel the urge to touch the cave and answer the genuine question *Is it soft like wax?* Models or diagrams may be helpful when explaining how the caves formed.

Use of direct quotes can help capture the essence of a different age, for example a reading from a letter detailing the discovery of a cave, or a postcard written by a visitor from an earlier age. Or you could try some living history - stepping into character either with full costume for an entire tour, or a simple hat for a scene or two.

Alternatively you could run an activity instead of a tour: Junior Guides Program, CSI Jenolan, Streamwatch activities or a photographic session. Each allows for different methods of interpretation.

Whatever you decide on you need to involve your visitors. Hands on activities and games; questioning and challenging or adding an element of competition will all focus attention.

In these days of interactive media it is also important to consider how you tell stories; people are used to being active participants, not passive listeners. Instead of saying "The explorers used candles and hemp ropes" try "Imagine going through this tiny hole into complete darkness, relying on just your candle and hemp rope. How do you think you would feel?"

While interpretation needs to be flexible it also benefits from planning and structure. Try to ensure a logical flow from one point to the next. This often requires a bit of thought as a cave is not designed as a neat, succinct narrative. Introduce your theme, build the body of your evidence as you proceed through the cave and remember to conclude by reiterating the major points that have been

covered. Many tours are derailed by a limp ending. "Thanks for coming. I hope you enjoyed your tour" is polite, but hardly memorable!

Begin each interpretive stop with a focusing statement to set the scene. Remember to keep your information clear and relevant for this particular audience. Be succinct. The visitors have come to experience the cave, not to hear the entire sum of your karst knowledge. Finish with a link to the next stop – a clue, something to look for, a question to be answered.

This may all seem much more complicated than the instruction to "Walk and talk", but it is also far more rewarding for the guide and satisfying for the visitor.

So if this is not happening on your tours what can be done? Firstly, consider how new guides learn their job at your site and what they learn. With each new guide learning from more experienced guides who have come through the same system there is the possibility of a watered down version of the original, containing a variety of Chinese Whispers, to develop as the standard tour. If there is a sameness to the tours at your site, rather than consistency of quality, then perhaps some of the techniques described can help to liven things up.

Fresh ideas and new ways of doing things can develop if you build opportunities for your guides to visit other cave systems. Guide exchanges may work for you. It is also extremely beneficial for guides to observe a range of other interpretive guides in action. Much can be learnt by watching both good and bad guides at work. Try to organise reciprocal freebies with as many organisations as possible.

For an excellent way of keeping your finger to the pulse of what is happening in the world of interpretation (guiding, signage and interpretive displays) join the Interpretation Australia Association. They run excellent workshops and hold great conferences with international speakers.

The final link of the communication (translation) model is the feedback loop. It is important to know if what you are doing is actually working for your visitors, your guides and your organisation. Check with your guides how things are working; ask for their ideas on how to improve things – be prepared to listen. Keep a Visitors' Feedback Book and record return visitation. Conduct visitor surveys. Be prepared to evaluate, adapt and change.

All this probably seems like a lot of work – and it is. Changing a guiding ethos is more demanding than changing a brochure or a logo, but it is also more meaningful, satisfying and effective in the long run.

Thematic interpretation encourages innovation and development of new product, exactly what economists are telling tourism and recreational businesses they need to do to survive in the current economic climate. You can use thematic interpretation to provide better product differentiation, with the end result that visitors stay longer and have more reason to return. Word of mouth from satisfied clients is ultimately much cheaper and more effective than paid advertising.

The variety that can be introduced via use of a range of interpretive themes eliminates guide boredom and staleness. Enthusiastic delivery by staff improves visitor experience. Applause is good for the ego, making for happier staff and so a pleasant spiral begins.

Improving skill levels also increase job satisfaction. The end result is that you save money on staff recruitment and training.

But perhaps the ultimate benefit to a land manager of using thematic interpretation is that you choose the messages that you want your visitors to take home. They depart with a greater understanding and appreciation of the karst environment. Hopefully they also become advocates for the protection of caves and other geo-heritage.

Palaeontology of Mammoth Cave

Lindsay Hatcher

Mammoth Cave is the earliest palaeontological cave site to be found within W.A.

Abstract

In 1904 Edgar Robinson – superintendent of the caves and cave guide Tim Connelly were constructing a walkway, when one of the gentlemen unearthed some rather large odd bones. In the same year Connelly notified his good friend Colonel LeSeouf.

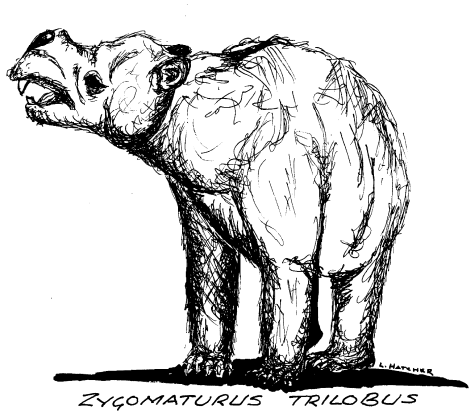
As a result Ludwig Glauert was seconded to the Museum with the brief of Paleontological Research in the entire South-West. During the years of 1909 – 1915 two sites in Mammoth Cave, were excavated by the W.A. Museum. Many bones of extinct animals including megafauna' bones were found. At this time the Mammoth Cave was also called the "Dawn of Creation", a name which probably originated from the discovery of fossils of extinct animals and suggesting that here, in this cave, was the beginning of creation

Excavations produced a sizeable fossil collection, some 10,000 specimens; Glauert's total excavation amounted to some 30 cubic meters of soil. But unfortunately the stratigraphic relationship was poorly documented, probably due to inadequate resources and time constraints, making any assessment of relative ages of the material extremely hard.

The assemblage contains 34 vertebrate species, most of which are small and typical of the south-west today. However several types of extinct marsupials are represented i.e. Megafauna our Giant Marsupials.

Introduction

Reports of the discovery of Mammoth Cave date back as early as 1895. Mammoth Cave was located by survey by Surveyor Mr Marmaduke Terry in September 1900, and explored by Tim Connelly and Ned Dawson, with Ned being the first to go through the cave and discover the "back door". Tim conducted unofficial tours through the cave until 1904 when it was officially opened as a tourist cave. He also named the cave "The Dawn of Creation" perhaps due to the expanse of light reflecting off the stream in winter or maybe because of the abundance of fossils found in the cave.



In 1904 Edgar Robinson – superintendent of the caves and cave guide Tim Connelly were constructing a walkway roughly below the largest solution pipe some 50 metres into the cave (i.e. near the top platform). One of these gentlemen unearthed some rather odd bones. In the same year Connelly notified his good friend Colonel Le Souef. At the time Le Souef had considerable standing within the scientific community; he had been responsible for establishing the Perth Zoological gardens in the 1890's.

Le Souef in turn notified Mr Bernard Woodward – Director of the W.A. Museum. At this time, no one was actively working in Palaeontology and very little work was being done in Archaeology.

Bernard Woodward contacted his cousin Mr H.P. Woodward who was working in the Mines Dept., with the fledgling Geological Survey of W.A. It turned out that H.P. Woodward did have on staff a young graduate just out of university, and freshly arrived from England, (the Midlands he believed) by the name of Ludwig Glauert.

Glauert was seconded from the Mines Dept. to the Museum with the brief of Palaeontological Research in the entire South-West. During the years of 1909-1915 two sites in Mammoth Cave; the "Le Souef" and the "Glauert" sites were excavated by the W.A. Museum. Many

bones of extinct animals including mega-fauna bones were found; the fossil material was removed and is now stored in the W.A. Museum.

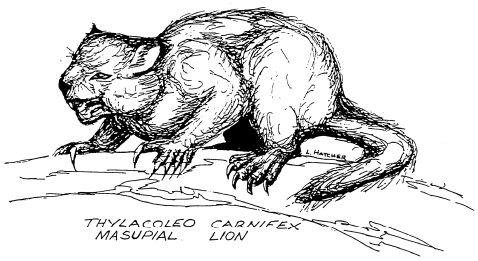
Glauert first completed the "Le Souef" dig – at the base of the old solution pipe. It was from this site; an Echidna (*Zaglossus hacketti),* Kangaroo-*(Simosthenurus occidentalis)* and Wombat-(*Vombatus hacketti)* were found. The almost complete wombat skeleton was found in the solution pipe which suggested it perished in the original pipe, which now lies on top of the rockpile. Glauert then moved to the north wall to what is known as the "Glauert" dig.

The material, in which the bones were embedded, comprised two groups; the lower series consisted of reddish coarse sand, containing fragments of wood and gastropod shells in addition to the bones, with occasional bands of black loamy soil, 25mm in thickness. Layers of stalagmite (flowstone) often enclosing the bones, wood fragments, etc., and bearing casts of eucalyptus leaves were not uncommon, and one of these layers was completely covering the sediments, thus protecting the animal remains. The upper layer was a sandy bed which was yellowish in colour; the bones it contained were much fresher in appearance, compared with the lower sediments.

Glauert believed that the bone bearing deposit was a remnant of a mass of bone breccia which at one time partly filled the large chamber. This remnant was protected by a coating of flowstone for many years until the protection was undermined by the stream flowing through the cave and much of the material with its priceless store of animal remains was washed away and lost to science.

Excavations produced a sizeable fossil collection, some 10,000 specimens; his total excavation amounted to some 30 cubic metres of soil. But unfortunately the stratigraphic relationship was poorly documented, probably due to inadequate resources and time constraints, making any assessment of relative ages of the material extremely hard.

The assemblage contains 34 vertebrate species, most of which are small and typical of the south-west today. Several types of extinct marsupials are represented i.e. **Megafauna** (Giant Marsupials): Giant Echidna (***Zaglossus hacketti***), Wombat (***Vombatus hacketti***), Wallaby (***Wallabia kitcheneri***), the Giant Wombat (***Zygomaturus trilobus***), extinct browsing Kangaroos (***Simosthenurus occidentalis*** and ***Simosthenurus browneі***) and the Marsupial Lion (***Thylacoleo carnifex***). Other groups of animals represented are those which still occur in Eastern Australia or Tasmania: the Koala (***Phascolarctos cinereus***), Tasmanian Devil (***Sarcophilus harrisii***) and Tasmanian Tiger (***Thylacinus cynocephalus***) which may still exist? The south-west corner seems to have changed very little even though the giant marsupial fauna has disappeared.



In the 1950's an American – Ernest Lundelius, researched Mammoth Cave, he was the person credited with "professionalising" palaeontology in W.A. He conducted the 1st carbon date in W.A. (from the Glauert dig in Mammoth), which gave a date of 37,000+ years before present (BP). Dating methods at the time could not date back further than this given date. Lundelius took many of the Mammoth bones back to the U.S.A., where they now reside in the Chicago Museum of Natural History.

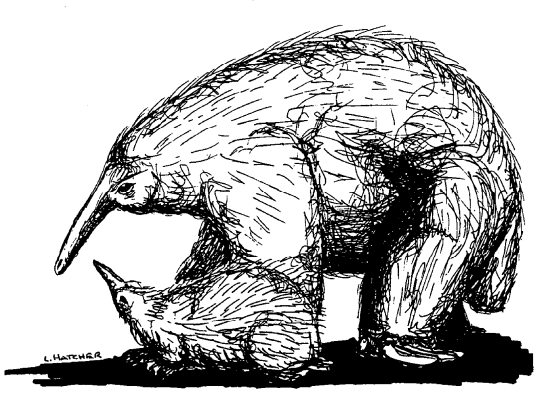
Unfortunately, the identification of Mammoth Cave as an archaeological site relies upon the re-analysis of bone material stored in the W.A. Museum. The original excavations by Ludwig Glauert and Ernest Le Souef at the beginning of the 20th century produced no archaeological material. This may be due to the focus of the researchers on megafaunal remains rather than archaeological material which can easily be missed by untrained eyes. The initial excavation unfortunately destroyed the stratigraphy of the deposit and thus much of the information that Mammoth Cave may have yielded has been irretrievably lost.

However during the 1960's Duncan Merrilees and Michael Archer while re-examining the bones and removing matrix from some of the material noticed a notch on the tibia of a large extinct kangaroo species (*Simosthenurus*). The

matrix followed the contours of the notch inferring that this had been made prior to its burial. Further investigation has supported the initial hypothesis that the notch was artificial, suggesting possible human deposition. This led to the bone material being re-examined by archaeologists, who concluded that some of the bone deposit in the cave could have been accumulated by humans (Archer, Crawford and Merrilees, 1980)

1. Researchers performed many tests on fresh bone to try and differentiate fracture pattern created as a result of human activity i.e., breakage by striking against a rock to extract the marrow or those caused by other means. The conclusion was that several of the femur bones were modified in such a way, the most likely explanation was deliberate breakage patterns were caused by humans for the retrieval of marrow.
2. Also some of the bone fragments appear to be partially charred, consistent with cooking in a small fire rather than incineration in a bushfire.
3. However natural processes may have also been responsible for some of the accumulation via solution pipes. The two deposits were found on top of the boulder pile, some 10 metres above the existing stream level. The first material found i.e. Bones; appeared to be articulated suggesting the animals were complete when they died or fell into the cave. It is possible that some of the material could have fallen through the solution pipes above the deposit, which have been subsequently blocked.
4. Some of the material may have accumulated as a result of animals using the cave as a lair, or it could have been used as roosting sites by birds and bats.
5. Heavy rains may have also contributed to the deposit, by washing in material such as bones wood fragments, leaves, gastropod shells and black loamy soil.

It is considered that the combination of notching, breakage patterns and the charring of bones suggests that humans were present at times during the accumulation of the Mammoth Cave deposit. It is easy to visualise an aboriginal hunting party bringing prey into the cave, cooking and eating the meat, breaking bones for marrow and leaving the fragments behind. It is also possible that this site was chosen for its ready source of water during the winter and spring months, or for its winter warmth, or its commanding view of the entrance from within the cave.



ZAGLOSSUS HACKETTI
GIANT EXTINCT ECHIDNA

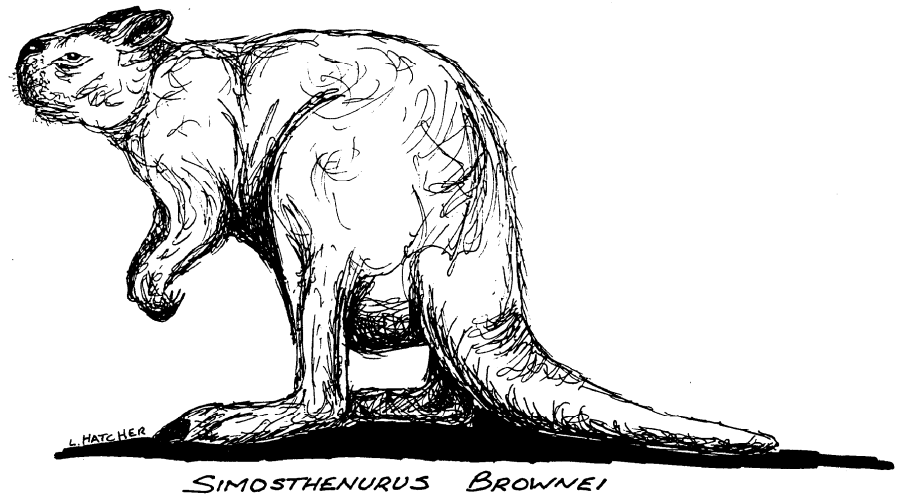
Unfortunately, dating of this deposit is difficult, as much of it has been removed. However it is tantalising, that some of the limb bones were cut, broken and burnt by people, though the cave has yielded no other archaeological evidence. A jaw of a Zygomaturus trilobus (Large Herbivore the size of a cow) is still adhering to the wall of the cave. In 1999 a small piece of flowstone directly above the jaw was dated at 44,400 +/- 640 years by Dr Linda Ayliffe using Uranium/Thorium isotope dating method. Another piece of flowstone was collected beneath the megafaunal layer with a resulting U/Th date of 55,200 +/- 1,100 years. This suggests that the Zygomaturus jawbone is between 55,200 and 44,400 years in age (approximately 50,000 years old). Archer, Crawford and Merrilees regard the Mammoth Cave Deposits as important, firstly in providing evidence suggesting that humans were present in the south-western corner of the continent at some time prior to 40,000 years BP, and secondly in appearing to provide one of the few cases for direct interaction between humans and some of the large now extinct species that were their contemporaries.

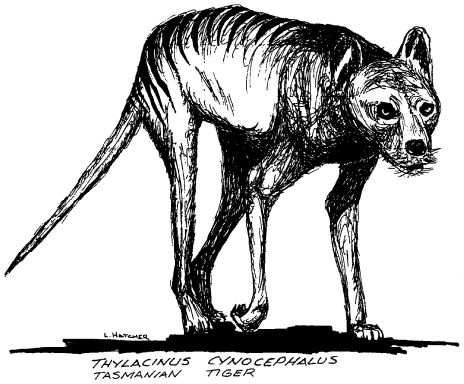
Most significantly, many of the species represented are megafauna. The reasons for why the megafauna became extinct, has been debated for many years with two main possibilities arising, climate change and/or the impact of the first human. Recent evidence suggests that the human colonisation of the

continent occurred some 56,000 +/- 4,000 years ago. This could mean that this event was contemporary with the extinction of the megafauna (Roberts, 2001). However, a site containing fossil evidence that humans preyed on the megafauna has yet to be discovered. Mammoth cave remains a unique site with the possibility that humans interacted with the megafuna.

It appears all Australian land mammals, reptiles, and birds weighing more than 100 kilograms, and six of the seven megafauna' genera with a body mass of 45 to 100 kilograms perished in the late Quaternary (last 2 million years). The timing and causes of these extinctions remain uncertain. However burial ages from 28 megafauna' sites infer extinction across the continent occurred around 46,400 years ago. The burial ages were obtained by using optical and $^{230}Th/^{234}U$ dating methods. The results rule out extreme aridity at the Last Glacial Maximum as the cause of extinction. However some of the youngest sites dated occur in the South-West of Western Australia Kudjal Yolgah Cave dated 46,000 ± 2,000 years and Tight Entrance cave has dates ranging 50,000 to 55,000 years for articulated megafauna. Mammoth Cave has yielded dates ranging from 44,400 to 84,000 years. The dating sequences carried out, suggests that the extinction of the megafauna occurred simultaneously in Eastern and Western Australia. It is also thought that the megafauna had vanished within 10,000 ± 5,000 years of human arrival 56,000 ± 4,000 years across a wide range of habitats and climatic zones.

The disappearance of the Tasmanian Tiger (***Thylacinus cynocephalus***) and the Tasmanian Devil (***Sarcophilus harrisii***) from the mainland of Australia seems to be related to the appearance of the dingo in Australia. The oldest reliable radiocarbon date for a Dingo is a little over 3,500 years BP (3,500 ± 50 years ago) from a cave on the Nullarbor. The youngest dated Tasmanian Tiger (***Thylacinus cynocephalus***) is a specimen also from a Cave on the Nullarbor 3,280 +/- 90 years BP.





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Track marking – the Yarrangobilly experience

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Abstract

At Yarrangobilly Caves in New South Wales, track marking has been used in a number of wild caves for more than 30 years with the aim of limiting visitation impacts. In most cases, the marked tracks have been installed to reduce damage to calcite decoration, but they have also been used to protect bone material and to minimise impacts on sediment deposits. Over the years, a variety of materials has been used, ranging from green paint to reflective markers and wire lines. This paper briefly covers the history of track marking efforts, reviews the methods used and considers their effectiveness and impacts on the caves. It also draws some conclusions that may be useful in considering track marking projects in other areas.

Introduction.

This paper had its origins in brief discussions last year with several people in Central Queensland who were wondering how best to limit the impacts of foot traffic in some of their caves. They had been advised to mark out trails with reflective markers but had not considered other methods that could be more effective.

As various track marking methods have been tried in some of the wild caves at Yarrangobilly, I thought there would be value in sharing some of the insights gained over the last 30 to 40 years.

The setting

Yarrangobilly is a karst area within the Kosciuszko National Park in southeastern New South Wales. The area has more than 300 caves in a belt of Silurian limestone about 10km long and 1km wide. Many of the caves have significant speleothem development and some have important historical, biological or geoscientific values. Four caves have been developed as show caves. Most other caves can be accessed by recognised speleo groups under a permit system administered by locally-based National Parks and Wildlife (NPWS) staff. Some of the more sensitive caves are gated (Figure 1) - including all but one of the caves mentioned in this paper - and have limits on the number of visits per year. In some cases there are also restrictions on which parts of a cave may be visited. Visitors must report on their activities, but there is no system of approved trip leaders or in-cave supervision, so there is an element of trust in administering the access regime. That is to say, the effectiveness of any track marking efforts relies on cavers' sense of responsibility and commitment to "caving softly".

Typically, cave floors are a combination of breakdown, mud, gravels and bedrock with patches of flowstone, so they are susceptible to mud tracking and trampling.

Figure 1: Gate in Eagles Nest Cave.

In the beginning …

The first record of track marking at Yarrangobilly appears to have been in 1966, when cavers noted the appearance of spray-painted arrows in Eagles Nest Cave (Dunkley, 1966) (Figure 2). It is not known who was responsible for these efforts, but a spray painted "Tom, Lin, Mel & Rick" probably gives us a clue. The arrows appear to have been intended as navigational aids rather than as cave protection measures. It is highly unlikely that the markings were officially approved.

Several years later, in 1970, paint made another appearance. This time it was in the newly discovered and highly decorated Janus Cave (Y58). Here, the markings were intended as a cave protection measure, but once again, it is highly unlikely the efforts were officially sanctioned.

The entrance to Janus Cave and the associated doline had been known for some time, but little attention was paid to it until 1969 – almost exactly 40 years ago – when an extension was discovered by the National University Caving Club - NUCC - (Webb, 1969). On the next trip several months later, the NUCC team discovered the large and spectacularly decorated Rawlinson Chamber (Alting, 1969) (Figure 3).

Rawlinson Chamber is a breakdown chamber about 100 metres long and 10 to 15 metres wide. Secondary calcite (flowstone) covers much of the floor (Figure 4), but in places this is just a thin crust on mud.

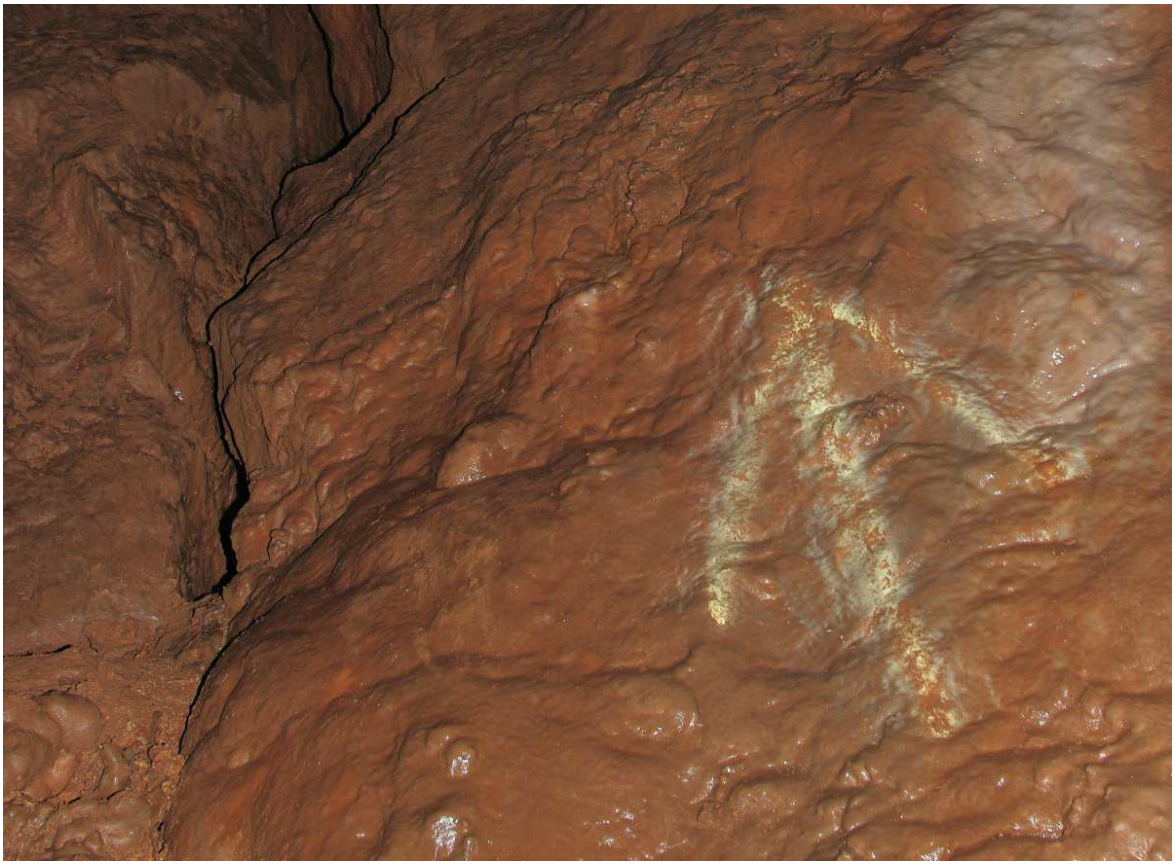

Figure 2: Painted arrow in Flat Bed Cavern, Eagles Nest Cave.

Figure 3:Rawlinson Chamber, Janus Cave

Figure 4:Flowstone cascade, Rawlinson Chamber, Janus Cave.

As knowledge of the beautiful chamber spread through the caving community, Janus Cave soon became a magnet for cavers. Unfortunately, the impacts of their visits rapidly became apparent as mud was released from under the flowstone and tracked around the chamber. Less than a year after its discovery, concerns were being voiced about the damage (Shepherd & Bell, 1970).

Before long, there was a well intentioned but completely misguided attempt to limit the damage by marking several trails around the chamber using green paint. As noted in the trip report, the party "painted several main trails in the Y58 chamber with green paint" (Mendum, 1970). Perhaps significantly, this was done on 1 April 1970. The paint trail comprised fist sized dabs every few metres (Counsell, 1971).

More serious efforts

The foundations for the marked tracks seen today in several wild caves at Yarrangobilly were laid in the 1970s and 1980s.

During the 1970s, Yarrangobilly was very popular with cavers. Many of the major caves were mapped, a range of cave studies were undertaken and there were many trips of a recreational nature. In short, there were many trips into some of the large and better decorated caves.

However, there were also increasing cave conservation and protection concerns and these led to the initiation of several track marking projects, largely at the behest of cavers.

Figure 5:Main chamber, Restoration Cave.

Figure 6:Wire line in Restoration Cave.

Restoration Cave (Figure 5) was the first cave to receive a measure of protection when a simple line of red plastic coated wire was strung around the most decorated part of the main chamber (Figure 6). When this was done, could not be ascertained, but it was before the end of 1971 (Counsell, 1971).

In the mid 1970s, the now defunct University of New South Wales Speleological Society (UNSWSS) undertook protection works in Eagles Nest and East Deep Creek Caves.

In Eagles Nest, UNSWSS initially used plastic covered wire to mark some of the route through Flatbed Cavern, the Railway Tunnel and the Crystal Stream and subsequently proposed a range of additional protection measures (Pavey 1974). Most of the UNSWSS proposals for marked routes (Figure 7), viewing areas and signs (Figure 8) were soon implemented (Warild, 1975).

Figure 7:Marked track in the Crystal Stream area of Eagles Nest Cave.

Figure 8:Marked track and sign, Railway Tunnel area, Eagles Nest Cave.

Figure 9:Flatbed Cavern area, Eagles Nest Cave. Note the in-grained mud on speleothems that dates prior to installation of the marked track.

In East Deep Creek Cave, UNSWSS designated small changing areas and placed signs requesting that people remove dirty boots and overalls before entering highly decorated areas (Pavey, 1975). Although these did not involve track marking *per se*, they had the same intent.

During the 1970s, flagging tape was used in Eagles Nest and East Deep Creek to 'fence off' special features such as bone accumulations, drip holes and isolated patches of floor decoration.

In the late 1970s, the Capital Territory Caving Group, also now defunct, attempted to remove the green paint trails in Janus Cave. It then re-delineated the trails using small reflective markers that were affixed to the cave with an epoxy adhesive.

By the early 1980s, it became apparent that the marked routes in Eagles Nest and Restoration Caves could be improved. The Canberra Speleological Society (CSS) submitted proposals to NPWS with the main focus on Eagles Nest where it wanted to use plastic coated wire to extend the route through the Railway Tunnel and Flat Bed Cavern areas, undertake clean up work (Dunn, 1981) (Figure 9) and to place a small footbridge (Figure 10) over some oolites and a crystal streamway (Brush, 1983). NPWS agreed to the works which were carried out by CSS through to 1984 (Coggan, 1984).

Only minor remedial work has been undertaken in Eagles Nest since the mid 1980s, but on a recent visit, a critical appraisal indicated there is scope to further improve the track. The wire lines are not continuous and it appears that cavers are going off track between the marked sections.

Figure 10:Footbridge in the Railway Tunnel, Eagles Nest Cave.

Janus Cave (Y58)

In 2000, CSS developed a proposal in conjunction with NPWS (Ingarfield, 2000) to redo the trails in Rawlinson Chamber of Janus Cave. The reflective markers, then 20 years old, were deteriorating and the epoxy was no longer holding firm. The proposal included:

- installing a continuous wire line without permanently disfiguring the cave (i.e. so that it could be removed without trace at a later date);
- 'fencing off' the principal features of Rawlinson Chamber, but providing visitors with reasonable viewing access;
- having regard to past usage patterns (i.e. directing visitors along routes that had already been established, where it was considered reasonable to do so);
- using a small number of signs to indicate the places where dirty clothing and footwear should be removed;
- removing all the old reflective markers; and
- cleaning selected parts of the cave, focussing on areas just beyond the wire lines to remove muddy tracks that visitors might be tempted to follow.

As discussions with NPWS progressed, CSS also suggested some additional works including the replacement of plastic matting (actually pieces of carpet protection mat) along the crystal streamway. The streamway is the normal - and most practical - access route into Rawlinson Chamber and at times is very active, resulting in the plastic squares becoming cemented into the floor and any mud on them being washed onto the white calcite floor. CSS proposed replacing the mats with a series of 30cm square stainless steel 'stepping stones' with small white rubber feet to limit the area of contact with the floor (Figure 11).

NPWS approved the proposals and agreed to procure all the materials needed. However, in view of cost considerations, aluminium was used to fabricate the 'stepping stones' and, as suitable wire was not available, electric fencing line was purchased. This is a 3mm plastic cord with stainless steel wires woven into it (Figure 12).

Figure 11:Aluminium and rubber stepping 'stones', Janus Cave.

Figure 12:Route marked with electric fence cord, Rawlinson Chamber, Janus Cave.

Figure 13:Electric fence cord in the lower level of Restoration Cave.

The approved works were carried out during 2002 (Brush 2002a & b).

Following its successful use in Y58, electric fence cord was used for track enhancements in Restoration Cave (Figure 13).

Cave impacts and durability of materials used

Paint obviously has considerable visual impact and while Hildreth-Werker *et al* (2006) note that it can break down quickly - which can be an issue in itself it is apparent in Eagles Nest that some of the painted arrows are still going strong after more than 40 years. There have been no concerted efforts to remove the paint for fear of further damaging the cave. Having said that, it appears the paint cleaning efforts in Y58 in the 1980s were reasonably successful.

The reflective tape markers in Y58 were attached with an epoxy adhesive. In a few places, the markers were on rods that were glued into holes drilled in the cave floor. So there was some permanent impact on the cave. Fortunately however, the epoxy had largely lost its grip after about 20 years. By then many of the markers had lost their reflective powers. As a further illustration of this problem, in Yongcheon Cave in Korea, which was discovered just 5 years ago, reflective markers are already showing signs of deterioration (Figure 14). Plastic retro-reflective discs have not been used at Yarrangobilly, but are likely to be more durable than reflective tape.

Figure 14:Trail markers in Yongcheon Cave, Jeju Island, Republic of Korea. Note the deterioration in the reflective material.

The aluminium stepping stones in Y58 appear to be reasonably durable, but they will need to be carefully monitored and replaced when they start to show signs of oxidation.

Flagging tape works reasonably well, at least in the short term. It can be tied to natural features in the cave (Figure 15), or simply laid out on the cave floor. However, observations in Eagles Nest indicate that it becomes brittle and breaks down into small (and unsightly) chips after just a few years. Once the tape becomes brittle, it is extremely difficult to remove all the pieces from the cave. This lack of durability is consistent with experience in the USA, where flagging tape is widely used for trail delineation (Hildreth-Werker *et al*, 2006), but as the authors note, although tape will last for up to a decade in some caves, in others it should be replaced every year or two.

Figure 15:Flagging tape in use in Eagles Nest Cave.

All of the wire/cord lines at Yarrangobilly have been installed without permanently altering the caves. The lines are simply tied to convenient projections or wrapped around loose rocks on the floor. Plastic coated copper wire appears to be very durable and is not showing any significant signs of deterioration after periods of more than 30 years in the caves. The electric fence line has been in place for up to 7 years and is performing well so far. However, it will need to be closely monitored for any signs of deterioration in the plastic cord to ensure that it is removed from the cave before it breaks down.

Effectiveness of the various track marking methods

As indicated earlier, paint is, or can be, highly visible, but …

Reflective markers have been widely used in some parts of Australia (Poulter, 1987) and they are certainly very effective for indicating the general route (Figure 16). However, they can leave the route open to interpretation and lead to the track becoming wider over time and, as noted by Hildreth-Werker *et al*, (2006), can encourage visitors to wander off trail between markers. Free standing markers could also be moved around at will by visitors.

Flagging tape is generally highly visible, depending on the colour used, but suffers from low tensile strength. Thus it is easily damaged if trodden on or walked into. This does happen.

Thin plastic coated wire is stronger than flagging tape but is less visible (Figure 17). This may be good from an aesthetic point of view and for photographers, but there is an increased likelihood of visitors walking into the line or over it without noticing. Twisted red and white bell wire works well because it stands out against a variety of backgrounds but does not detract from photos as much as flagging tape.

Figure 16:The removable reflective markers used in Yongcheon Cave, Korea are good for indicating a general route, but their wide spacing can leave the precise path open to interpretation.

Figure 17:A subtle red wire line in Restoration Cave

Electric fence cord is reasonably visible - white and orange lines have been used at Yarrangobilly – but it can detract from photographs. The line is immensely strong and it is easily tied to convenient projections or loose rocks. It really does seem to be quite effective – even without energising the wires!

But do cave visitors at Yarrangobilly stick to the trails? The short answer appears to be sometimes. As noted above, the trails have been laid out for various reasons:

- to restrict the area of damage to calcite/flowstone floors;
- to minimise trampling of sediment deposits; and
- to reduce general mud tracking through caves.

It seems that where visitors perceive an area of decoration to be clean or delicate they stick to the track. For example, there are areas in Eagles Nest where the track is no wider today than it was 35 years ago (Figure 18). However, in other places, particularly on sediment banks, where visitors may perceive there is nothing worthy of protection, the marked trails are less effective. It appears to be a similar story in some of the breakdown chambers where the route is over large slabs of bare rock. For quite a few years after the route was marked out in this area in 1983-84, there was a muddy trail over the slabs bounded by a wire. Now however, the muddy trail has spread beyond the wire boundaries (Brush 2009) (Figure 19).

Figure 18:Crystal Stream, Eagles Nest Cave. The wire line has been in place since the mid 1970s.

Figure 19:Flatbed Chamber, Eagles Nest Cave showing muddy trail extending beyond the track boundary.

Conclusions

Experience gained at Yarrangobilly over the last 30 and more years indicates track marking can be effective in restricted access caves, even though there is no system of approved trip leaders or other in-cave supervision. This is particularly so where there is a continuous line of wire or electric fence cord. Reflective markers can be useful for drawing attention to specific points on the line, but these markers are less effective when used alone and reflective tape can breakdown relatively quickly.

Marked routes work very well in areas of decoration, but are less effective in areas of breakdown, on bedrock or on sediments. In such areas, it appears visitors are less willing to keep to a marked route, especially if there are already footprints beyond the track. A problem that gets worse over time.

How can the effectiveness of the marked tracks in wild caves at Yarrangobilly be improved? There is probably no single solution, but it is suggested that a multi-pronged approach is used:

- more clearly delineating track margins;
- cleaning beyond the marked track;
- issuing track notes to each visiting party;
- giving specific instructions before entering a cave; and
- specifically excluding access to areas outside marked tracks unless there is a valid (and approved) reason for doing so.

Acknowledgements

This paper would not have been possible without the support of many people, including current and former NPWS staff at Yarrangobilly Caves and in particular George Bradford, the current Manager and Jo Vincent (nee Ingarfield), a former Manager. In addition, the assistance of various members of the Canberra Speleological Society Inc (CSS), who have worked on trail marking and cleaning projects at Yarrangobilly since the early 1980s, is gratefully acknowledged.

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Close to the bone: Revamping the Victoria Fossil Cave visitor experience.

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Abstract

The viewing area in Victoria Fossil Cave was established in 1970 to allow visitors to the cave to view the fossils deposit. It was built during a phase of active research when researchers were often in full view and able to speak to visitors about recent discoveries. The original infrastructure elevated visitors but there were many shortcomings with the design.

- Line of sight for visitors was compromised with handrails interrupting the view of the deposit.
- Visitors were a substantial distance from the deposit and close up viewing not possible without compromising safety of visitors and fossils.
- Visitors could get no sense of the size of the deposit due the cave morphology.
- Materials used in infrastructure were by today's standards inappropriate, steel handrails that had rusted. The paths and platform were concrete.

The redevelopment set out to achieve 7 objectives

- To create a clearer view of the deposit when viewed from a distance.
- To allow visitors a close up view of fossils.
- To provide visitors with a view of the entire deposit to give a better sense of its dimensions.
- To utilise more cave friendly materials for protection of the cave environment and utilise "reversible" infrastructure-for easy removal when the time comes.
- To create a more comfortable and flexible working environment for site interpreters.
- To create a more comfortable environment for visitors.
- To create a more immersive, interactive visitor experience

This paper outlines the thinking and processes behind the redevelopment of the viewing area, difficulties and how they were overcome.

Introduction

Naracoorte Caves National Park is a World Heritage Site listed for extensive fossil remains found within caves in the park. Although fossils were reported as early as the 1860's (Woods 1862) with additional small finds in 1908, fossils as a tourism product was not implemented until 1970 after the discovery of an enormous fossil deposit (now called the Fossil Chamber) in Victoria Cave (now Victoria Fossil Cave). The site was developed with the objective of linking research to tourism and was complemented with a display in a small visitor centre (Wells *et al* 1979, White 1999). Development was constrained by difficulties creating access to the Fossil Chamber and by materials available at the time. The cave was relit in 1993 with some sections of Victoria Fossil Cave improved with the removal of rubble left through creating visitor access, replacing out dated infrastructure and further upgrading of lighting systems (Bourne & Bradford, 2003). The Fossil Chamber itself was largely the same as it was first developed with concrete paths and galvanised steel handrails. A grant was received from the Australian Government through the Natural Heritage Trust World Heritage program. This paper describes the redevelopment of the Fossil Chamber and recreating a more immersive visitor experience.

Fossil Presentation

Fossils have been an integral part of the Naracoorte Caves experience since 1970. Access to the Fossil Chamber was established soon after its discovery through a partnership and vision of both management and researchers to present science as a tourism

product (Wells *et al* 1979). Initially, visitors could interact with scientists excavating on their monthly forays to the site and witness exciting discoveries first hand. After five years trips became less frequent and then focussed on sections of the deposit away from visitors line of sight. A display interpreting the fossil history was established at the main visitor precinct approximately 1.5km north of the cave.

Small improvements were made to the presentation of the Fossil Chamber with a replica skeleton of a extinct short-faced kangaroo *Simosthenurus occidentalis* and later a Marsupial Lion *Thylacoleo carnifex* added. Site Interpreters' in cave resources were regularly updated including sketches of extinct megafauna, casts and modern comparative bone material. Presentation of the fossil values was greatly enhanced with the opening of the Wonambi Fossil Centre 4 December 1998. The computer-animated models of extinct megafauna brought the fossils "to life" for visitors and established a focal point for regional tourism.

Despite the significant investment in fossil presentation above ground and advances in other areas of Victoria Fossil Cave, the main infrastructure in the Fossil Chamber had not been altered since its installation. The visitor experience offered was no longer adequate at a World Heritage Site so a project was developed and funding sought for its implementation. A grant of $100,000 was received from the Australian Government through the World Heritage program within the Natural Heritage Trust.

Project Objectives

A number of objectives were established for the project as a sub set of the overall goal of improving the visitor experience, in line with Guidelines for Cave and Karst Protection (Watson *et al* 1997) and based on principles outlined by Hamilton-Smith *et al* (1999) and Spate *et al* (1999).

- To improve viewing of the fossil bed from a distance
- To allow visitors a close up look of the fossil deposit
- To provide visitors with a view of the entire deposit
- To remove old infrastructure and replace with more cave-friendly materials
- To create a more flexible working environment for site interpreters
- To improve comfort for visitors
- *To create a more immersive, interactive visitor experienc*e

Project implementation

Consultation

Many stakeholders were consulted with this project. Fossil values at Naracoorte are protected under the World Heritage Convention 1972 and the South Australian National Parks and Wildlife Act 1972. In addition, Victoria Fossil Cave has been placed on the South Australian State Heritage Register. Palaeontologists were consulted regarding the placement of infrastructure closer to the fossil deposit than was currently in place; a heritage advisor gave advice on state heritage, and approval sought from the local council regarding development on a State Heritage Site. The project was also discussed with a number of ACKMA members and a huge number of cave sites visited to view the materials that other cave sites were using. An ambitious plan was conceived to lower the main viewing platform by at least 60cm and over one metre at one point and install a new close up viewing platform immediately adjacent to the fossils. One of the major challenges to overcome was how to implement the project without closing the cave to visitors and continuing to provide satisfactory tours while the work was being completed.

Design

An architect was engaged to design the close-up viewing platform. The chamber was carefully surveyed and mapped and preliminary drawings provided. It became apparent that to enable Australian standard stairs to be built down to the platform even more rock than was originally thought would need to be removed. The drawings proved to be extremely valuable as they enabled contractors to be engaged to construct the stairs and platform while concrete and rock were being removed and the site was being prepared.

Stainless steel was the obvious choice as the frame for the platform. The handrail chosen

was a 38mm dimpled 316 grade stainless steel rail, selected for grip, durability in the cave environment and low sheen. A similar product had been noted in Waitomo but apparently is a rarely used product as it took many months to find a potential supplier. A fibreglass composite marketed as "Envirowalk" was chosen for stair treads and platform, a product used at Chillagoe and Jenolan and probably other cave sites.

Potential suppliers for the production and installation were sought and the successful tender had one strategy that separated his team from others: he would construct a timber replica and ensure this fitted prior to commencing work on the stainless steel final product to guarantee an exact fit. This was fortunate, as modifications were required to both the final drawings and to remove further rock from the cave to ensure a perfect fit. It also significantly reduced impacts on the cave with all welding construction in the workshop also giving a better engineered result.

Removing old infrastructure

Prior to the submission of the funding application, Conservation Volunteers Australia (CVA) was contacted regarding the possibility of their crews undertaking the bulk of the concrete and rubble removal. With approximately one third of available funds allocated to the stairs and platform and nearly the same for improving lighting, it left less than $40,000 for site preparation and establishing new paths. Engaging contractors or employing extra staff to undertake the work would have been well beyond the budget.

CVA supplied teams of volunteers, mostly international on the basis of one week paid and one week cost covered by one of their corporate sponsors. Teams varied in size with up to eight people and a supervisor supplied. Work commenced in December 2007 and removed approximately five square metres of concrete path and rock to a depth of approximately one metre. This work was just beyond the access for visitors and site interpreters hence minimal disruption to cave tours. All material was removed from the cave which involved placing it in ten litre buckets, carrying approximately 30 metres and down a short staircase, placing six buckets in a wheelbarrow and transporting over 50 metres along the concrete pathway to the winch hole; an 18 metre deep, half metre diameter shaft drilled into the cave in the 1970's as an access point for construction materials. Buckets were then emptied into a 60 litre steel bucket and lifted to the surface using an electric winch and emptied in a trailer to the transported away from the site. At peak efficiency ten cycles of the 60 litre bucket could be achieved each hour. The task appeared daunting to say the least, but with energetic volunteers working as a team progress was quicker than expected.

Work was halted over the summer holiday period and commenced again as visitation slowed. Keeping the cave open and tours running became challenging and a strategy was employed. Work would commence before 8 am and continue until 10.30 am when the site was prepared for visitors. Plastic chairs were brought in as seating and tools and the worksite covered with hessian. It was fairly crude, but effective however visitors seemed to quite understand that it was work in progress and appreciative they could still visit the cave. Workers left the cave by 10.45 am and returned at 11.30 am. The next shift would continue until 2.30 pm when the cave was again prepared for visitors. Workers entered the cave again at 3.30 pm and continued until exhaustion set in or enthusiasm waned. Working conditions were so humid and the work so demanding a change of shirt was necessary for every shift! All steel handrails, approximately 50 metres were removed from the cave when it was deemed safe enough for visitors to access without them.

Teams exchanged after five days although one extremely enthusiastic hard working English volunteer stayed for the entire ten day shift. His dedication to the project was apparent when he returned after Easter for the final shift. A Green Corps team working on the park were enlisted for the final push to completion. A total of 170 "person days" were taken to remove approximately 30 square metres of concrete path and 20 cubic metres of limestone rubble. It was felt that most of what was removed was material originally moved to the site to establish the viewing platform, confirmed when cigarette packets and soft drink cans were recovered from deep within the removed material.

Installation

As rock and concrete removal was progressing, retaining walls were constructed. In some sections it was possible to use the natural cave

as a barrier. In keeping with the objective of improving viewing, all modifications were made to ensure safe visitor access could be achieved without handrails except those on the stairs and viewing platform. Retaining walls were constructed from rocks broken up from the old viewing platform to reduce (albeit slightly) the amount of material to carry out of the cave.

Pavers were chosen to replace the concrete floor for relative ease of installing and their removability should alterations be required in the future. Brick size limestone coloured pavers were selected over larger pavers for largely aesthetic reasons. Once the floor level was close to the desired level, it was pounded with crowbars and sledgehammers to provide the necessary base material for laying pavers. A small amount of limestone "crusher fines" were brought into the cave for a level surface for paving. The Green Corps team transported the pavers into the cave as back loads for the winch removing rubble. Like every other part of the project, it was laborious and demanding but achieved through persistence of the crews involved.

The laying of the pavers was possibly the easiest part of the project. All cutting was done outside the cave to avoid dust and all paving completed in two short days.

The stainless steel and Envirowalk viewing platform was constructed external to the cave and brought into the cave in sections. Installation was completed in five hours.

Part of the project was the upgrade of lighting to create more mystery and atmosphere in the Fossil Chamber. A Clipsal C-Bus system was chosen because of its remote capabilities and for the ability to "ramp" lights on and off. To maintain consistent lighting throughout the cave, dichroic lamps were chosen rather than upgrading to LED technology. It is proposed to upgrade the entire cave in the short term. The C-Bus system was only installed in the Fossil Chamber as the linear nature of the rest of the cave provides limited opportunity for the system.

The final result

The project was completed in July 2008. The new viewing area has been well received by cave visitors and site interpreters alike. All objectives were met and the project came in on budget. The new infrastructure meets the current best practice in cave management and will be easily removed should the need arise in the future. It could not have been achieved without the use of volunteers of Conservation Volunteers Australia and Green Corps. Their teams' dedication and commitment to achieving the best possible result ensured success and made it a most enjoyable project. The ongoing support from the Australian Government through the World Heritage funding program has greatly improved the presentation and management of the Naracoorte Caves World Heritage site.

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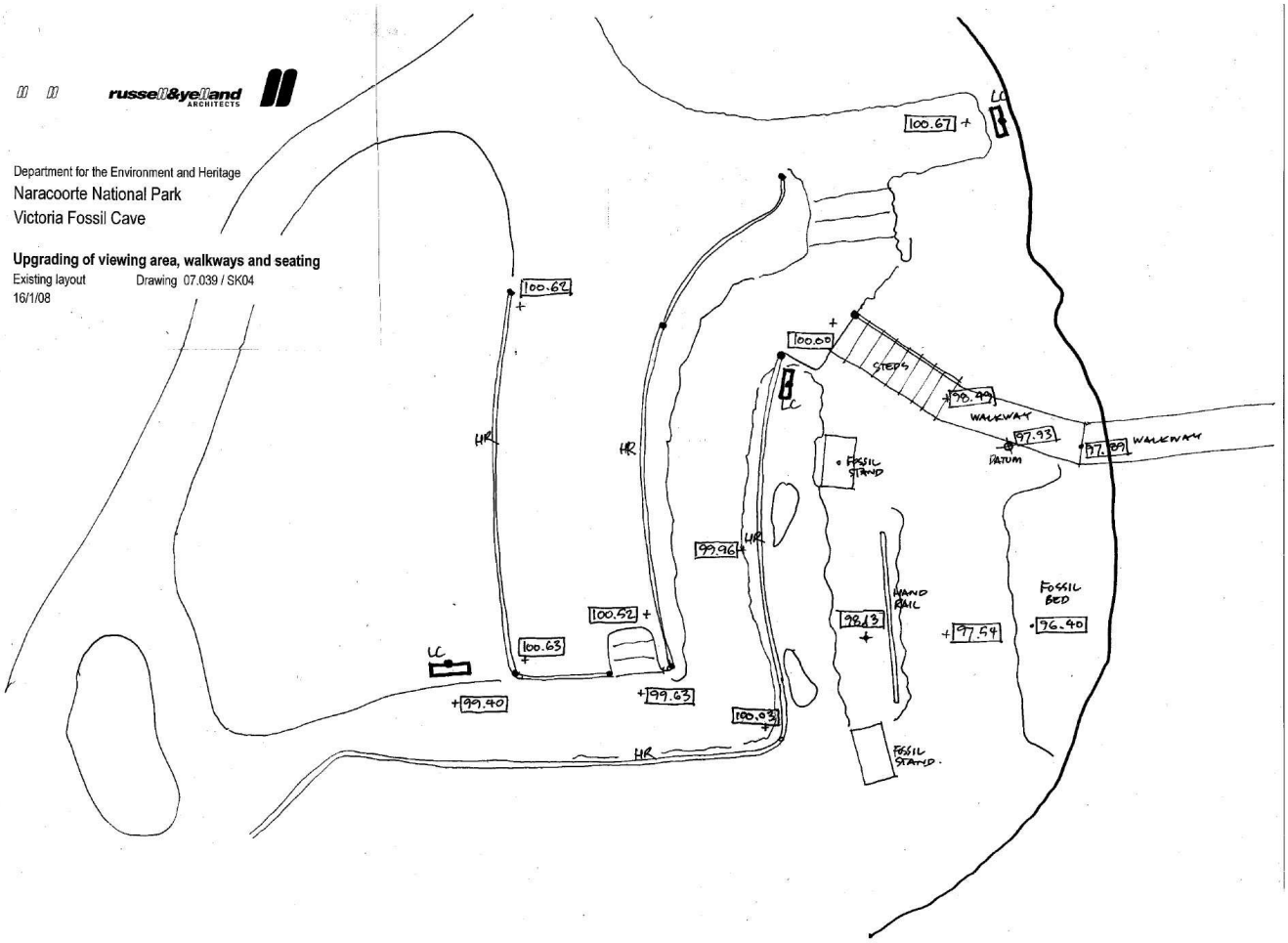
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Department for the Environment and Heritage
Naracoorte National Park
Victoria Fossil Cave
Upgrading of viewing area, walkways and seating
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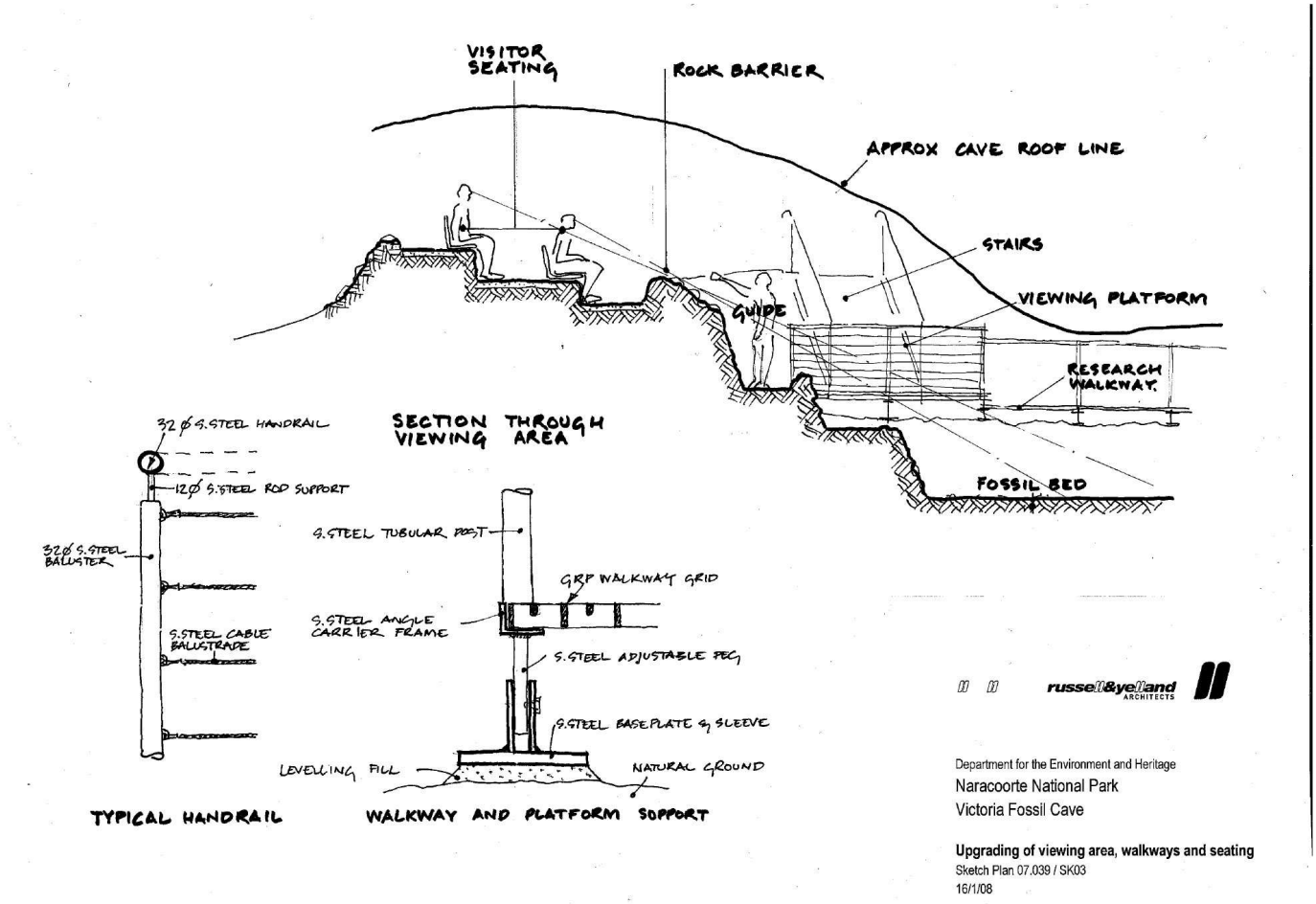
VISITOR SEATING
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APPROX CAVE ROOF LINE
STAIRS
VIEWING PLATFORM
GUIDE
RESEARCH WALKWAY
FOSSIL BED
SECTION THROUGH VIEWING AREA
32 ø S.STEEL HANDRAIL
12 ø S.STEEL ROD SUPPORT
32 ø S.STEEL BALUSTER
S.STEEL CABLE BALUSTRADE
S.STEEL TUBULAR POST
GRP WALKWAY GRID
S.STEEL ANGLE CARRIER FRAME
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Department for the Environment and Heritage
Naracoorte National Park
Victoria Fossil Cave
Upgrading of viewing area, walkways and seating
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White knuckles in the underworld: the 'wild' days of the Tasmanian Caverneering Club

Nic Haygarth and Arthur Clarke

Abstract

Australia's first speleological organisation, the Tasmanian Caverneering Club (TCC), was established in 1946. It ushered in an exciting post-World-War-II era of cave discovery in Tasmania.

The TCC's instigator, geology professor Sam Carey, channelled students, field naturalists and bushwalkers into underground exploration. Equipment and techniques were relatively primitive. Sam's war-issue Blitz Wagon vehicle was kept busy answering government requests that the TCC explore and advise on existing and former show caves. At Newdegate Cave at Hastings, the Binney Tunnel was excavated with the idea of opening new underground passages to tourists.

Wild caves and white knuckle adventures were the real revelation, however. The Ida Bay karst in southern Tasmania remained largely unexplored more than half a century after Europeans first entered some of its caves. Both Mystery Creek Cave and Exit Cave were probed, with astonishing results. In northern Tasmania, the discovery of Lynds Cave, and the gradual revelation of Croesus and Kubla Khan's splendours (particularly Kubla Khan's spectacular 'Pleasure Dome' chamber), were early highlights.

In 1960 a northern branch of the TCC established by Launceston-based member Bob Woolhouse and others extended cave exploration in the Mole Creek region.

Some early cavers returned to the terrestrial world of bushwalking, rock-climbing or bird-watching. Increased leisure time, improved camera technology and specific speleological interests, especially cave biology, gave others new scope for developing their subterranean interests, however.

Introduction

One night in June 1943, by the light of the moon, nine men paddled across Cleveland Bay from Magnetic Island in northern Queensland. It was war time, and floating mines guarded Townsville Harbour. Had the 'friendly' invaders been spotted, these mines would probably have been detonated, with potentially fatal results. The men in the 'folboats' — folding canoes — moved smoothly into the harbour, however. Silently they negotiated the minefield and, led by Captain S Warren 'Sam' Carey, approached 15 docked vessels, including two Allied destroyers. Amidst the hubbub of stevedoring, the Z Special Unit operatives fixed a disarmed limpet mine to each ship — then retired to breakfast in town.[1]

This surprise stunt should have been a triumph for Carey. It proved the feasibility of 'Operation Scorpion', his secret plan to attack the Japanese fleet by canoe in occupied Rabaul Harbour, New Britain. Embarrassing the Allied defences in Townsville won him Allied enemies, though, and lack of available back-up thwarted Scorpion's implementation. Instead of limpeting the Japanese, covert operative Carey had to content himself with parachuting out of a BG Liberator bomber.[2]

A trained geologist, Sam Carey will also be remembered for subterranean exploits. He instructed his war-time commandos in 'caverneering', as he called it, using the Mount Etna Caves near Rockhampton as a secret training ground.[3] Carey preferred the term 'caverneering' to 'caving', because he believed 'caving' carried unfortunate connotations of a 'cave in' or suggested 'cavemen'.[4]

When post-war settlement brought Carey to Tasmania as Chief Government Geologist (and later Professor of Geology), he had the skills, the will, the technology, plus the military and professional bearing, to forge a 'caverneering' revolution. Tasmania's four present show caves opened before World War II, with Newdegate Cave at Hastings the last to be discovered in 1918. Cave exploration, on the other hand, was generally a spontaneous activity. There were few dedicated cavers — and the general public knew of few 'wild' caves.

The Tasmanian Caverneering Club (TCC), which Carey established in 1946, changed this situation. The objects of Australia's first speleological organisation were

> to foster Caverneering [sic] in Tasmania. To explore and survey Tasmanian caves, study cave fauna, and cavern phenomena generally, and to place on record the results of such investigations, and to offer them for publication in scientific journals and magazines. To endeavour to ensure the preservation of Tasmanian caves and to protect them from vandalism. [5]

Here, then, was an organisation whose stated aims included exploration, scientific study and preservation — virtually a blueprint for developing today's karst consciousness.

Carey's efforts accelerated cave exploration and expanded cave and karst conservation in the post-World War II period. The Mole Creek Karst National Park is one of many expressions of this growth. Wild cave tours and adventure caves have joined the four show caves as a means of introducing the general public to karst.

Tasmania's post-war bounty

Carey's vision of Tasmania's 'underground wonders' is reminiscent of immigrant responses to the island's terrestrial landscape. If Carey was not overwhelmed by the subsurface landscape like, for example, 20th-century highland tourism operator Gustav Weindorfer was by Cradle Mountain, he emulated Weindorfer in selecting a field for scientific investigation and advocating its protection.[6]

Several more recent arrivals have been seen to bring an enlightened European or global perspective to the Tasmanian environment, shaking local complacency about the island's magnificent natural heritage.[7] Three conservationists come to mind in this regard: the kayaker/photographers Olegas Truchanas and Peter Dombrovskis; and a mainland *immigrant* who has also been known to wield kayak and camera, Greens leader, Senator Bob Brown. Truchanas and Dombrovskis, who were instrumental in efforts to save Lake Pedder and the Franklin River from hydro-electric development respectively, both came to Tasmania from Europe as the result of the World War II political shake-up and the post-World-War-II resettlement it shaped. Dombrovskis had a short, brutal experience of Europe, being only five years old when he left war-ravaged Latvia in 1950, but his mentors had a global perspective. He learned kayaking and photography from Truchanas and came under the spell of internationally-known conservationist photographers like Ansel Adams.[8]

World War II delivered Tasmania other nature-lovers. An exotic perspective on the landscape was not the only useful attribute of these migrants. A few brought experience in caving and related sports like hiking in their native place. Secondly, curiosity about their new home led some to explore the Tasmanian environment. A third attribute was the need to socialise, to make new friends in a new place, encouraging them to join clubs.

The war conferred more than settlers on Tasmania, however: it spawned advances in transport technology and army surplus gear such as four-wheel-drive vehicles, rubber rafts and hardhats. These were a boon to developing adventure sports. In the years 1949-51, for example, kayaking parties used army surplus folboats to negotiate the then wild King, Pieman and Franklin Rivers.[9] War-time training exercises and military fitness regimes encouraged the take-up of adventure sports in peace time when, all of a sudden, demobbed troops brought leisure time, disposable incomes and a sense of release from war-time constraints to bear on their ex-army equipment. By the late 1950s and early 1960s, many of these Tasmanians also had private motor vehicles, making them increasingly mobile.

The exploration bug

The TCC was born in 1946 when Carey persuaded bushwalkers, amateur botanists and geology students to explore Tasmania's karst topography.[10] Exploration was an attractive concept. When Olegas Truchanas arrived in Tasmania from heavily populated Europe in 1948, the former Lithuanian resistance fighter was intrigued by the idea that he might be the first person to see parts of almost unpopulated south-western Tasmania — and the same sense of 'being the first', an explorer or a pioneer, applied to caving, only the *terra incognita* of cavers was underground, rather than on the surface.[11] 'There was a cave I went into,' TCC member Paul AC Richards recalled,

> …and I was fairly thin and small and was able to squeeze into this small chamber. There was the exhilaration of

> being the first person, the only person in this whole universe to have been there.[12]

Some enjoyed exploration or adventure in both realms. Caving and bushwalking, another growth sport of the time, complemented each other and overlapped memberships. In 1947, for example, Hobart Walking Club member and foundation TCC member Leo Luckman led unsuccessful attempts on unclimbed Federation Peak.[13] In 1953-54 the Luckmans and fellow caver Edith Smith retraced Sir John and Lady Jane Franklin's epic 1842 march from Lake St Clair to Macquarie Harbour, through the Franklin River forests.[14] Other avid hikers among early TCC cavers included Peter Allnutt, Rhona Warren, Ken Iredale, Heather Gulline, Des Lyons, Pat Higgins (later Pat Wessing) and Joe Piccone.[15]

Caving's incorporation of elements of new adventure sports like rock climbing and rafting probably also won it converts. Carey taught TCC members the basic techniques of cave surveying and rock climbing. With war-time rationing still in force, available equipment was basic. Ex-army boots, heavy, steel, army-issue helmets, hemp ropes and hand-held carbide lamps were used at first. Boiler suits, gloves and torch batteries were then hard to come by. Ladders were constructed from wire and tubing in members' back yards. Paraffin wax, linseed oil, castor oil and even mutton fat were used as waterproofing agents.[16] Karabiners were unobtainable locally, with the result that in abseiling

> the rope had to be wound around the bottom, and you lowered yourself down slowly. Des Lyons tried to speed it up one day, and got a rope burn in a very awkward place. So we had to import karabiners from England. We didn't really have any gear at all.[17]

Photo: Joan Hallam practising her abseiling at Taroona about 1946. Photo by Leo Luckman courtesy of Jessie Luckman.

TCC's first assignment came from the Tourist Department, manager of three Tasmanian show caves and charged with general responsibility for promoting tourism in Tasmania.[18] The Tourist Department asked the new club to explore beyond the tourist sections of several caves and to devise master plans for future development. Unfortunately government later ignored all the TCC master plans.

One remarkable endeavour which did result from this activity, however, was the four-year excavation of the Binney Tunnel. This was dug to provide 'all weather' access to new chambers which the TCC found beyond a sump in Newdegate Cave at Hastings. One such chamber was christened the Mystery Chamber, because it contained 'mysteries' or helictites, which fascinated early cavers. The Binney Tunnel also opened the Binney Chambers or Caves — both features being named after Tasmanian Governor Sir Hugh Binney, who was the club's patron. The excavation was painstaking, cavers being able to work only five or ten-minute shifts by candle light with a restricted oxygen supply in the cramped conditions.[19]

Photo: Tasmanian Caverneering Club surveying the underground river, Newdegate Cave, 1946. (Left to right) Max Stephens, Pat Kirwan, Jessie Luckman, Neil Jones. Photo by Leo Luckman courtesy of Jessie Luckman.

Photo: TCC descending into Erebus Cave, Hastings, probably in 1948. Photo by Ken Iredale.

Photo: Ken Iredale digging in the Binney Tunnel, Newdegate Cave, some time in the period 1948-50. Photo by Leo Luckman courtesy of Jessie Luckman.

Finally, in September 1950, the Binney Tunnel was ready to accommodate Sir Hugh Binney himself. The Governor was not very sprightly, but it was reasoned that his performance in the confined space might be improved by placing two female cavers in front of him. Sure enough, Binney's refusal to be upstaged by ladies spurred him to squeeze through the tunnel. TCC secretary Ken Iredale had the pleasure of pulling the Governor's leg, quite literally, by hauling him out of the far end and into the Binney Caves.[20]

Widening horizons

TCC also ventured into the Gunns Plains and Mole Creek districts, exploring the newly discovered Lynds and Croesus Caves near the Mersey River. The club's means of transport to these areas was an almost asphyxiating World-War-II 'Blitz Wagon'. In fact, travelling in this vehicle was almost as hazardous as digging the Binney Tunnel, as Jessie Luckman recalled:

> It was an awful thing. If you were inside, it sucked up all the exhaust. Sam [Carey] of course drove like a maniac. He never went around corners. He always went through them. They [passengers] would have to be allowed out every now and then to breathe. It was a death-trap…[21]

Pat Wessing remembered passengers sitting on the wagon's roof in order to breathe better, their feet dangling through the trapdoor. While travelling through towns, they would duck to avoid the attentions of the police.[22] An inflatable rubber raft shared the Blitz Wagon's roof space.[23]

Long straws in Lynds, Little Trimmer and Newdegate Caves prompted TCC caver Des Lyons to speculate about world records, but greater revelations awaited.[24] In 1954 a TCC party penetrated beyond the entrance chamber of Exit Cave for the first time, beginning the process of exploring a cave system now (in 2009) known to extend more than 30 kilometres. Getting to and from Exit then took most of the weekend, caving being done only on the Saturday evening. The 'Wind Tunnel' passage, the remarkable 'Pendulum' formation and Exit's spectacular glow-worm display were unveiled. Rising waters holed the seven-member TCC party up in the same two-person tent made by Jessie and Leo Luckman out of an old parachute — another example of army issue improvisation.[25]

A notable debutante on that trip, Albert Goede, featured prominently as TCC ventured far and wide. In December 1957, with the aid of airforce-surplus rubber rafts, Goede, Jim Poynter and Frank R Brown were the first to enter and be dazzled by the 'Pleasure Dome' in Kubla Khan.[26] Two years later a five-man TCC party flew into New River Lagoon one by one to explore caves near Precipitous Bluff. A dickey seat behind the pilot's was the only passenger accommodation on the 'one-and-a-half-seater' Tiger Moth.[27] Keen cave photographer Rien de Vries was disappointingly sans camera when he spotted a thylacine beneath the Raglan Range while on a later trip to scout for limestone caves on the Franklin River. [28]

Photo: The discovery of Kubla Khan's 'Pleasure Dome', December 1957. Jim Poynter mesmerised by helictites. Photo by Albert Goede.

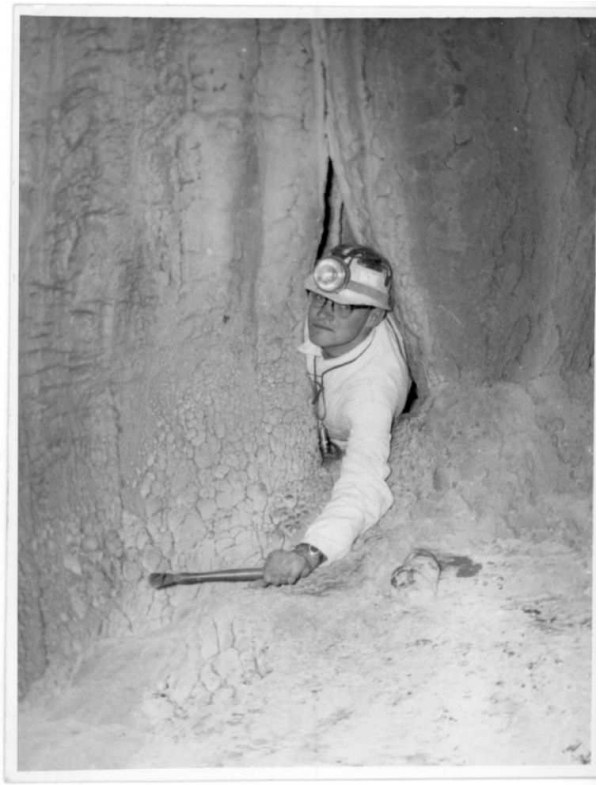

Photo: Albert Goede exploring the 'Pleasure Dome', Kubla Khan, December 1957. Photo by Frank R Brown courtesy of Albert Goede.

The Luckmans were among those who eventually renounced caving for hiking. 'We were much more interested in being out in the sun', Jessie recalled, 'and left the caving to the caverneers…'[29] Optometrist Ken Iredale, who spent his working day in an office, likewise opted for wide open spaces over tight subterranean squeezes.[30] The development of specialised interests such as cave biology, hydrology and cave photography encouraged others to stick with the underground sport. In these specialised fields, amateurs entered a realm previously dominated by professionals. '…we want to find the new stuff [undiscovered caves]', wrote the editors of the 1963 TCC *Caverneering Handbook*,

> but if you prefer to take photographs or do serious studies of the hydrology or biology of caves we'll welcome you with open arms too.[31]

Just as caving and hiking were allied, TCC overlapped membership with the Tasmanian Field Naturalists' Club, established in 1904. Sam Carey, Max Banks, Jessie Luckman, David Elliott and Rhona Warren were among those who joined both clubs.[32] TCC members began collecting cave fauna at Mystery Creek Cave in 1947, but some years passed before speleos became serious collectors of Tasmanian cave fauna.[33] The first to do so were Elery Hamilton-Smith, the husband and wife team of Albert and Therese Goede, and Bob Cockerill. Hamilton-Smith's articles and Aola Richards' introductory paper describing JR Schiner's ecological classification of cave animals, together with the cave zones and habitats proposed by René Jeannel, encouraged development of this interest.[34]

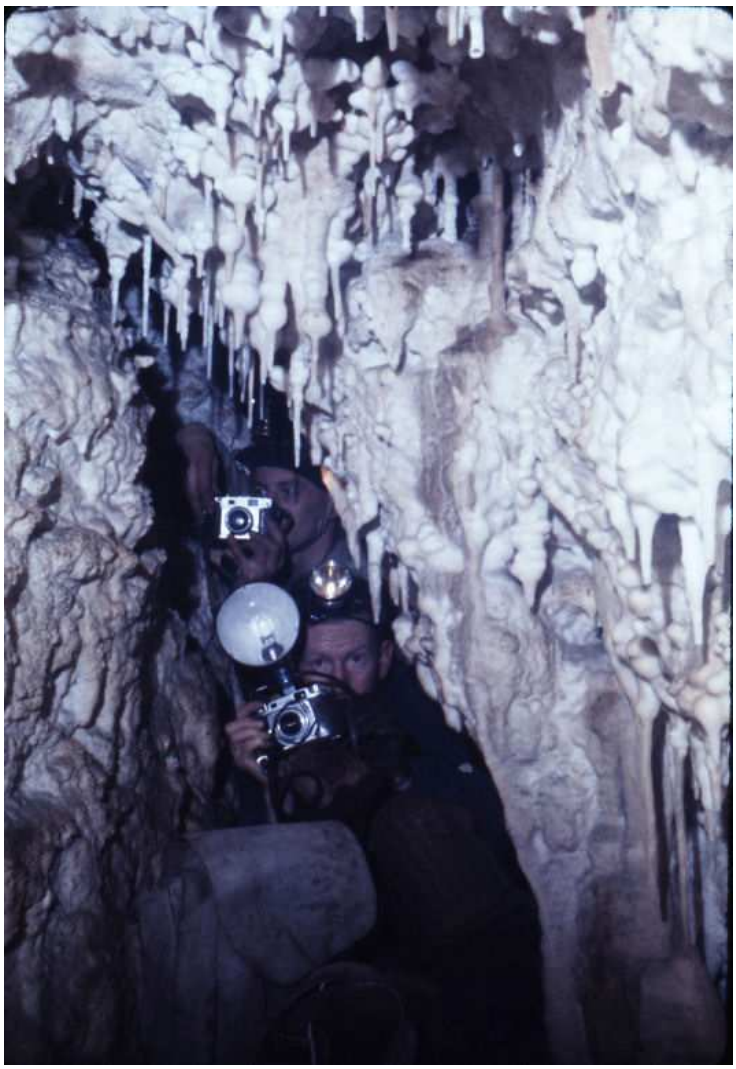

Photo: 'Photrogs' in Baldocks Cave, 1963. Photo by Bob Woolhouse courtesy of Gill and Keith Chapman.

From its early days, photography had a social and documentary role in outdoor recreation. The visual recording of events, achievements and camaraderie has bonded sporting club members and helped generate a club identity. Some adventure sportsmen took their interest in photography further, however, recognising the opportunities afforded by being 'on location' which were denied the non-sporting professional photographer.

With the advent of recreational caving, cave photography became much more dynamic. What cavers lacked in technical camera skills, they gained in spontaneous action subject matter: the frightening descent of a steep pitch, for example, or an awe-struck caver locked in a moment of discovery. Photography also became more user-friendly in the post-war period. Flash powder, with its potentially explosive and frequently suffocating results, had long been the chief source of underground illumination. Flash sheets, a paper form of flash powder, magnesium ribbon and, eventually, the entirely smokeless flash bulbs improved the accuracy of exposures. Electronic flash units were cheaper, but dangerous to operate in damp cave conditions and unsuitable for producing the Kodachrome or Ektachrome colour transparencies which were now favoured.[35] Ken Iredale and Rien de Vries were among the first TCC cavers to embrace colour photography, with Mole Creek cave exploration their central theme.

The young guns of Launceston

In 1961 a Northern Branch of TCC was established in Launceston by a British immigrant with overseas caving experience, Bob Woolhouse, and Brian Duhig. It differed from its parent body in that none of its early members were hikers. TCC Northern Branch had a significant membership cross-over, however, with the Northern Alpine Club. Cavers such as Ralph Power, Bob Yates, Noel Barratt, David Barratt, Ian Gasking and Gerald Lewis represented the Alpine Club's new guard during the 1960s.[36] Interest in geology, hydrology and fauna infused Northern Branch caving from its outset. Teenager Paul AC Richards, for instance, experimented with exposing an x-ray plate by glow-worm light, and marvelled at the development of 'cave pearls' in Croesus Cave's gour pools.[37] Improvisation and a sense of being pioneers characterised the new branch just as it did the established one. Ladders were manufactured from durallium and wire on a template in Frank C Brown's back yard. The photographic team of Woolhouse and Brown improvised an effective flash system — a 'flash gun', as they called it — out of an old army torch which fitted onto Brown's helmet. When Brown 'saluted', as he put it, he triggered a button on his visor, which illuminated Woolhouse's camera shot. The pair concentrated on capturing caving action — and there was plenty of that.[38]

Photo: Bob Woolhouse at the entrance to Little Trimmer Cave, Mersey River. Photo by Frank C Brown.

Photo: TCC Northern Branch exploring a flooded Hidden Cave, 1963. Photo by Bob Woolhouse courtesy of Gill and Keith Chapman.

One of the Northern Branch's first exploration targets was Marakoopa Cave beyond the tourist section. In 1963 three Northern Branch members, Bob Yates, Gerald Lewis and Ralph Power, were trapped in the sump known as the Fireplace at Marakoopa for 12 hours when it flooded.[39] At around the same time, Rover Scouts associated with the club verified the top entrance to Croesus Cave — by shooting a hole through it with a pistol from inside the cave.[40]

The dolines around Devils Pot in the foothills of the Great Western Tiers were so enormous that, as Bob Woolhouse put it, 'the normal clues for navigating about sloping ground don't work'. Dolines dropped away to 'great holes'. They were so steep that the old eucalypt forest they contained had escaped logging. Consequently the eucalypts were dying, leaving a criss-cross of massive trunks for the explorers to stumble over.[41] On the club's first Devils Pot trip only the roar of its waterfall led the cavers through the sleet. Bob Woolhouse recalled that

> We got down until things began to seem a little dicey and then we put a rope on Gaskin [sic] and sent him to see what happened. He got down another 80 feet or so [about 25 metres] until he looked over a ledge and saw a possum below him. The possum stepped backwards, missed the ledge and somersaulted slowly out of sight. It was a long time before it hit anything. We retired rather shaken.[42]

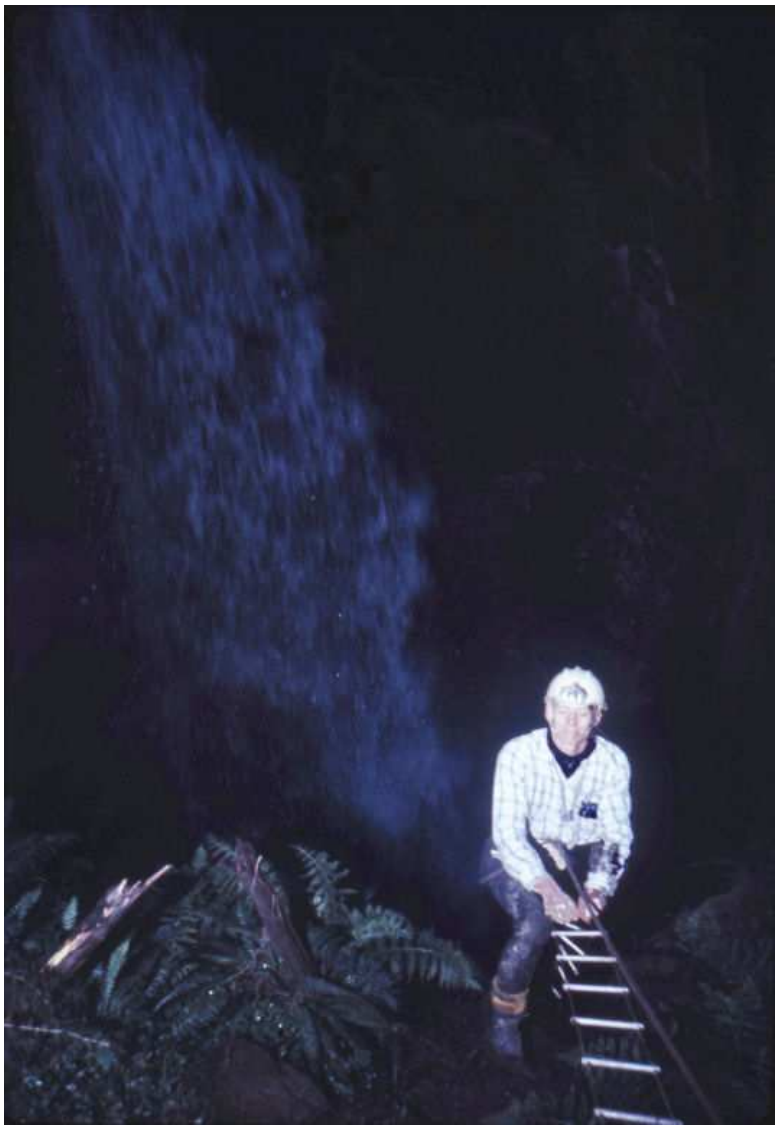

Photo: TCC Northern Branch descending into Devils Pot. Photo by Bob Woolhouse courtesy of Gill and Keith Chapman.

In 1965 Woolhouse descended the first pitch in the vertical shaft known as Execution Pot. Progress beyond this pitch depended on him being able to widen a small hole at its base with a crowbar. Woolhouse outlined the circumstances of his failure to do so in the club magazine *Troglodyte*:

> 11.35 Woolhouse clears large rock from passage, crawls in, clears second rock and pauses for breath
>
> 11.40 Realises he is not alone and goes from prone position to halfway up ladder in one graceful movement. Snake goes 4ft up wall where stopped by small overhang.
>
> 11.45 Woolhouse half way up ladder, snake 4ft up wall. Look at one another. Impasse...
>
> 12.10 Ford & Sterling push Wilkie down ladder armed with 3lb hammer.
>
> 12.20 Wilkie confirms existence of snake.
>
> 12.30 Poke snake off wall with long stick. Snake rears and announces it is a tiger.[43]

The tiger was tamed with the hammer, after which gelignite was invoked to clear the rock obstruction. When that failed to do the job, club member Ralph Power mysteriously produced two slabs of TNT. *Troglodyte* recorded the conversation as Paul AC Richards and Power placed the charge in the suitably-named Execution:

> **Ralph and Paul at the bottom of Execution**
>
> Paul: How many slabs are you going to use Ralph?
>
> Ralph: The whole flamin' lot mate.
>
> Paul: Hell you'll blow up Mole Creek mate.
>
> Ralph: Yeh what a pity, should stir them up a bit.
>
> Paul: OK, you know what you're doing mate.
>
> Ralph turns back for 0.1 second, to find that Paul is half way up ladder.[44]

With 9 metres of fuse and a 12-metre ladder climb to escape from the shaft, fellow TCC members retreated to the rim and watched while Power set off the charge. He lived up to his name. The blast rocked eucalypts on the surface and produced a hole cavers could enter, with a 60-metre drop beneath it. The cave system below was very disappointing, however, and the club never went back.[45]

Photo: TCC Northern Branch's first attempt to blast through the entrance pitch of Execution Pot, Mole Creek, in May 1966. This image - Fusing the gelignite.

Photo: Richard Porch and Noel Barratt lay the charge.

Photo: The blast shifted only a small volume of rock, necessitating further explosions. Photos by Bob Woolhouse courtesy of Gill and Keith Chapman.

Longneck challenge

Meanwhile, Ida Bay still challenged TCC's original Hobart-based branch. Inaccessibility frustrated Exit Cave's exploration. The cutting of the 'Kokoda Trail' over Marble Hill to the cave in 1959 reduced the approach time to six hours, but Dennis Seymour demanded better, posting a reward of two dozen longnecks (two slabs of beer) for the discoverer of a route through Mystery Creek Cave into Exit.

The cutting of a shorter external access track, the so-called 'Brooker Highway', by cavers in 1966 encouraged exploration beyond Exit's 'Rockfall'. With an estimate that only 1200 feet (about 360 metres) now separated explored passages from the far end of Mystery Creek Cave, imminent bacchanalia seemed assured.[46]

An astonishing find kept cavers sober. The establishment of Camp 2 inside Exit led to the discovery of the 'Mini Martin' vertical entrance to the cave, when a caver realised that the 'rock' he was sitting on was actually a fallen tree trunk — perhaps 150 metres below the surface. A scramble in the rainforest above by Brian and Jeanette Collin revealed the shaft opening. In August 1967 two TCC members, Allan Keller and John Marshall, set a new Australian depth record of 720 feet (about 220 metres) by descending 'Mini Martin' into Exit Cave.[47]

In February 1968 the hydrological link between Exit and Mystery Creek Caves was finally established when six pounds of green fluorescein dye released into Mystery Creek emerged from Exit.[48] In October of that year a tight squeeze discovered inside Mystery Creek Cave was marked by a matchbox — hence its name 'Matchbox Squeeze'. Suspicion of a vertical connection led cavers to scour the hill outside for an entrance they descended by ladder. 'Midnight Hole' recalls the late hour at which they found the same matchbox — and 'Matchbox Squeeze' — at the base of this daunting drop.[49] Not even a bottle could squeeze through the Exit-Mystery Creek dye channel, however, and only the sound of one longneck clinking toasts the 50th birthday of Dennis Seymour's unclaimed reward.

Exit wounds

In 1967 Tasmania's Hydro-Electric Commission announced that it planned what some considered the greatest vandalism ever perpetrated upon the state: the flooding of Lake Pedder. Preserving and protecting this lake soon became a defining showdown for many Tasmanians — and not just hikers or those who had previously considered themselves conservationists. If Gallipoli blooded Australian nationhood, the Lake Pedder debate blooded Green Tasmania.

The TCC was already campaigning to protect karst. Its charter, after all, included preservation of caves and protecting them from vandalism. While these aims may have been submerged sometimes in the dust clearing from gelignite explosions, the fog of despatching fearsome reptiles and the challenge of finding potential new tourist sections in established show caves, ecological awareness within the club was strong and the responsibilities of exploration understood. Unreserved caves such as Croesus and Kubla Khan were gated, best practice caving was encouraged, and, in the Australian Speleological Federation (ASF), club members found a national forum for cave conservation issues. The ecological impact of Tasmania's industrial economy had been apparent in karst areas long before the Middle Gordon Power Scheme threatened Lake Pedder.

In 1959 the Ida Bay karst was included in Australian Paper Manufacturers Ltd's logging concession. The TCC petitioned the Scenery Preservation Board to protect Exit Cave — the scene of astonishing new revelations as exploration intensified from the mid 1960s.[50] The proposal for an Exit Cave State Reserve, though, was an opening gambit in one of Australia's longest conservation disputes, one extending far beyond the bounds of caving clubs and beyond the scope of this paper.

Sam Carey had trained his commandos in the use of caves as a base for covert operations behind enemy lines.[51] Their training ground, the Mount Etna Caves, was later damaged by a peace-time 'enemy', limestone mining. Similarly, for years the karst environment of Exit Cave rocked to blasts from an encroaching quarry. The cave's deliverance from industry proved that political savvy, smart science, media skills and, above all, a 'greener' public were the keys to winning the modern conservation 'war'.

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Climate and Glowworm Monitoring at the Waitomo Glowworm Cave, New Zealand

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Abstract

This paper discusses two aspects of environmental monitoring at the Waitomo Glowworm Cave. The first is the automated climate monitoring system — the equipment in use, the purpose of the system, and its role in day-to-day cave management. The second topic outlines recent attempts to use photomonitoring methods to census the glowworm population.

Introduction

The Waitomo Glowworm Cave is situated in New Zealand's North Island, approximately 3 hours south of Auckland. It is a relatively small cave, with a passage length around 700m on two levels. The lowest level is a stream passage that contains a spectacular display of the bioluminescent glowworm, larval stage of the dipteran *Arachnocampa luminosa*. The cave was first explored in 1887 and has operated as a tourist cave since 1889. At the height of visitation (1996) visitor numbers reached over 400,000 per year. In 2008 there were 261,000 visitors to the cave.

Serious concerns over the cave's wellbeing and management practices were first voiced during the early 1970s. A period of research ensued, eventually leading to the formation of a scientific advisory group. Today that group is the Environmental Advisory Group (EAG). The role of the EAG is to advise the cave's operator on the protection and management of the cave and its contents.

Two key aspects of cave protection are managing the cave's microclimate and protecting the glowworm display. An automated climate monitoring system has been in operation since 1998. Many alterations and improvements have been made to the system during this time. Quantitative glowworm monitoring has been attempted in the past but a robust, long-term monitoring programme is still evolving.

Waitomo Glowworm Cave climate monitoring

Climate processes

The Waitomo Glowworm Cave has an upper abandoned phreatic level and an active lower vadose level. Each level contains an entrance. From its submergence, the stream flows through the Glowworm Grotto, sumps, resurges at the Demonstration Chamber then sumps again before resurging into the Waitomo Stream (Figure 1). The upper levels connect to the stream level in several places. The upper entrance was artificially enlarged soon after discovery to allow tourist access, and a door was later added for security. The door also allows cave climate to be managed.

The fundamental climate process in the cave is the airflow that occurs when a thermal gradient exists between inside (cave) and outside air. An upward airflow occurs when outside temperatures are cooler than the cave, as warm air rises out the top entrance. A downward flow occurs when outside temperatures are warmer than the cave, as cold air flows out the lower entrance. The door can be used to control the ventilation rate of the cave. Upward and downward flows are often associated with winter and summer respectively (Figure 2).

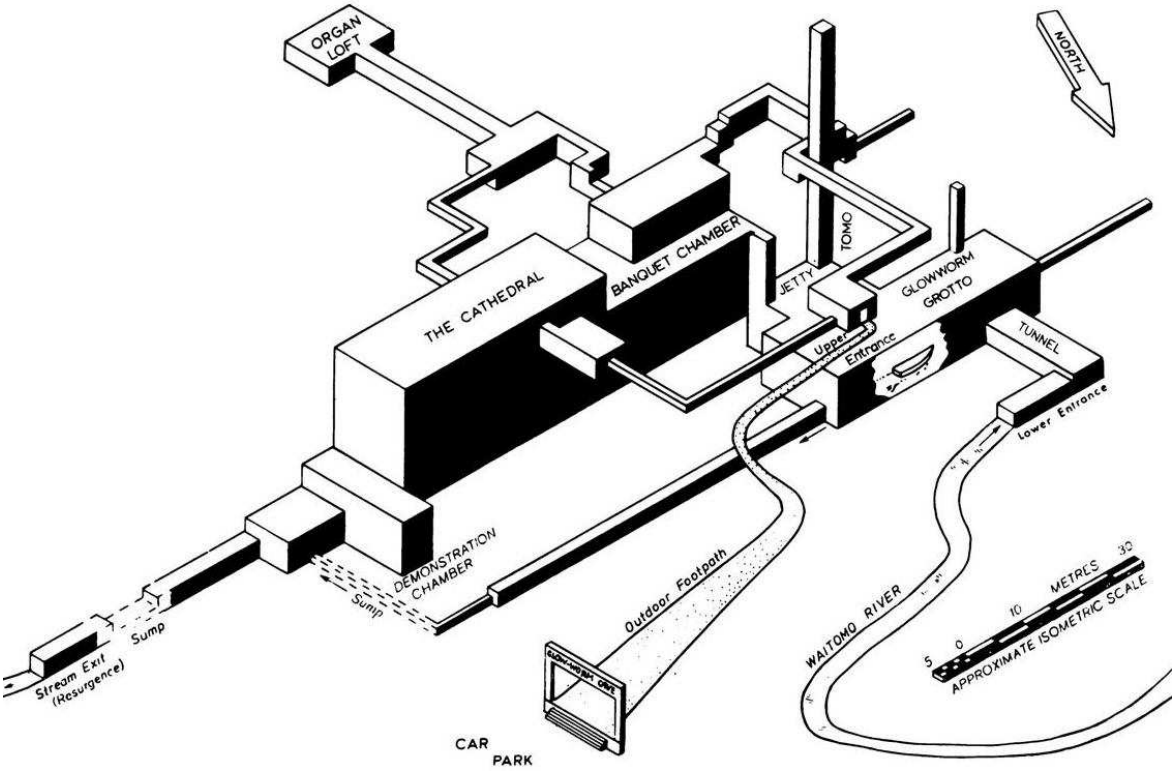
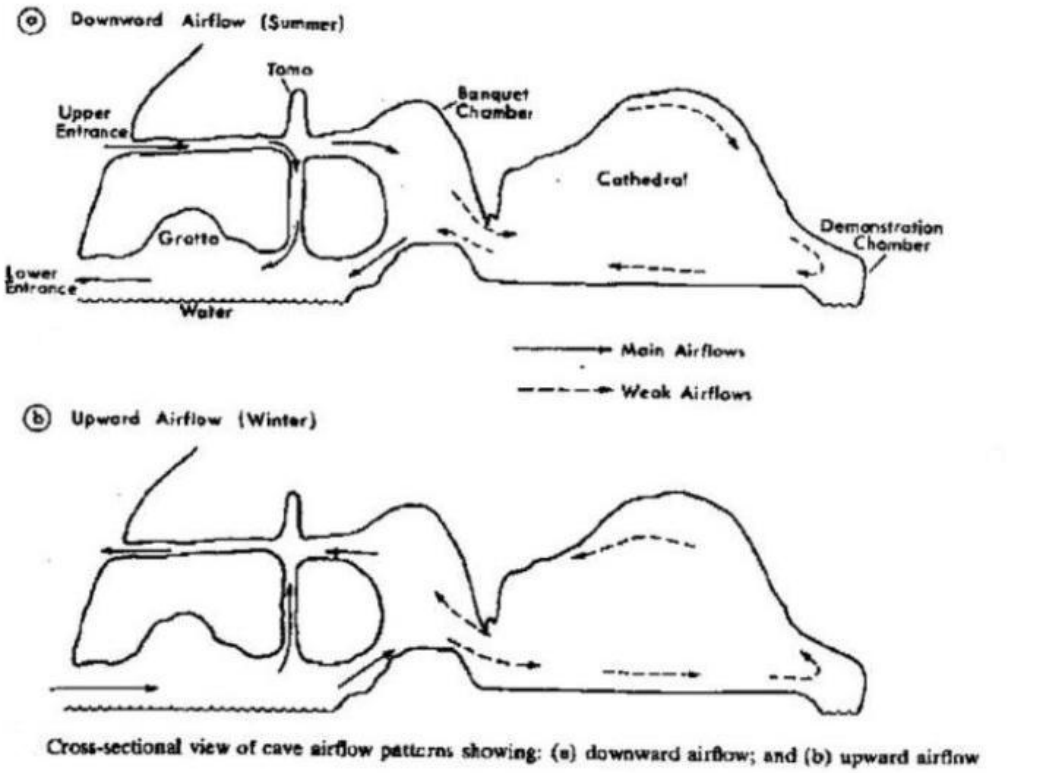


Figure 1. Schematic layout of Waitomo Glowworm Cave (from de Freitas *et al.*, 1982)



Cross-sectional view of cave airflow patterns showing: (a) downward airflow; and (b) upward airflow

Figure 2. Cross-section of the Waitomo Glowworm Cave showing airflow patterns when outside air is cooler or warmer than cave air (from de Freitas *et al.*, 1982)

Why monitor cave climate?

There are several reasons for monitoring cave climate in the Waitomo Glowworm Cave. The primary reason is to ensure tourism has minimal negative effect on the cave, the glowworm display and other cave features. Real-time climate data enables day to day environmental management decisions to be made as climate conditions, visitor numbers and other parameters change. Underlying this, the cave operator, Tourism Holdings Limited (THL), are obliged to look after the cave to a level specified in a lease agreement with the cave owners, the Ruapuha Uekaha Hapu Trust and the Department of Conservation. The lease includes requirements to monitor cave climate.

Potential effects of cave climate

Several climate conditions can have negative effects in the cave.

Excessive drying (evaporation) causes glowworm desiccation and damage to speleothems and other cave surfaces. These conditions occur with increased air movement, changes in temperature and reduced humidity.

Higher temperatures cause the glowworm killing fungus *Tolypocladium extinguens* to become more virulent (Figure 3a).

Low ventilation rates and/or high visitation rates lead to high carbon dioxide (CO_2) levels. This in turn increases CO_2 levels in percolation and condensation waters, leading to the corrosion of speleothems and rock surfaces. The Organ Loft is a dead-end passage that is particularly susceptible to CO_2 build up and has sustained condensation corrosion damage in the past (Figure 3b). Currently, tours in Organ Loft are restricted to early morning or late afternoon.

Figure 3a) Glowworm larva affected by the fungus Tolypocladium extinguens, which becomes more virulent at higher temperatures

Figure 3b) Example of condensation corrosion in the Organ Loft caused by historical high CO_2 levels (before real-time monitoring and ventilation management)

Automated climate monitoring system

Dataloggers

Climate monitoring at the Waitomo Glowworm Cave uses a network of 3 linked Campbell CR10x dataloggers: a master logger with 2 slave loggers. Data is collected and stored on the dataloggers, which are downloaded and archived every two weeks.

Data is also displayed real-time in the day supervisor's office. The real-time data is transferred to the supervisor's office via approximately 100m of 8 core copper cable. The data logger output signal is RS232, which does not travel well over long distances, so it is converted to RS485 then back to RS232 once it reaches the supervisor's office. In the future, fibre optic cable with a digital signal may be investigated, to avoid any possible electrical interference.

Sensors

Carbon dioxide is measured using non-dispersive infrared Vaisala CO_2 sensors with a 0-5000 ppm range. Temperature and humidity is measured using aspirated wet/dry bulb psychrometers with Campbell 107 sensors. Aspirated wet/dry bulb psychrometers are the most reliable way of accurately measuring high levels of humidity, such as those typically found in cave environments. Airspeed and direction are measured using a Young ultrasonic anemometer. An ultrasonic anemometer can measure airflow at lower intensities than a cup anemometer, and doesn't have the moving parts that require greater maintenance, or can fail, in the harsh cave environment. Outside temperature is measured with a Campbell CS500 temperature/humidity probe. Rock temperature is measured at 3 and 6 cm depths using bead thermistors. Rock temperature was initially measured using Campbell 107 sensors but these proved to be unsuitable. Experimental work is underway to determine better ways of measuring rock temperature. A magnetic switch records whether the door is open or closed.

Monitoring sites

Carbon dioxide is measured at two sites, cave temperature and humidity at three sites, airflow direction and speed at one site and rock temperature at one site. Outside temperature and humidity is measured in the forest near the top cave entrance (Figure 4). Climate parameters are logged at 10 minute, 30 minute or 4 hour intervals. Sensors were installed at sites that were thought to be key points for observing cave climate. Sites are sometimes changed under the advice of the EAG, as understanding of the cave increases. Proposed new sites are tested and correlated by experimentation with portable loggers.

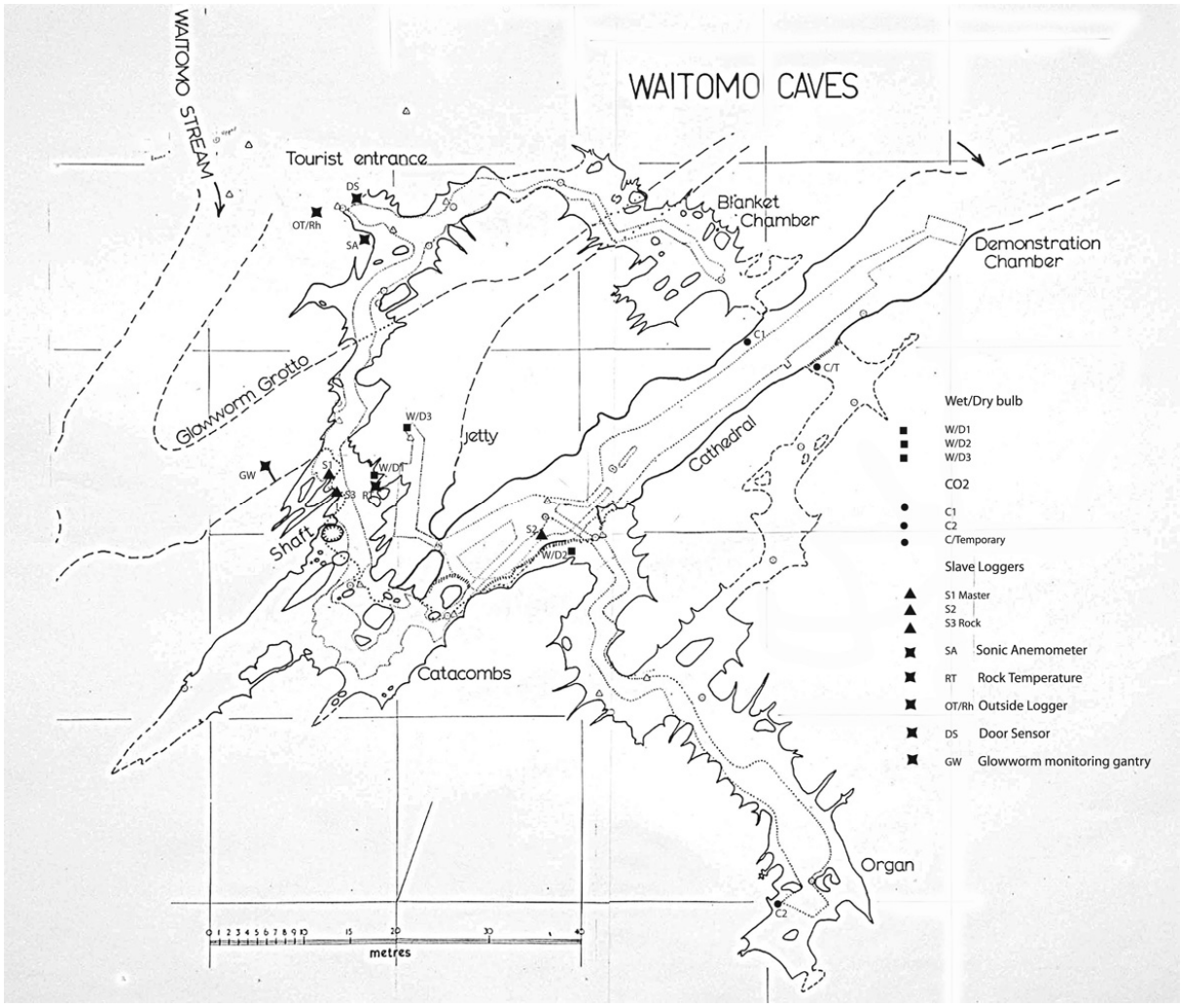


Figure 4. Waitomo Glowworm Cave logger and sensor locations

Real-time climate data and day to day cave management

Real-time climate data is used to manage the cave on a day-to-day and hour-to-hour basis, as outside climate conditions and visitor numbers change. All attempts are made to try and keep the cave within a predetermined set of parameters (table 1).

Climate parameter and target	Management method
CO_2 < 2400 ppm	Open door, limit or stop tours
Temperature 14-16°C	Keep door closed
Relative humidity > 98%	Keep door closed
Vapour pressure deficit < 0	Keep door closed
Airflow - minimise	Keep door closed

Table 1. Climate parameters and management methods

As can be seen in Table 1, the method for minimising cave carbon dioxide levels can conflict with managing temperature, humidity and airflow. The means there is often a balance between managing one parameter and another. In practice, high CO_2 levels occur in summer when visitation is high, but excess ventilation is thought to be more concerning in winter when cold air can enter the Glowworm Grotto and cause glowworm desiccation. A reliable real-time monitoring system is important particularly on days when CO_2 approaches the upper limit and ventilation or tour restriction are required. Table 2 shows the management strategy used by day supervisors to keep CO_2 levels below the 2400 ppm limit as levels rise and fall. Figure 5 gives a month of CO_2 data (December 2008) with some examples of the causes of high CO_2 and how opening the door can influence CO_2 levels.

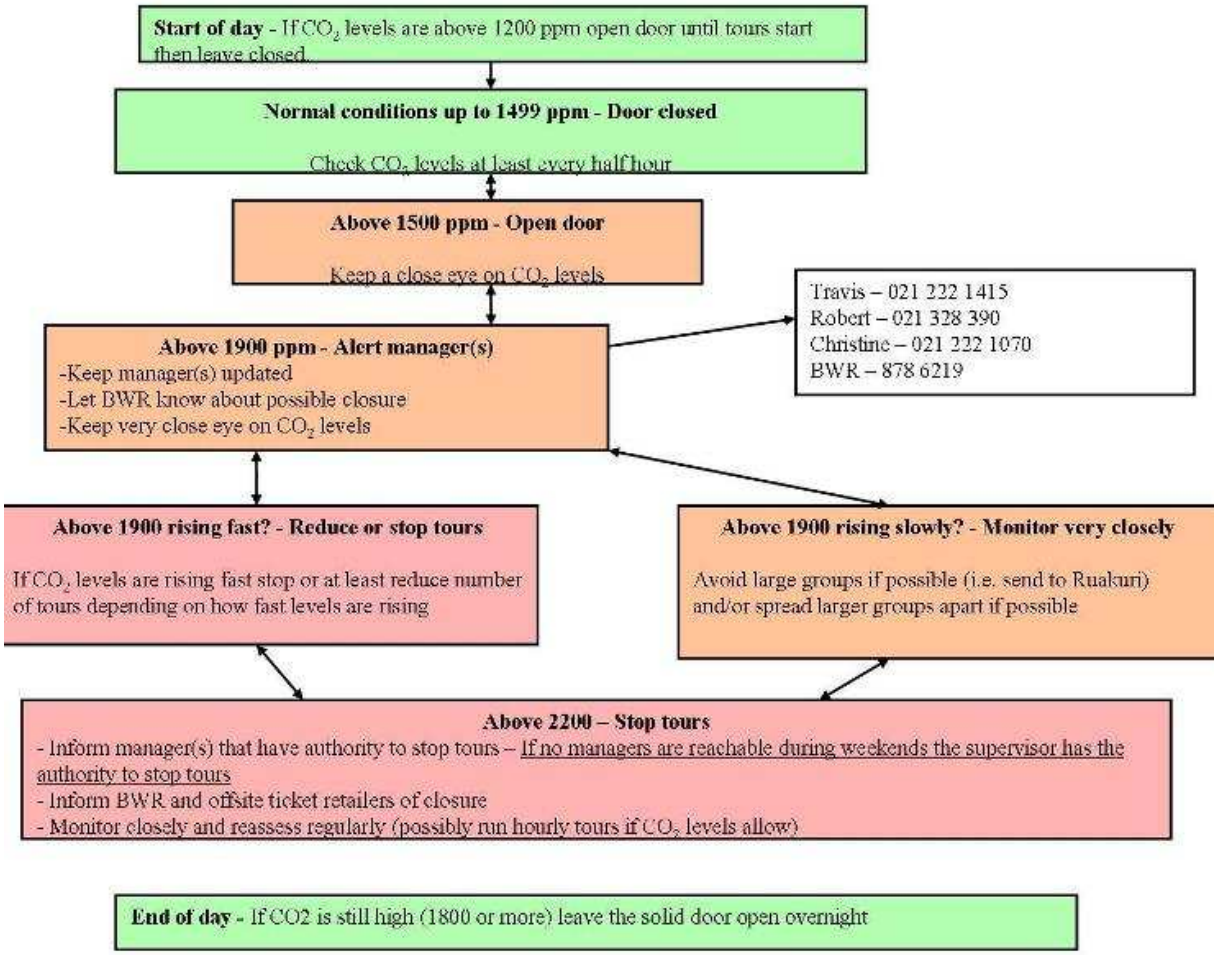


Table 2. Flow chart used to manage CO2 levels in the Glowworm Cave on a day-to-day basis

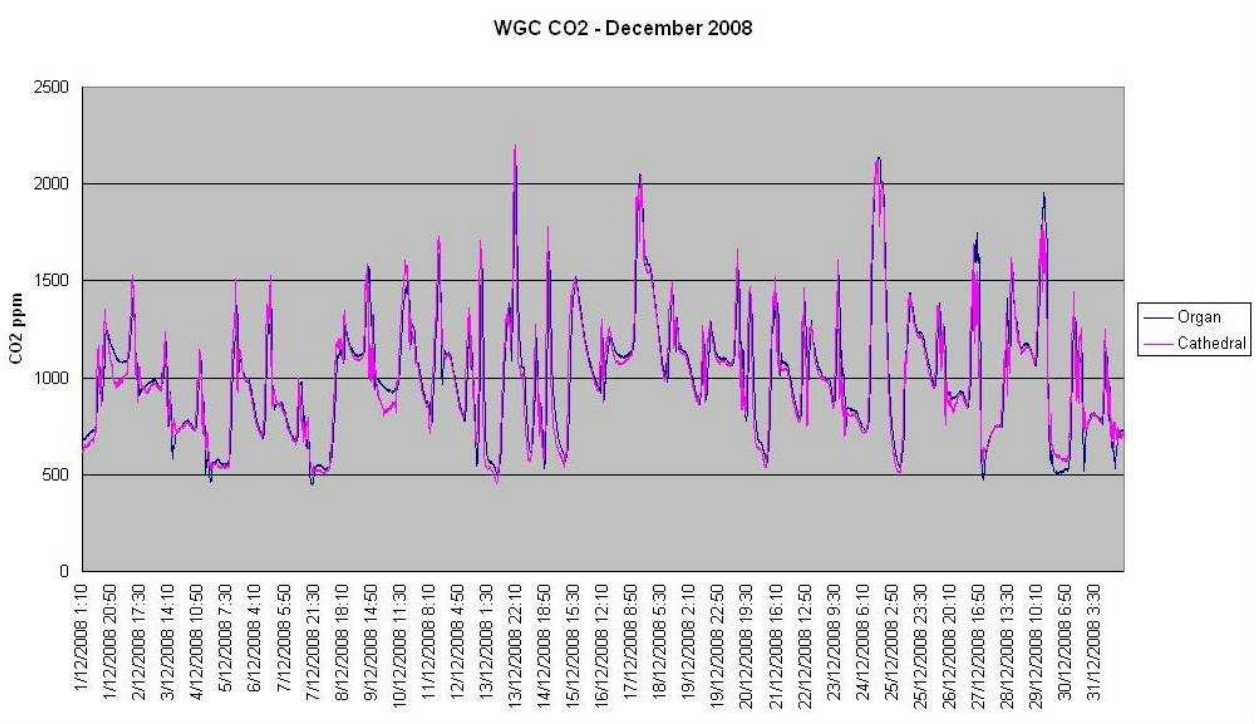


Figure 5. Plot of Glowworm Cave CO_2 at the Organ Loft and Cathedral for December 2008. Arrows show some of the factors that have caused levels to rise plus 1 occasion that shows a sharp reduction of CO_2 resulting from using the cave door as a CO_2 reducing management tool

Climate monitoring – latest refinements and developments

As a result of the Environmental Advisory Group reviewing climate data biannually, management practices and logger network refinements are continually being made. An example of this is a year-long study in the Glowworm Grotto. Four temperature loggers showed that the temperature/humidity sensor site at the boat loading area was slightly different from the rest of the Grotto, possibly due to people waiting for the Glowworm Grotto boat ride. Since the objective of this sensor was to measure climatic changes affecting the core glowworm population, it was decided that the sensor site needed to be moved further out into the Glowworm Grotto.

Another example of refinement to the network is the current investigation to identify a better site for the Cathedral CO_2 sensor. Calibrating the sensor requires abseiling down the Cathedral wall to gain access. An alternative site with better access is under investigation, using a portable data logger to determine how the new site's CO_2 record will correlate to the current site.

A new development is a study, by a University of Waikato MSc student supervised by EAG member Dr Chris Hendy, entitled "*Non-anthropogenic Sources of Carbon Dioxide in the Waitomo Glowworm Cave, Waitomo*". The main finding of this THL-funded study was that the Waitomo Stream is a CO_2 sink during normal flow and a CO_2 source during high river flow. The study also found that drip-water entering the cave during rain events can have CO_2 concentrations greater than 5000 ppm. The study recommends leaving the cave door open during rain to prevent CO_2 rising, if it appears that the river will rise. Ventilation is safe because while it is raining, the outside air is humid so the risk of drying out the cave is low.

Glowworm monitoring

Glowworm population counts have been attempted in the past but a robust, ongoing system has yet to be developed. Work has been underway over the last year to develop a census photomonitoring system. The aim is to incorporate the whole or a large proportion of the Glowworm Grotto ceiling population. This section reports on why monitoring is needed, and the methods and results to date.

Why monitor glowworm numbers?

Glowworms are a key attraction in the cave. Monitoring is being established to gain a better understanding of the glowworm population. If there was a subtle long term decline in glowworm numbers it might not be picked up under current environmental monitoring which

was based on quadrates at the edges of the main population. The aim is to better identify any changes in glowworm numbers, seasonal population variation and to give warning of any gradual or dramatic reduction in numbers i.e. from the effects of tourism or from catchment issues.

Method in development

Photomonitoring of the Glowworm Grotto ceiling has been attempted by taking a sweep of overlapping digital photographs running the length of the Grotto. Photographs are taken from a wall-mounted boom. Each photograph overlaps the next by about one third (roughly 15° intervals) along the length of the Grotto. Attempts at using a 1970s glowworm study site proved problematic because the boom was not perpendicular to the Grotto wall causing skewed photographs. This was rectified by finding a new site that allowed the boom to be mounted perpendicular to the Grotto wall and as near as possible to the centre of the Grotto. Photographs from this site are easily repeatable between photomonitoring visits. The main difficulty is that the best monitoring site is only accessible by boat.

The photographs are taken from an extendable aluminium boom attached to the cave wall by a single stainless steel bolt (removable type bolt). The boom extends 2 m towards the middle of the passage (Figure 6). A digital SLR camera is attached to the boom head, which is adjustable in 3D and marked with increments of degrees. An infrared camera remote is used to trigger the camera in order to avoid bumping or shaking the boom. The camera is "zeroed" directly upward using a bulls eye (circular bubble) level rested on the camera lens. Photos are then taken at ~ 15° intervals, panning through a vertical plane from 30° downstream to 30° upstream.

Figure 6. Monitoring boom and camera set up

Camera and settings

The camera used is an Olympus E-500 SLR with a 17.5 - 45 mm lens. Manual camera settings are used with the lens zoomed out to its widest field of view. Exposure settings between 20 and 60 seconds were trialled with 60 seconds proving to be the best. ISO is set to 800 and f-stop to 3.6. Autofocus and noise reduction are set on with the flash off.

Photograph processing

Once photographs are taken they are stitched together, creating one large picture of the Grotto ceiling. In this case, Canon stitch is used but any photo stitching program could probably be used. However, it was found that it is important to check photos prior to stitching to make sure there are good clusters of glowworms for the software program to make good stitching matches. The program can occasionally stitch the photographs together in the wrong places so it is important to check the stitched seams. The original photographs are archived. Figure 7 is an example of 1 glowworm photograph from a set of 5 prior to stitching.

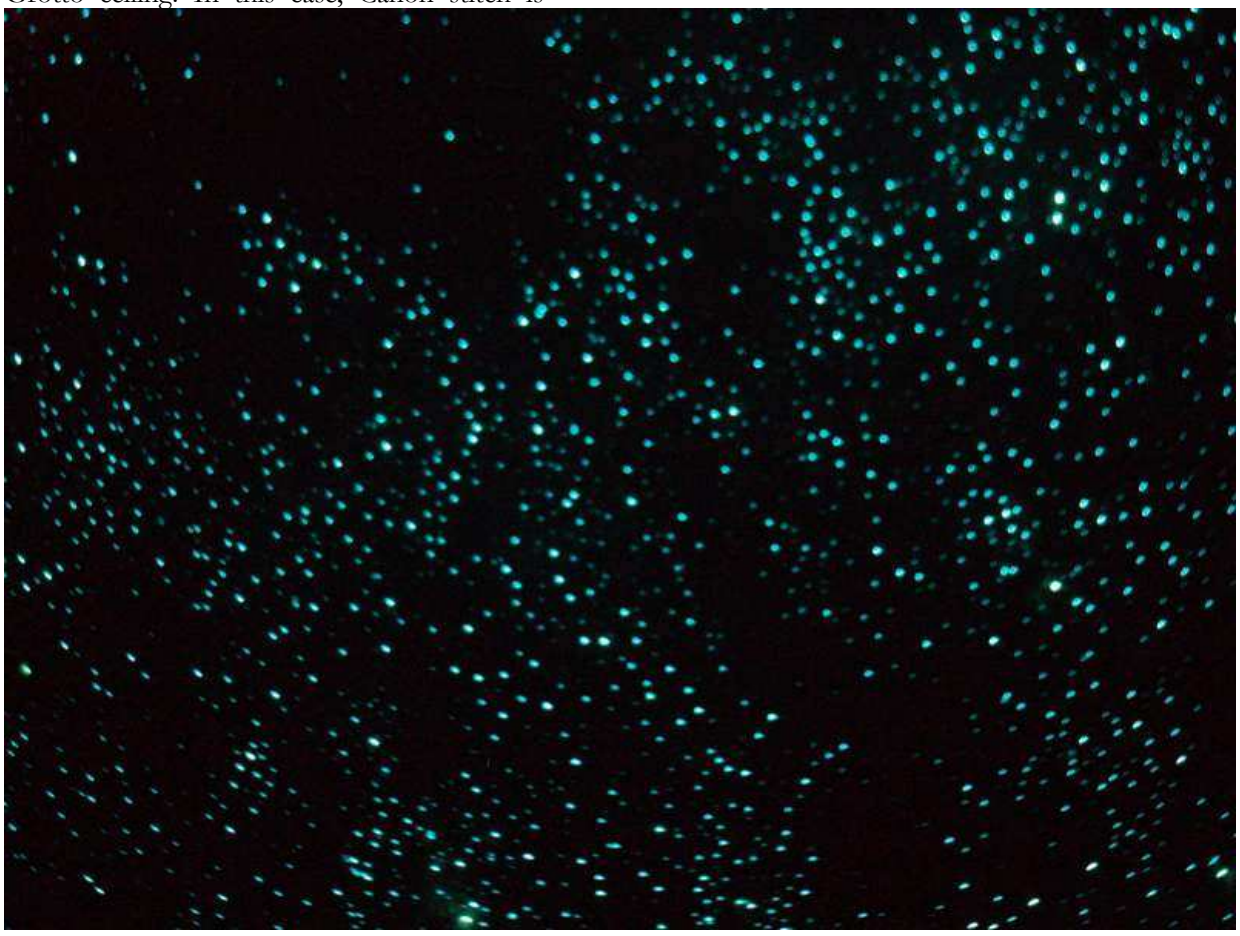


Figure 7. An example glowworm photograph prior to stitching

Photo analysis

The stitched photograph is analysed using a program called "Image J". Image J is public domain software for analysing images. Image J counts all glowworm lights above a user selected size threshold e.g. all particles/lights larger than 4 adjoining pixels. Thresholds can also be set to remove camera pixilation noise from analyses. Noise varies with different exposure settings so experimentation was required to determine the best threshold setting for each exposure. Exposure was later standardised at 60 seconds.

Future glowworm monitoring work

More work is required on the monitoring system. Some variables need to be investigated, such as whether all glowworms are glowing when monitoring is done, or whether the camera is picking up smaller glowworms. Current work by Dave Merritt shows that the number of glowworms glowing and light intensities vary at different times of the day so this needs to be taken into account. Future work will endeavour to validate photographic counts by comparing lights numbers to physical light counts and actual glowworm counts.

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Acknowledgement

Dr Dave Merritt of the University of Queensland has helped considerably with developing photoanalysis protocols.

Adventure Activities as a Management Tool

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Abstract

This paper aims to stimulate discussion of the role of adventure activities in a karst environment. Many karst areas offer guided tours to the public but by offering a range of adventure opportunities you can reach a whole new market, build return business, help develop community interest in karst environments and instil a minimal impact ethic in your visitors.

The paper will look at a range of commercial adventure activities, from kids' soft adventures to spotlighting walks (via caving), which are suited to karst environments and discuss how they can be used to encourage visitors' understanding and support of management decisions. It will consider whether the licensing of commercial operators to provide adventure activities can support management needs in the same way as in-house activities.

The paper will also touch on the ways in which providing opportunities for staff adventure activities and encouraging speleological club involvement can benefit management.

Introduction

Many show cave systems now run an adventure tour, or even a range of adventure tours, in order to increase visitation or lengthen duration of visits. However it is important that cave managers also consider how these tours and other adventure activities can be of direct benefit to the cave systems they are responsible for. They should aim to capitalize on these benefits, whilst minimizing the inevitable impacts.

Not all activities will be suitable for all systems, depending on access, staffing, training and proximity to sources of visitors; however the potential for growth is vast. The range of activities could include off-track tours, adventure caving, children's activities, youth activities, school adventures and surface activities. Staff caving and the activities of speleological societies, whilst not commercial activities, are also a valuable means of assisting cave and karst managers.

Off-track tours allow the less adventurous visitors to experience an undeveloped cave or a cave that has had only primitive development. The cave might be one that is no longer shown due to increased visitor numbers needing larger spaces or previous damage making it a less attractive show cave proposition; or it may be part of the system which is easily accessed on foot, but has not been seen as a commercial proposition and has not ever been developed. This is not how visitors see it; they see it as somewhere special that is open to only the few. For them access to such areas creates a sense of exclusivity and privilege.

For cave managers this type of tour allows visitor access without expensive infrastructure such as lights, walkways and railings. Without lights the likelihood of lampenflora is greatly reduced, though the risk of inadvertent damage to the cave and formations is increased if the cave is totally undeveloped. If the cave has been previously developed the tour can be used to illustrate the impacts of previous practices. This provides a counterpoint to current methods of managing and maintaining show caves. It can create a supportive environment for your innovative, low impact management practices. Hopefully it will get your visitors thinking about how we all need to keep improving the ways in which we interact with the natural environment. Off track tours can also provide a platform for more in depth historical interpretation, building a greater understanding of the significant events in the history of your system.

Adventure caving is now widely available in cave systems throughout Australia. It allows for a range of opportunities from 'soft' adventures to truly challenging experiences such as Jenolan's Naked Lady full day tour. An activity such as caving which involves all the senses is a truly memorable experience. In a risk averse world where most people are increasingly divorced from nature it also provides many people a rare opportunity to genuinely challenge themselves both physically and mentally. For families caving together it

can be a wonderful bonding opportunity. Hardly surprising then that it is so popular.

There are obvious financial benefits to cave managers; adventure caving can both lengthen visitor stay and attract a different market segment. By providing a range of activities with varying levels of difficulty return visitation can also be increased. The less obvious but equally important benefits are that a number of people who have their first caving experiences as paying clients go on to join caving clubs. By imparting a minimal impact ethos at this early stage of their caving careers we can expect that they will continue to be minimal impact cavers. Even those for whom it is a one off experience may take their minimal impact learning into other areas of their lives. The more environmentally aware people there are in the community the more support we have for protecting our catchments. In addition, by increasing membership of speleological societies we are broadening our support base in the community.

Traditionally cave tours have been a family oriented activity and it is important that we continue to provide this great chance for families to build the shared memories that a cave tour provides. We've all heard that wonderful comment "I came here as a kid and wanted my kids to see this fabulous place'. But children also have different developmental stages that a standard cave tour does not necessarily cater to. To immerse kids in the cave environment we need to do more. Hands on, flexible activities that cater to their needs can be a wonderful adjunct to the traditional family based tour. These days children are used to interactive, involving and immersive experiences, where they are central to the action. We need to provide them with activities that tick all these boxes but also connect them to the natural world, in particular the karst landscape. They need to believe that the natural world is even more exciting than any virtual one.

At Jenolan we run a range of children's activities in addition to a wide range of more traditional cave tours. The four current kids' activities are "Stones& Bones", "Animal Discovery", "Junior Guides" and "Junior Explorers". They range in length from1.5 hours to 3 hours. While it might be hard to maintain a child's interest for 3 hours on a show cave tour it is relatively easy in an activity based program, where you can vary the time of the activity components and depth of info provided according to the interests of the group. This is done by having a range of activities and games, some active, some creative and some more intellectual, but all fun.

During "Stones & Bones" the children follow the treasure map left by a scientist of old in an activity that focuses on geology and paleontology. The tour goes on and off track, so kids have the added excitement of using helmets and headlamps. Looking for, finding and examining treasure is far more memorable than just listening to someone talk about fossils, animal bones and rock.

The "Animal Discovery" activity looks at current and extinct fauna through a series of games and action that takes place above and below ground, linking the caves to their surroundings. A take home puzzle book is included to remind children of their visit. Again the use of props and interactivity helps the messages about cave critters and how dependant they are on their environment to stick in the child's mind.

"Junior Guides" and "Junior Explorers" are longer activities where the children become the guides and explorers. Both programs are themed, aiming to leave the children with a definite message. In "Junior Guides" the children look at all the aspects of karst that a guide is involved with; show caverns, wild caves, daylight caves and the areas above ground are all visited. Children learn how all these areas are interconnected by water. This allows them to consider how when they interact with water they also affect many places and the creatures and plants that live in them. The children aren't concerned with the learning experience, but due to the carefully structured program the message does get through. What makes it so memorable for the kids is that they get to be the guide and in charge of what is happening and they get up close and personal to some really cool places. Watching their dismay at the possibility that they may get dirty turn to delight as they crawl through muddy passages is a reminder of just how divorced many kids are from the natural world in the 21st century.

In "Junior Explorers" they love drawing their own maps, naming the features and following their maps to safety. For once in their highly

organized lives they are in control of their own destiny. They also love playing the explorers matching game to discover some of the magnificent places that are not seen on show cave tours. Along the way they develop some observational and navigational skills. But for us the advantage is that they develop a sense of possibility – "Maybe I can discover the next cave…" Hopefully we are planting a seed that will one day turn into a fully fledged caver. At the very least these kids now understand that there are still uncharted parts of the planet to explore.

A children's activity program has many advantages for cave managers; financially it can attract a new visitor group, parents who like to feel they are giving their children stimulating, educational opportunities, and by providing a range of activities you can also build return visitation. More importantly it provides a new vehicle for conveying messages about the karst environment and how we can help to protect it. Most important though, it will help you to build an emotional connection between kids and karst.

The youth market is a difficult one to crack. For many teens a day out with the family can seem a bit daggy, even if they secretly enjoy the experience. To meet the needs of this group we need to provide experiences aimed squarely at them. Activities that are 'cool', can be seen as 'extreme' and as theirs exclusively will hold appeal. Caving provides youth with a perfect opportunity to take risks, feel tough, challenge themselves, be physically active and interact with their peers. If you have an option of using a cave away from the tourist precinct that is not used by other groups you can also play on the satisfying sense of exclusivity.

Teens can of course be a demanding client group, so why should you work at attracting them at this stage, rather than just waiting for them to grow up? Well for a start this is a largely untapped market. Also, just as with children's activities, the parents usually need to supply transport, which means they will require cave tours and meal breaks to fill their time while they wait. Like children's activities though the real benefits are long term; you are inspiring a new generation to care about karst and caves and building a support base in the community. Hopefully even building up a future pool of speleologists.

Developing school adventures will bring the same long term benefits for children's and youth based activities. It will also increase mid-week visitation, return visitation and may inspire family visits. From the school's perspective there are many aspects that cave adventures can cater to, including team building and leadership programs and syllabus based adventures. In addition a range of other activities can be provided on site and we can provide risk management documents, which are very attractive to most teachers, saving them the need to develop these for themselves.

Surface activities that may be offered to schools or the general public include spotlighting, orienteering, bushwalking and abseiling. Having a range of activities makes your site more attractive as an all-in-one destination.

Spotlighting is a very popular family activity, allowing visitors a chance to encounter nocturnal wildlife. As people tend to have an emotional response to animals this provides karst managers with a great opportunity to strengthen visitor attachment to the site and also to broaden their understanding of karst ecosystems. Financially, spotlighting is a good incentive for families to stay overnight.

Orienteering and abseiling activities are of interest to schools who are using the site as an outdoor education camp or for Duke of Ed training. Orienteering may also be of interest to those visiting as part of either the science or geography curriculum. It can also be a fun family activity. If you incorporate karst surface features as markers you will increase participants' knowledge of, and potentially interest in, karst geoheritage. Again there is a financial incentive in increasing mid-week visitation.

Bushwalking is an activity that is relatively cheap and easy to provide which is of interest to groups ranging from families and schools to inbound visitors. Being easily affordable it is likely to induce longer visits if properly promoted. Managers can use self guided walk brochures, signage or guided tours to highlight many aspects of their karst area, from history, flora, fauna or geology, thus providing a more holistic appreciation of the karst geoheritage.

To summarise, surface activities can lengthen visitor stay, attract a broader market and allow for packaging of product; most importantly

they provide an opportunity for managers to increase visitor understanding of and connection to karst landscapes and ecosystems.

Staff caving trips can also be of enormous benefit to karst managers. To begin, if a range of activities are offered, suitable to a range of skills and interests, it is a great way to build team spirit and keep morale high. Everyone can be involved, get to know each others strengths and share knowledge. Caving skills can be developed and maintained. Staff familiarization with the system will increase and, along with this, a sense of ownership will consolidate.

The benefits to management cover a broad spectrum. An increased sense of ownership and strong team spirit means staff are more likely to stick around, saving money in recruitment and maintaining a skilled workforce. Show cave tours are improved by deeper knowledge of the system and improved ability to answer questions. Guides are also likely to put a more personal stamp on their tours when they have a wider experience of the system.

Obviously the more caving experience an adventure guide has the better they will be able to deal with anything that may crop up on an adventure tour. Staff who may have been hesitant to take on this type of tour may discover their inner adventure guide, allowing greater flexibility in rostering. Staff fitness levels will also improve with regular caving trips.

With the increased level of karst understanding that inevitably comes with time spent underground (without the distractions provided by visitors) your staff may even begin to make some interesting discoveries, such as the diprotodontid recently found at Jenolan on a staff caving trip. This discovery has led to a renewed interest in paleontology amongst the staff, which has in turn fed through to our visitors.

The benefits to the caving community of having access to cave systems are many and varied, chief amongst them perhaps being the opportunity to visit and experience such amazing places, possibly discover new ones, develop skills and build understanding. The sense of belonging to a group and sense of connection to place should also be considered.

Karst managers should see speleos as partners in cave management, rather than as a threat to their resources. Needs of each group should be discussed and clearly understood by both parties.

Caving clubs can provide a major support base for karst managers, lobbying for government support and encouraging interest in caves among the general public. They are also a valuable knowledge source, often having an understanding of areas of cave history that can be easily overlooked when the focus is understandably on show cave history. Many cavers have valuable skills in geology and earth sciences, biology, chemistry, surveying, paleontology or rescue. These skills can be utilized by cave managers. Desirable projects and studies that are beyond the budget boundaries can be undertaken by caving clubs. Cavers will often happily take on management instigated projects, but managers should be prepared to consider their ideas also.

In order for this to happen though, the clubs need to be able to attract and train new members, which means that "recreational" caving trips must also be permitted, to allow for cave familiarization and leader training.

Trained cavers are also a potential source of experienced employees. Where there is overlap between the two groups the information and experience sharing creates a more vibrant workforce and can aid communication between management and cavers.

Where there are rights there are also responsibilities. In all adventure activities the preservation of the karst environment should be the prime consideration. Respect and encouragement should also be given to those who participate in adventure activities. Various interest groups will all benefit by working together rather than seeing each other as adversaries.

Remember, the more people who feel a genuine sense of connection to a site, the more people who will contribute to its preservation and even come out fighting in defense of that site should it ever be under threat in any way. These supporters are thus an invaluable asset for cave managers. Along with the aforementioned advantages this should ensure the place of adventure activities as a valuable tool in the karst management kit.

Draft Caves And Karst Policy

John Watson

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Abstract

The Western Australian Department of Environment and Conservation (DEC) has a specific role in the conservation and protection of caves and karst under three main legislative instruments:

- The *Conservation and Land Management Act (1984)* – relating to the management of protected areas such as national parks, nature reserves and State forests
- The *Wildlife Conservation Act (1950)* under which wildlife (flora and fauna) is protected State-wide (hence including stygofauna and troglofauna)
- The *Environmental Protection Act (1986)* which also applies State-wide and addresses environmental pollution, consideration of statutory land use planning processes and assessment of major development proposals, all of which may involve potential impacts upon caves and karst

The draft *Caves and Karst Policy* has been developed to a near final stage through consultation both internally (DEC staff) and externally (a number of karst and speleological experts including several ACKMA members).

This presentation will provide:

- an update of progress with the draft policy,
- an indication of some of the major strategies proposed and
- an outline of the steps required for its finalization towards release for more general public comment

Introduction

My interest in cave management spans some 30 years having been the inaugural Regional Superintendent of Southern National Parks (1978) and then the South Coast Regional Manager of the Department of Conservation & Land Management (CALM) and its successor, the Department of Environment & Conservation (DEC), until deciding to step aside as Regional Manager in late 2007. Since then I have been working part time on DEC Land Use Planning work in Albany and part time drafting a State-wide *Draft DEC Caves & Karst Policy*.

I am also lead convener of the 4th Conference (Yallingup), an inaugural member of ACKMA and the inaugural convener of the IUCN (World Conservation Union) Task Force on Caves and Karst 1992-1997. I am also very interested in the management and protection of mountains being a member of the IUCN/WCPA Mountain Theme Group since 1991. But today my story focuses on caves and karst…

As humans we have had a very long association with caves and yet to many of us they remain frightening and dangerous places… a bit too far out of our comfort zone for most people… This does have bearing on the subject of my talk because whereas we here today may be comfortable with the subterranean environment many, possibly most people are not. Hence it can be a real challenge for decision makers including policy makers to fully understand the values and complexities of caves and karst.

Although issues associated with caves and karst are well known to most of you, there are some people who have only joined the conference this morning and so I will very quickly start with a few reminders of some of the values and issues associated with caves and karst…

- Anthropological value as windows into early human civilizations through cave paintings and artifacts.
- In historical times many caves have been significant tourism draw-cards. For example, at one time in the early 20th Century, there were over a dozen

tourist caves in the Leeuwin-Naturaliste area.

- Yanchep, which some of you visited last weekend, was one of Western Australia's first national parks. Indeed from 1900 to around 1912 the 'Caves Board' managing Yanchep, Yallingup and the Margaret River Caves was essentially a one man 'protected area agency' of the day.
- Western Australia's south west is world renowned for its spectacular calcite speleothems including some remarkable helictites. Unfortunately you will not be able to see the feature known as *The Halo* as it has long since disappeared due to accidental damage – a sobering reminder of the fragility of many cave environments.
- Land use planning in karst areas requires care, not only because of the impacts on karst and caves but also because of the economic ramifications of surface collapse and subsidence which can be quite dramatic where buildings and infrastructure are destroyed.
- In terms of landscape, karst can be quite spectacular such as the classic tower-karst of China and Vietnam.
- And at the other end of the scale there are many examples of stygofauna (subterranean creatures which live entirely in water). Stygofauna and troglofauna in general are increasingly recognised as critical components of the karst subterranean environment . The Western Australian Pilbara is now known to be a global hotspot in this regard.

Legislative and information base for the draft policy

DEC was established in July 2006 by amalgamating CALM and the former Department of Environment, hence there are 3 main acts affecting DEC's interests and responsibilities for karst.

- The CALM Act (1984) is the primary instrument for the protection and management of protected areas (*i.e.* national parks and nature reserves), including provisions for the preparation of statutory management plans.
- The Environmental Protection Act (1986) provides the primary mechanism through which land use, pollution and drainage impacts upon karst can be addressed outside protected areas through environmental protection and assessment of proposals that may impact on karst values.
- The Wildlife Conservation Act (1950) provides State-wide protection to wildlife (flora and fauna) and hence includes protection of stygofauna and troglofauna.

There already is a partial DEC caves and karst policy relevant to caves and karst (DEC Policy Statement 18, 2006) containing some three pages dedicated to Cav*ing* and Cave Div*ing* but only in the context of recreational activities requiring management by DEC within protected areas.

However, when commencing the draft policy it was obvious that in the context of DEC as opposed to CALM the policy could apply Statewide and address wider aspects of cave and karst protection and management under the broader provisions of the Environmental Protection Act and Wildlife Conservation Act. Indeed the EPA Guidance Statement 33 (2008) has an excellent section (Chapter B9) on karst as part of the broad ranging advice offered in the context of land use planning.

This chapter contains three very useful checklists to remind planners of some of the key issues to consider in the context of karst. One checklist describes possible threats to the cave and karst environment, another lists some of the issues and values associated with karst and a third lists potential measures that might be taken to protect karst.

A number of other resource documents were invaluable in developing the DEC draft policy, in particular the IUCN Guidelines for Cave and Karst Protection (*Watson et al,* 1997) and the recent review of World Heritage Caves and Karst (Williams, 2008).

Hence we already have an excellent platform both locally and more broadly on which to develop the new draft caves and karst strategy.

Development of the Draft Policy

Using various existing sources, especially those referred to above, a preliminary draft document was prepared which was then circulated to a number of departmental and external 'experts' in order to identify any significant omissions and necessary improvements to the existing text. The external consultation included a number of ACKMA members and protected area agency personnel around Australia. A second draft was then prepared and circulated more widely within DEC and again to the external advisors. This resulted in some 140 substantive comments on the preliminary draft from some 25 people.

The main thrust of the comments was as follows:-

- There was strong support for the drafting of a policy and there were mostly very positive comments on the bulk of the draft.
- Wider inclusion of karst was suggested *e.g.* the Pilbara/Rangelands calcrete aquifers.
- There was a need for improved scientific research permit procedures and collecting protocols.
- A separate policy might be required for stygofauna and troglofauna.
- There was strong support for a karst officer or karst unit within DEC.
- A DEC karst data base was required.
- Indigenous interests should be expanded upon.
- Urban housing growth and industrial development should be identified more clearly as key threatening processes in some karst areas.
- The draft policy should be publicly available for general comment prior to its finalisation.

The current version of the draft policy prepared in response to the comments received contains a set of broad policy objectives which address issues within the State's protected area system, issues outside the protected area system, and issues which apply generally within Western Australia (*i.e.* both within and outside the protected area system).

For each policy objective there is a short background and descriptive text and then a series of proposed 'Implementation Strategies'. Within the State protected area system both the consolidation of karst protection and subsequent management by DEC in response to threats are addressed. The issues outside the protected area system focus around the existing EPA Guidance Statement No 33 and the objectives applying State-wide include issues such as advocacy for caves and karst, staff training and general awareness raising. There is also reference to liaison with other agencies and with bodies such as ACKMA, the ASF and speleological groups.

In summary, DEC is in the process of finalising a draft policy for caves and karst in Western Australia. This draft will be released for general public comment. The help and comment already given by a number of ACKMA members and other experts has been invaluable and is gratefully acknowledged. We look forward to receiving additional input from you all in due course.

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Waitomo Glowworm Caves Facilities Redevelopment

Greg Martin

Abstract

The entire visitor complex at the Waitomo Glowworm Caves was lost by fire on 14 December 2005. Since that time major negotiations have taken place between the land owners, Ruapuha Uekaha Hapu Trust and the Department of Conservation, with the lease holders for the resource, Tourism Holdings Limited, to achieve a significant rebuild of these facilities to meet today's tourism market. This presentation will cover some of the issues in the design of this $11 million facility and some of the challenges that are being faced in a global economic downturn and a nationally declining international tourism market. The Waitomo Glowworm Caves are an iconic tourist destination in New Zealand and are part of the 'tourism brand' contributing to the national identity of the country

Introduction

The Waitomo Glowworm Caves are an iconic tourist destination in New Zealand with a large percentage of international visitors visiting the resource each year. The caves have been a tourist attraction now for 112 years. On 14 December 2005 the entire visitor facilities complex was destroyed by fire, possibly caused by an internal electrical fault in the building complex. The caves were closed to tourism for just two days while site works took place and temporary buildings were located to enable the venture to continue operating.

The Waitomo Glowworm Caves are owned jointly by the Department of Conservation and the Ruapuha Uekaha Hapu Trust. There is a management partnership between the Crown (Department of Conservation) and the Hapu Trust to run the resource which is leased out to Tourism Holdings Limited who are a major national tourism operator. This management partnership flows from an agreement with the Crown for the settlement of a land claim by the local Maori people under the Waitangi Tribunal in a mediated settlement which was completed in June 1990. That settlement provided for a 32 year licence over the site and it was that licence that was purchased by the current operators, Tourism Holdings Limited. By coincidence the 32 year term of the licence provided for a right of renewal after 16 years and that renewal was just six months after the fire in June 2006.

On considering rebuilding the facilities, Tourism Holdings Limited wanted to use the opportunity to recreate the visit to Waitomo Caves as a new experience and to hopefully develop the resource to have greater appeal to the domestic market. Eighty percent of tourists to the Caves are international and as a consequence the resource is very susceptible to the fluctuations of external events such as the oil crisis, the Gulf War, SARS and the current global economic downturn.

The intense heat of the fire, through what was entirely a timber structure, resulted in major damage to a grove of large redwood trees which were believed to be planted on the site in the early 1900s. The former buildings were nestled amongst these trees which provided shelter, shade and a certain ambience for the many thousands of visitors that waited in this location prior to their cave visit.

Part of the design brief for this new structure was to recreate an iconic structure that provided for the shelter and ambience that had been provided for many years by the redwood trees. The designers came up with the concept of a large canopy which would have the multi-storeyed buildings and infrastructure placed underneath it. This canopy will draw visitors into the cave entrance and is constructed of massive timber beams in a basket weave pattern reminiscent of a hinaki or traditional Maori fishing net.

The roofing material for the canopy is to be a high tech Teflon product which has been used in a number of locations around the world and was most recently seen in some of the significant stadia's built for the Beijing Olympics. Part of the British Museum has this material used very effectively in the roof. This Teflon will be laid across the canopy in large pillows which will be inflated by pneumatic pumps which will adjust continuously to maintain a constant pressure and envelope. The material is highly translucent and the pillow will provide insulating properties which should assist in the controlling of temperatures within the structure. The Teflon, is by its very

nature, a non-slip surface and maintenance (such as cleaning and washing down) is expected to be required infrequently.

The Ruapuha Uekaha Hapu Trust conducted a ceremony to formally bless the site prior to the commencement of works on 11 November 2008. Site works have now commenced with the benching of the three main levels which will make up the platforms for the new facilities over which the canopy will be erected. This is the first time in the world that construction of a canopy of this dimension has been attempted using timber beams and frames. The beams are being laminated by a specialist firm in Nelson (at the top of the South Island). Each beam provides part of the curvature of the canopy and each length is made up of three separate components. Not only does each beam curve, but it also twists to make up the design for the structure. The gluelam beams have required significant engineering input and peer review and international engineers are also taking particular interest.

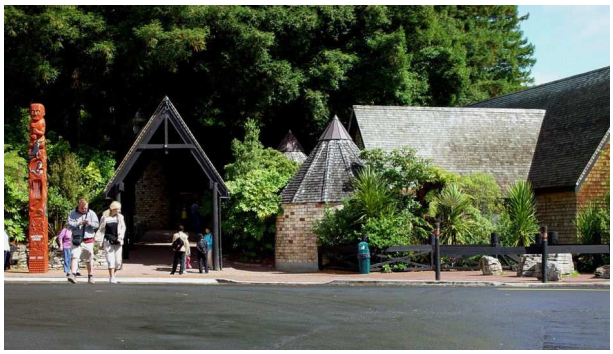
Some prototypes, for two thirds of the beam structure, have been erected on the contractor's industrial site in Hamilton City. The prototypes have provided an opportunity to design and redesign the connecting mechanisms and to trial the construction prior to the major activity taking place on the construction site.

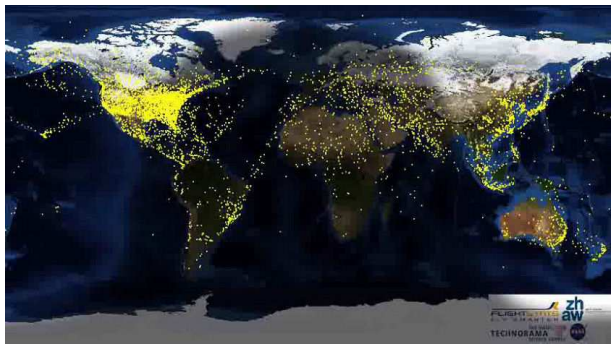
The design of the whole complex has been through a number of consultative processes with the owners and Tourism Holdings Limited. One of the major considerations has been the flow of visitors through the site. The provision of toilets has always been an essential item at the Glowworm Caves as a large number of the visitors travel by coach from Auckland and the Caves are often their first stop prior to proceeding through to the tourist destination of Rotorua. To accommodate this, a large bank of toilets have been incorporated into the design and will be excavated into the bank on the high side of the canopy and will be part of the anchor points for the 11 spans of beams that will make up the canopy. The visitor flow has also needed to consider the public safety aspects on arriving at this destination. Visitors will be encouraged, through design and management on the site, to enter the facility through the underpass on the main road. The internal construction is on three platforms with different levels providing office and staff administration, a café, a 400 seat restaurant, and flexible space for displays, promotions, conference facilities and the like. The main flow through the building will be past the ticketing facilities and will be maintained on one level.

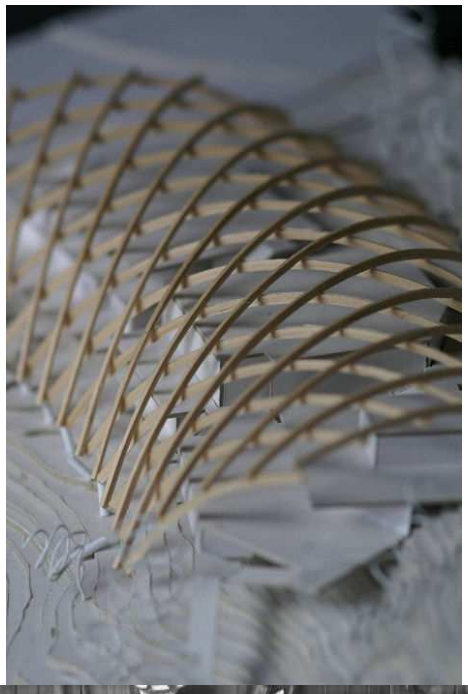
Another significant design feature relates to the exit from the cave where the main pathway will be completely realigned to achieve a very gradual gradient for the return back through the facilities buildings, souvenir shops and cafés, to again exit through the underpass on the main road.

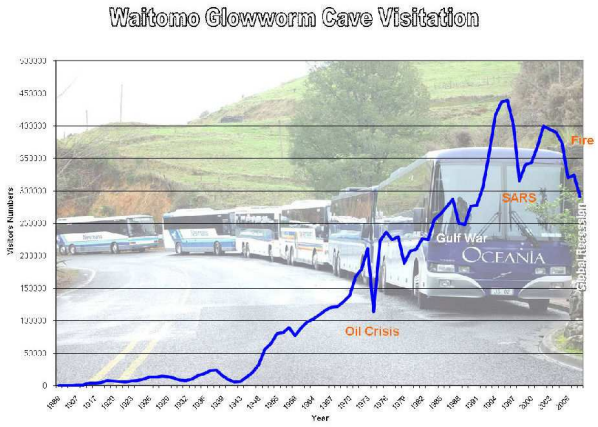
As part of the whole package Tourism Holdings Limited have been looking at a general upgrade and enhancement of delivering the cave experience to the visitors. The Glowworm Caves are iconic through a more than 100 year history of visiting the Glowworm Grotto on a boat trip in silence, observing these natural wonders. Part of the development will include constant attention to enhancing the visitor experience with a focus on the continued employment of local people and Hapu Trust members to impart to visitors their traditions, culture and history associated with their place. The revamp will also take into account signage and interpretation and cultural elements to be incorporated into the overall theme for the design.

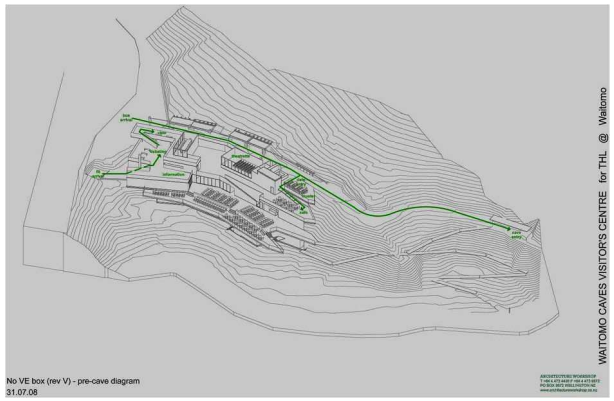
A significant aspect has been the sighting of Te Pou Tane Mahuta, the traditional carved pole which has had to be sighted so that visitors can easily have photographs taken by this significant feature. The construction is anticipated to be completed in February 2010 and is likely to be officially opened by the Prime Minister, the Hon John Key, who is also the Minister of Tourism. He visited Waitomo earlier this year and met the Caves staff and has been familiarised with the project which is significant in terms of his portfolio as Minister of Tourism.








Waitomo Glowworm Cave Visitation
Fire
SARS
Gulf War
Oil Crisis
Global Recession
Visitors Numbers
Year


WAITOMO CAVES VISITOR'S CENTRE for THL @ Waitomo
No VE box (rev V) - pre-cave diagram
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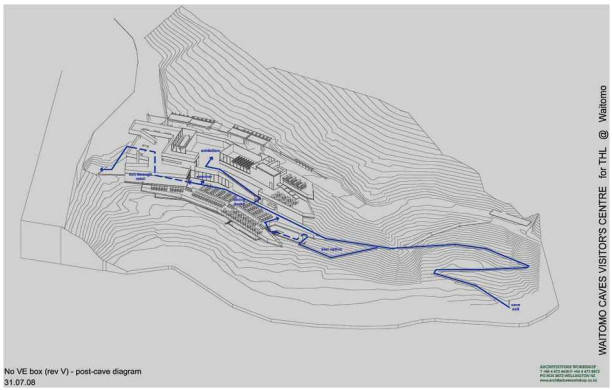
WAITOMO CAVES VISITOR'S CENTRE for THL @ Waitomo
No VE box (rev V) - post-cave diagram
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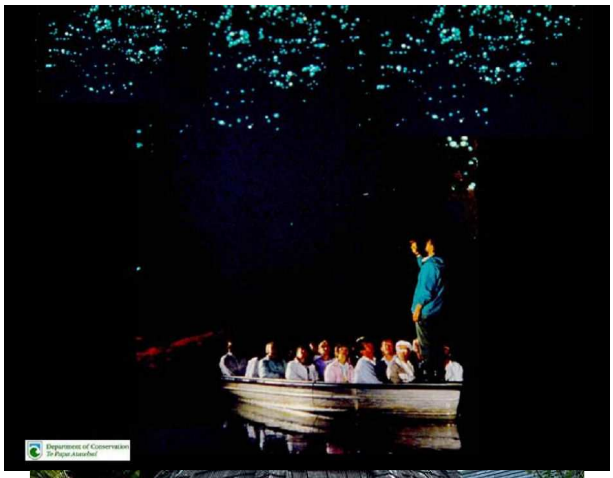


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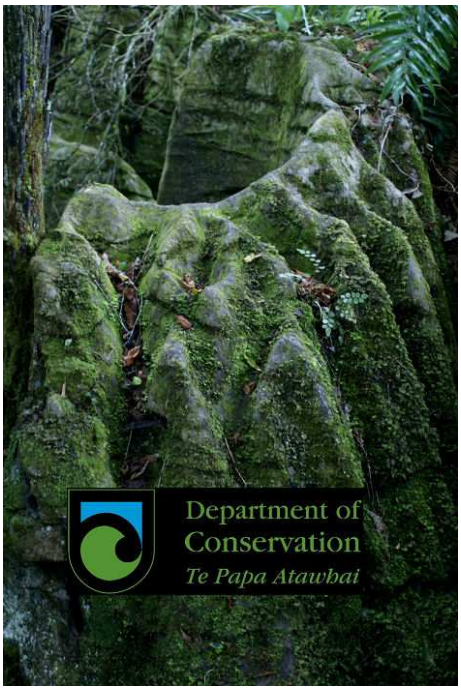
Department of
Conservation
Te Papa Atawbai

Cape Range And Ningaloo Reef: A Semi-Arid Karst And Coastal Area Unlike Any Other

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Abstract

The Ningaloo Coast Region of Western Australia is an extraordinary semi-arid karst and coral reef marine environment. The Gondwanan associated geomorphology of Western Australia's Cape Range, with basic rocks of the coastline of the ancient Tethys Sea, reflects continental drift, subsequent uplifting and evidence of seven of thirteen global geologic themes as identified by Dingwall *et al.*, 2005. Unusual tectonic plate subduction and orogeny processes have created an emergent landscape in which sea level changes over long periods are evident in four wave-cut terraces. Cape Range also has an extensive network of over 700 caves, mesocaverns and anastamosing tubes extending down to an anchialine groundwater zone. The earth's history, paleoclimate and past life forms are recorded in a rich fossil and sub-fossil accumulation, particularly in relation to the Ningaloo Reef development as a near-shore barrier reef, not a "fringing" reef as thought until recently. An outstandingly rich array of on-going geomorphic, karst, hydrologic and oceanographic processes occur. These are associated with marine, avi-fauna, terrestrial and subterranean speciation, endemism and refugia processes. The Cape Range is a centre of endemism and a relictual taxa refuge for one of the world's largest and most significant groups of terrestrial and aquatic troglobitic species surviving within a karst system, including the only known example of a Remipede (*Lasionectes exleyi*) community in the southern hemisphere. The Ningaloo Coast oceanic currents and nutrient cycles; marine flora and fauna speciation, endemism, refugia, breeding/spawning and migratory processes are also outstanding. The outcome is one of the world's most unique and complex combinations of highly diverse lithological, hydrological and ecological processes. Although the authors are convinced of the area's global significance, recognition of its values through adequate protected area status and management has been a slow process, with some way to go in the future.

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[2]. Professor Elery Hamilton-Smith, AM, has been an Honorary and/or Adjunct Professor at the International Centre of Excellence, University of Wageningen, Netherlands; at the Faculty of Health Sciences, LaTrobe University, Bundoora, Victoria; at the School of Information and Environmental Sciences, Charles Sturt University, Albury, N.S.W. He was also the Chair of Task Force on Caves and Karst, International Union for Conservation of Nature / World Commission on Protected Areas. He has contributed to the nomination assessment process of numerous World Heritage areas globally.

Introduction

The Ningaloo Coast of Western Australia is on UNESCO's World Heritage Tentative List and will likely be nominated by the Australian Government during 2010. The Ningaloo Coast is the formal name for the nomination

area extending southwards along the coast from the Muiron Islands and Northwest Cape. The area includes the Ningaloo Reef and the Cape Range. The Ningaloo Coast property has a total area of approximately 601,000 ha, (263,343 ha of Ningaloo Marine Park-State Waters), 28,616 ha of Muiron Islands Marine Management Area, 258,500 ha of Ningaloo Marine Park–Commonwealth Waters and 50,581 ha of Cape Range National Park (refer to Figure 1). The area predominantly occurs within the area of the Carnarvon – Ningaloo Coast Strategy (WA Dept. of Planning and Infrastructure, 2004 – refer to Figure 2.)

Elery Hamilton-Smith and Dennis Williamson were engaged by Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) to provide a comparative assessment of the Ningaloo Coast as background information to the nomination process (Hamilton-Smith & Williamson, 2008).

The Assessment Process and Criteria

Two key considerations had considerable influence over the assessment:

- the qualifications of the Ningaloo Coast for inscription to the World Heritage list under the Natural Criteria of UNESCO's Operational Guidelines (UNESCO, 2008)
- comparison of the natural features and qualities of Ningaloo Coast to those of other globally significant coral reefs and karst systems (World Heritage and other outstanding natural heritage places).

Key World Heritage Natural Criteria included:

- Criterion (vii) - to contain: a. superlative natural phenomenon; or b. areas of natural beauty and aesthetic importance;
- Criterion (ix) - ecological and biological processes;
- Criterion (x) –"in situ" ecological or biological diversity or conservation value.
- Criterion (viii) - to be outstanding examples representing major stages of earth's history, including:
    - the record of life;
    - significant on-going geological processes in the development of landforms;
    - significant geomorphic features, or;
    - physiographic features.

For each criterion the nominated property must represent:

- "outstanding universal value" in representing the "best of the best" natural sites in the world; and
- "integrity" in terms of containing all or most of the significant natural elements and processes, as well as exhibiting site boundaries and buffer zones that will facilitate the protection, management and long-term sustainability of the features, phenomenon and processes that are assessed to be of World Heritage value.

International Comparisons

The Ningaloo Coast has been compared against 14 currently inscribed World Heritage Sites exhibiting karst and or coral reef environments and 8 other sites of world significance. These sites are mapped and listed in Figure 3.

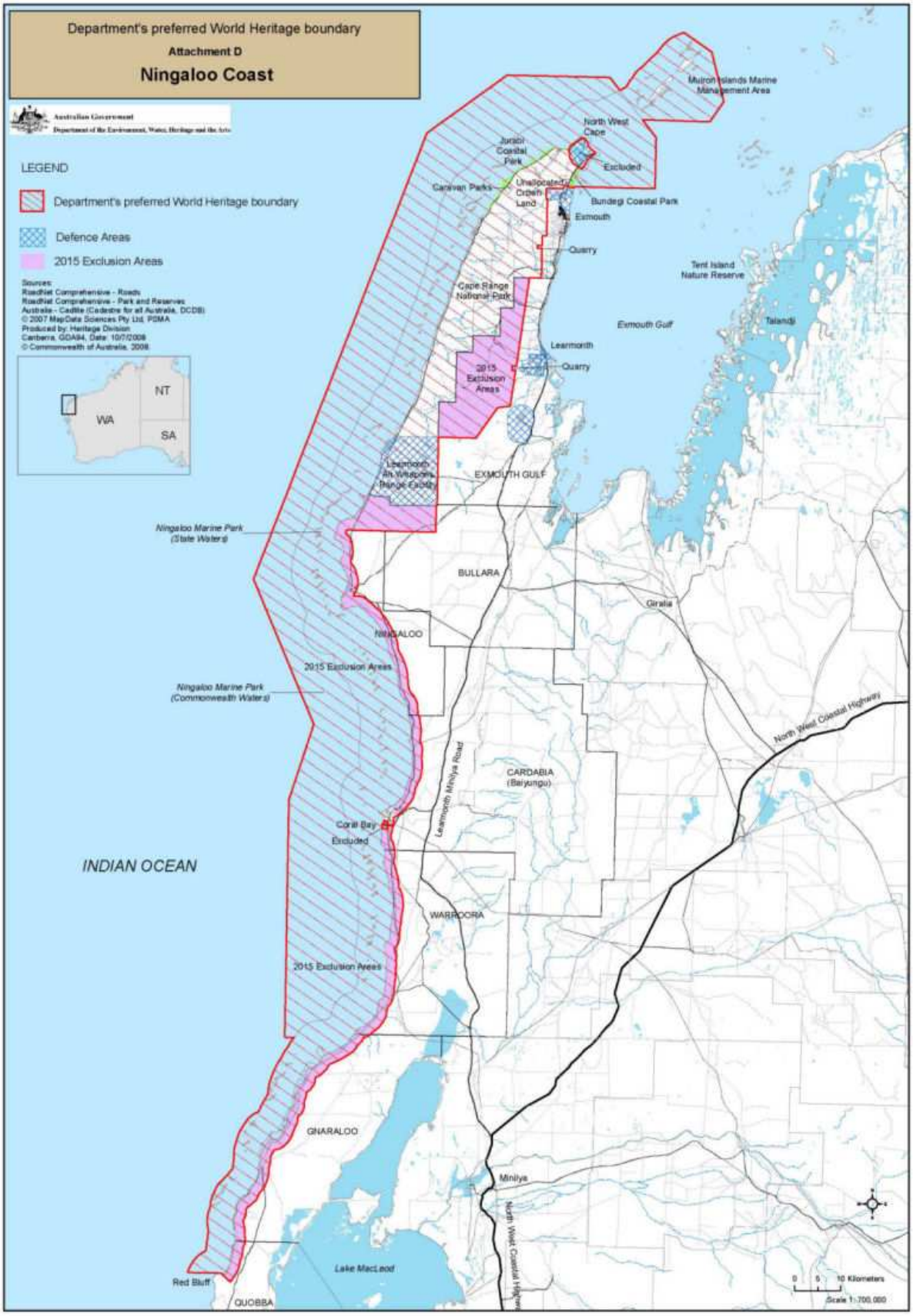
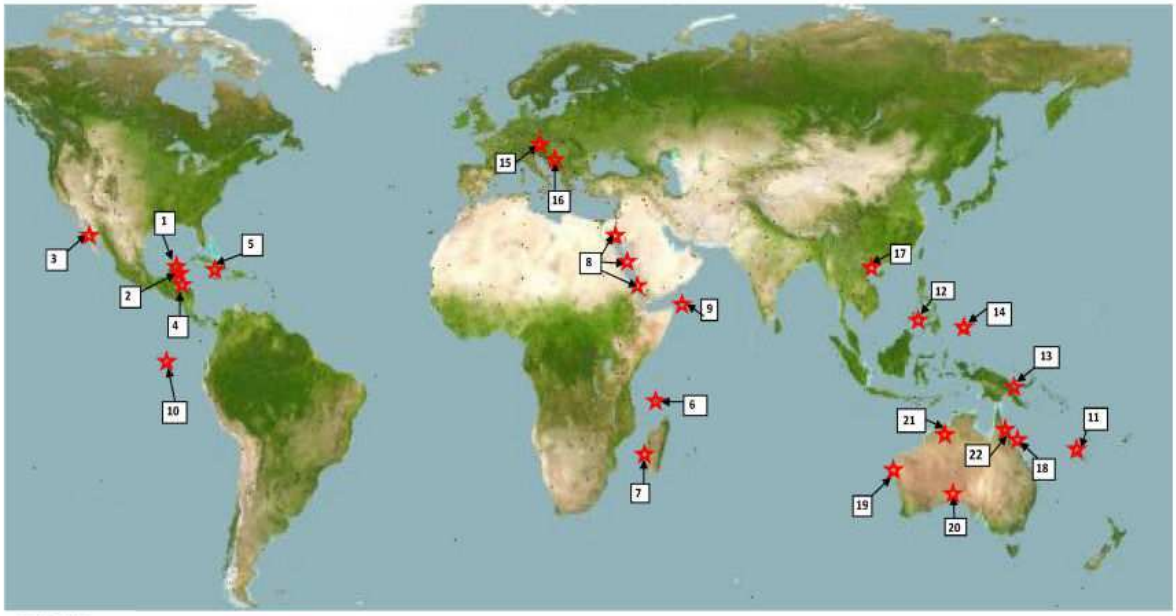


Figure 1 The Ningaloo Coast Nomination Area (Source: DEWHA, 2008)

Figure 2 The Carnarvon – Ningaloo Coast Regional Strategy Area (Source: WA Dept. of Planning and Infrastructure, 2004)



LEGEND

Atlantic (Meso-American) Sites

1. Yucatan Coastal Reef
2. Sian Ka'an Reef
3. Islands and Protected Areas of the Gulf of California, Mexico
4. Belize Barrier Reef Reserve System,
5. Desembarco del Granma WHA, Cuba

Indian Ocean

6. Aldabra Atoll WHA, Seychelles
7. Tuléar (Tuléa) Reef, Madagascar

Middle East

8. Red Sea Coral Reefs (including the Eilat Reef, Israel
9. Socotra Archipelago WHA, Yemen

Pacific

10. Galapagos Islands WHA, Ecuador
11. Lagoons of New Caledonia WHA
    Tubbataha Reef National Marine Park WHA (in conjunction with the Puerto Princessa Subterranean River NP), Philippines
12. Huon Peninsula, Papua New Guinea
13. Palau

European

14. Postojna Cave, Slovenia
15. Vjetrenica Cave, Bosnia and Herzegovina

Southeast Asian

16. Ha Long Bay WHA, Vietnam

Other Australian Sites

17. Great Barrier Reef
18. Shark Bay
19. The Nullarbor
20. The Kimberly
21. Chillagoe-Mungana

Figure 3 International Sites Used for Comparisons to the Ningaloo Coast
(Source: Adapted from UNESCO World Heritage Commission Map of World Heritage Sites, 2008)

Criterion (vii) Assessment and Findings

World Heritage Guideline 1

World Heritage Guideline 1 calls for: *"Natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view".*

Fourteen Ningaloo Coast features were found to meet the above World Heritage guideline. Potential OUV themes noted following each feature or phenomenon as: A = Aesthetic; S = Scientific; E = Emblematic. Some of the key features that meet Guideline 1 include:

- bathymetry;
- coral reefs and lagoons;
- the whale shark and other marine megafauna ;
- Cape Range karst formation with marine terraces and an extensive system of caves and mesocaverns (refer Figure 4);
- Cape Range subterranean fauna (including the rare Remipede Community);
- a hotspot of non-marine endemic molluscs and unique and diverse vegetative species mix from temperate, arid and tropical provinces;
- groundwater and hydrologic system underlying Cape Range and interconnected with Indian Ocean and Exmouth Gulf waters (refer Figure 5).

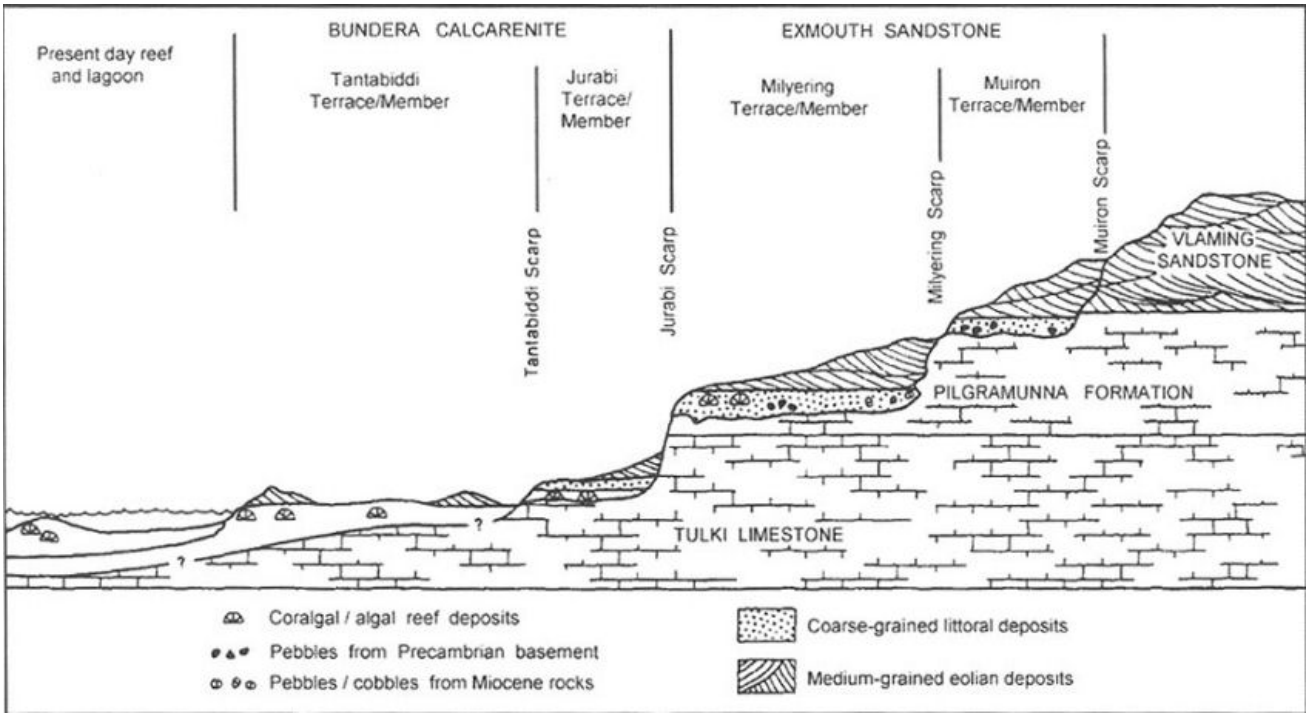


Figure 4. Four Wave Cut Marine Terraces of Cape Range
(Source: INQUA, 2006 – after van de Graff *et al.* 1976)

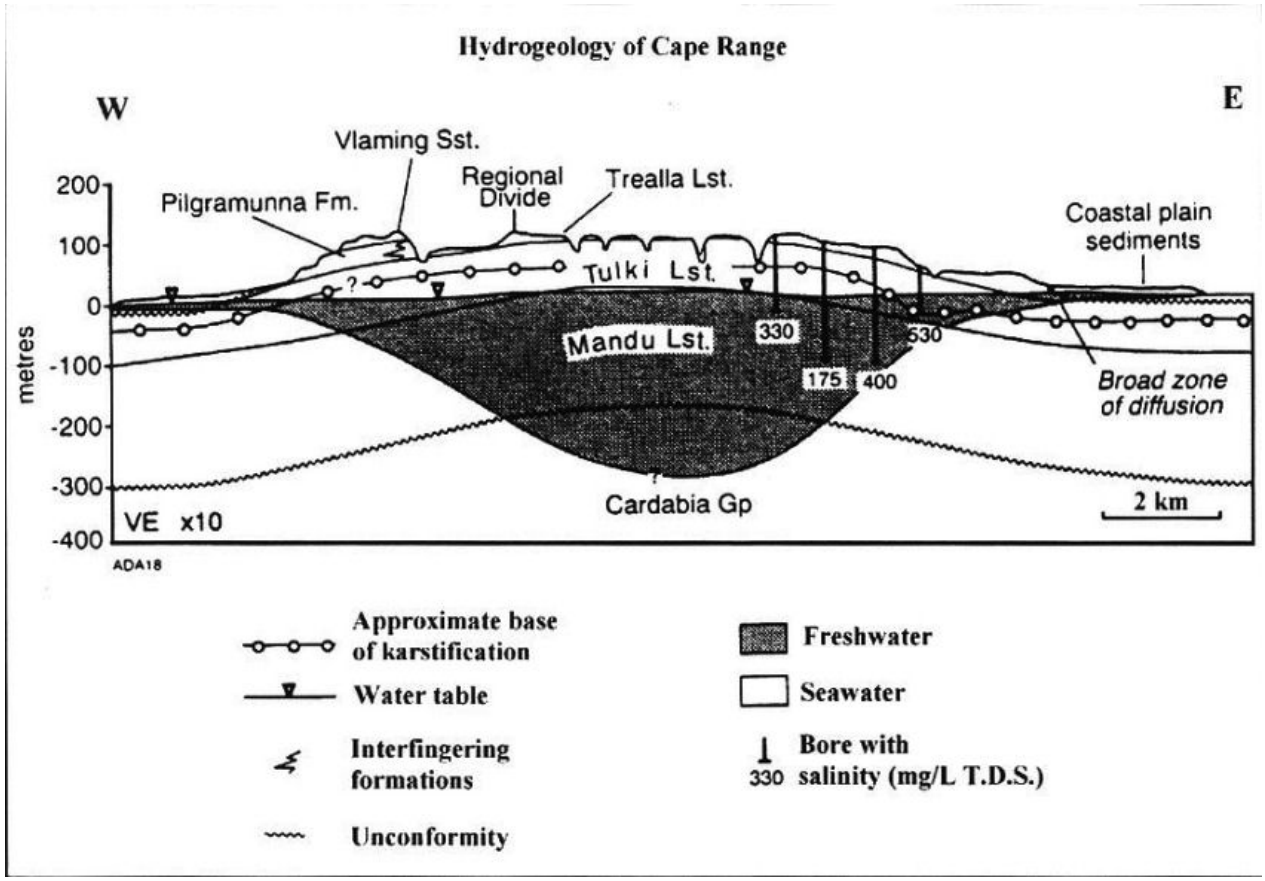


Figure 5 Hydrogeology of Cape Range
(Source: INQUA, 2006 – after Allen, 1993.)

World Heritage Guideline 2

World Heritage Guideline 2 calls for: *"Geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation".*

Under Guideline 2, we would include Declared "Rare, Endangered, Threatened or Vulnerable" or "specially protected" species of animals and plants of the Ningaloo Coast property as noted below (refer to Kendrick and Mau, 2002 – 2002 Biodiversity Audit for WA – Carnarvon Bioregion: Cape Range Subregion - CAR1):

- Whale shark S, A, E;
- Blue, Southern Right, Fin, Sei and Humpback Whales S, A, E;
- Loggerhead, Leatherback, Green, Hawksbill and Flatback Sea Turtles and their nesting areas S, A, E;
- Dugong (special protection) S, A, E;
- 13 species of migratory birds (CAMBA & JAMBA Treaties Protection) including:
    - the White-Winged,
    - Bridled and Caspian Terns,
    - White-Bellied Sea-Eagle,
    - the Wedge-Tailed,
    - Flesh-Footed Shearwaters,
    - the Brown Booby, and
    - Wilson's Storm-Petrel S, A;
- Mangroves:
    - red, white and ribbed-orange;
    - found in the northern half of the Marine Park;
    - largest community occupying 31 ha at Mangrove Bay;
    - also found in tidal creek systems such as the mangal at Yardie Creek S, A;
- Approx. 38 species of WA Schedule 1 mammals, birds, reptiles, fish, arachnids, crustaceans, and millipedes S, A;
- Cape Range Remipede Community at Bundera Sinkhole S, A, E;
- Camerons Cave Troglobitic Community S, A;
- Troglobitic and Stygofauna communities on Northwest Cape S, A;
- Ephemeral creekline drainage communities S, A;
- 8 species of Declared Rare and Priority Flora S, A;

(Again, the potential OUV themes include: A = Aesthetic; S = Scientific; and E = Emblematic.)

Cape Range National Park is also of high conservation value floristically, containing many range-end populations of flora at the limit of heir distribution. Cape Range Peninsula lies at the overlap of three biogeographical zones, including species from temperate, arid and tropical provinces.

World Heritage Guideline 3

World Heritage Guideline 3 calls for: *"Natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty".*

Guideline 3 is satisfied by the features and phenomenon noted under Guidelines 1 and 2, including:

1. The precisely delineated marine areas of the property include the following geological and physiographical formations constituting the habitat of threatened species of animals and plants of outstanding universal value:
    - the West Australian, Leeuwin and Ningaloo Ocean Currents that create the outstanding conditions of water temperature ranges, salinity concentrations and nutrient transport within the property to support the diversity of coral, molluscs and fish, as well as the declared rare, threatened, endangered or specially protected species S;
    - complex intertidal and subtidal geomorphic features in ocean waters S;

2. the Muiron Islands (continuation of Cape Range) are precisely delineated low, dome-shaped limestone islands. Displayed on the west are limestone cliffs, sandy beaches, intertidal rock platforms and seafloor slopes to continental shelf edge 30 km seaward. Displayed on the east are low dunes and sandy beaches gently sloping seaward with patch reefs and coral bommies, gradually levelling out into soft, muddy substrates. S, A;
3. marine habitats and coral structures as delineated in Figs. 3 and 4 of the Management Plan for Ningaloo Marine Park and Muiron Islands Marine Management Area (CALM, 2005) and:
    - coral reef communities (intertidal, shallow/limestone and subtidal) S, A, E;
    - deep water mixed filter feeding and soft bottom communities S;
    - macroalgae (limestone reef) S;
    - pelagic water (deeper than 100 m) S;
    - shoreline and subtidal reefs (low relief – lagoonal and low relief – seaward) S, A;
4. unusual and restricted terrestrial, marine and subterranean habitats including:
    - rock shelter areas providing habitat for small colonies of Rock Wallaby;
    - the nutrient rich mix of tropical and temperate water currents that attract the whale shark and a diversity of marine life;
    - mangal at Mangrove Bay and the aquifer in which blind aquatic fauna live S;
5. Cape Range includes a complex system of karst landforms, including:
    - closed depressions S;
    - surface solution sculptures S;
    - sinkholes (e.g., Bundera Sinkhole) S, A, E;
    - shallow uvula S;
    - caves (including rock shelters, short horizontal caves, larger horizontal caves, vertical caves, caves of the coastal plains, protocaves and mesocaverns) S, A, E;
    - Tulki Limestone caps S;
    - biokarstic features (tufa accumulations and the Ningaloo Reef) S, A, E;
6. hydrogeologic features and systems forming habitat for subterranean fauna:
    - Cape Range groundwater mound (freshwater) S;
    - karst aquifer system at crest of range (in Mandu Limestone) S;
    - internal drainage and cave openings on the crest of the range S;
    - drainage line infiltration. S.

World Heritage Guideline 4

World Heritage Guideline 4 calls for: "*Cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance to the international community as a whole".*

Cultural significance is not assessed in this comparative analysis. Features of natural significance that would meet the criteria include:

1. Ningaloo coral reef and lagoons (refer Guideline 1) S, A, E;
2. exceptional diversity of visually vibrant marine life and species (refer Guideline 1) S, A, E;
3. mass spawning of corals (refer Guideline 1) S, A, E;
4. the Whale shark and other marine megafauna (refer Guideline 1) S, A, E;
5. Cape Range Remipede Community at Bundera Sinkhole (refer Guideline 1) S, E;
6. troglobitic and stygofauna communities on Northwest Cape (refer Guideline 1) S, E;

7. the West Australian, Leeuwin and Ningaloo Ocean Currents that create the outstanding conditions and habitat for marine life (refer Guideline 2);
8. Cape Range's complex system of karst landforms and hydrogeologic features (refer Guideline 2) S;
9. Declared "Rare, Endangered, Threatened or Vulnerable" or "specially protected" species of animals and plants of the Ningaloo Coast property (refer Guideline 2) S, A, E.

In relation to Guideline 1 and Guideline 4, common scenic attributes of Natural World Heritage Sites as has been noted by Scenic Spectrums (2007), include:

- high degrees of naturalness;
- unique and dramatic landscape features;
- a strong sense of grandeur;
- outstanding, exceptional and superlative scenery in a world-wide context.

Highly scenic features and alterations are classified as:

T – underwater terrain and substrate materials;

S – sessile organisms;

F – fish and mobile invertebrates;

M – mammals and megafauna;

W – sea water features and characteristics

A – alterations.

The scenic features are assessed according to their degree of occurrence:

👁👁 👁 Extensive /High Visual Influence;

👁👁 Dispersed Moderate Visual Influence;

👁 Sparse /Low Visual Influence.

The assessment showed that Ningaloo Reef stands on its own visually with its own magnificent array of sealife, including:

- a wide array of fish and invertebrates,
- its spectacular megafauna (led by the whale shark), and
- its remarkable range of coral species varying widely in form and colour, along with equally varied sponge gardens.

Cape Range taken on its own is not in the same league scenically as World Heritage Areas such as the Grand Canyon, the Protected Islands of the Gulf of California, Socotra, etc. and such areas as the Kimberley Ranges, the Bungle Bungles, the Olga Ranges, or the Western Tasmanian Wilderness. However, spectacular views are certainly available from various locations, including the Shothole Canyon and Charles Knife Canyon areas.

Figures 6 and 7 provide examples of some of the features noted under Guidelines 3 and 4 above.

Figure 6 Flora and Fauna Species Biodiversity of Ningaloo Reef (Whale Shark, turtles, mana ray, fish spp. and coral spp.) (Sources: WA Dept. of Environment and Conservation and WA Tourism Commission websites, 2008)

Figure 7 Shrub steppe and spinifex grassland vegetation of the Cape Range as displayed in the Shothole Canyon and Charles Knife Canyon areas
(Sources: WA Dept. of Environment and Conservation and WA Tourism Commission websites, 2008)

Criterion (viii) Assessment and Findings

Outstanding or Superlative Examples of the Earth's History

Five key conditions of Criterion (viii) are satisfied by the Ningaloo Coast's display of outstanding or superlative examples of the earth's history, including:

- the strong linkage to ancient Pangean and Gondwanan supercontinent and Tethys Sea origins demonstrating the continental drift theory through superb and rare examples of endemic and anchialine subterranean fauna, including the outstanding remipede species;
- tectonic elements, including:
  - one of only two Afro-trailing edge type plate margins in the world (Hamilton-Smith *et al*, 1998, p. 15); and
  - the processes of tectonic plate subduction and orogeny;
- a particularly outstanding example of an "emergent" landscape affected by uplift and sea level changes over long periods of geologic time as clearly demonstrated by the presence of four superb wave-cut terraces;
- rich fossil and sub-fossil occurrences that provide an outstanding record of the earth's history, paleoclimatic phenomenon and past terrestrial and sea life, especially in relation to reef development;
- an outstandingly rich array of on-going geomorphic, karst, hydrologic and oceanographic processes, including:
  - an extensive network of over 700 caves; and
  - mesocaverns and anastamosing tubes extending down to an anchialine groundwater zone[3].

Global Geological Themes Represented

The Ningaloo Coast provides evidence of 7 of the 13 UNESCO Global Geologic Themes (Dingwall *et al*, 2005), including:

- tectonic and structural features;
- stratigraphic sites;
- fossil sites;
- caves and karst systems;
- coastal systems;
- reefs, atolls and oceanic islands; and
- arid and semi-arid desert systems.

Our investigation has also revealed that Ningaloo Reef is not predominantly a "fringing reef" as has been commonly assumed and reported in many previous reports and publications. Ningaloo Reef totals approx. 282 km length with approximately 223 km of near-shore "barrier" reef (or what some marine scientists may refer to as a "bank barrier reef" and approximately 59 km of "fringing reef".

This is demonstrated through the standard definitions of reef types (http://www.coris.noaa.gov/about/what_are/ - v Reference:%20Intro%20to%20Marine%20Ecology and http://www.starfish.ch/reef/reef.html). It is also illustrated by HyMap satellite image baythymetric map by Heege (2008) of Ningaloo Reef near Yardie Creek Australia, 2005 and through photographs and illustrations published by Collins, et. al. (2002, 2003 and 2006). However, Ningaloo is a globally substantial coral reef of very high quality by world standards and the only significant reef on a western edge of a continent (S, A, E).

Criterion (ix) and Criterion (x) Assessment and Findings

Ecological/Biological Processes and In Situ Species and Biodiversity Themes

Criterion (ix) and (x) pertain to the ecological and biological processes and to the in situ species/biodiversity themes. Our findings show that the Ningaloo Coast meets these two criteria on the basis of the following processes and themes:

- Oceanic Currents and Nutrient Cycles, including for example:
  - oceanography and unusual complexity of currents, water temperatures and bio-geographic regional influences;
- Marine Flora Speciation, Endemism and Refugia Processes, including for example:
  - part of WWF's Western Australian Marine Global 200 Ecoregion No. 212;
  - a sponge biodiversity hotspot on the North West Shelf;
  - a centre of endemism for rich biodiversity of marine species, including:
    - at least 250 species of coral representing 54 genera of hermatypic (reef building) corals;
    - 600 species of mollusc;
    - 500 species of fish, and
    - unknown number of sponge and other sessile species;
  - 3 species of turtle and one bird listed as vulnerable;
  - 13 species of seabirds listed on JAMBA and/or CAMBA recorded seaward of the outer reef;
  - 3 species are listed as endangered (blue whale, southern right whale and loggerhead turtle).
  - Ningaloo Marine Park is only one of two places remaining in the world where the whale shark (world's largest fish) regularly

[3].Mesocavernous limestone is produced by freshwater permeating the rock, so it usually occurs at the junction between rock beds or along the joints. But at Cape Range, given the distinctive character of the rock, it extends throughout almost the whole of the limestone, resulting in a spectrum of microclimates which in turn fosters the remarkable speciation which has taken place, as discussed under Criterion (ix) and Criterion (x) below.

- congregate and has the largest surviving whale shark community in the world;
- The reef's fauna changes within short distances, ranging from tropical to temperate species;

- Terrestrial Flora Speciation, Endemism and Refugia Processes, including for example:
  - part of WWF's Carnarvon Xeric Scrub Global 200 Ecoregion No. 128 that has a Deserts and Xeric Shrublands Habitat Type classified as Critical/Endangered;
  - outstanding species richness for an arid area (much higher species density than other WA regions- 288 spp. /1000 km2) with some endemism due to 2 overlapping tropical and temperate bio-climatic zones with many taxa at the southern-most or northern-most extent of their range;
  - endemic, rare or otherwise protected flora and fauna species, some with genetic subdivisions of the same species north and south or east and west;
  - a hotspot for non- marine mollusc endemism, with 10 such species known. These species were considered Red List and non-marine molluscs are known to be in global decline (Lydeard *et al.*, 2004).

Avifauna Speciation, Endemism and Migration Processes, including for example:

- 13 species of seabirds listed on JAMBA and/or CAMBA recorded seaward of the outer reef.

Subterranean Fauna Speciation, Endemism and Refugia Processes, including for example:

- Cape Range is a centre of endemism and relictual taxa refuge for one of the world's largest and most significant groups of terrestrial and aquatic troglobitic species surviving within a karst system, including fish, amphipods, isopods, remipedes, and insects;
- the only known example of a Remipede (*Lasionectes exleyi*) community in southern hemisphere (Humphreys, 1999b); a rich array of other rare, endemic and threatened stygobitic fauna, including fish, hadziid amphipods, gammarid amphipods, copepods and ostracods;
- the aquifer adjacent contains atyid shrimp, thermosbaenaceans, diverse amphipods and *Ophisternon* (the blind eel);

Anchialine Groundwater Habitat Processes, including for example:

- a complex stratified anchialine hydrological environment that provides refuge habitat for the survival of one of the world's most superb and diverse assemblages of unique and threatened troglobitic and stygobitic fauna species (Humphreys, 2000a and 2000b).
- Cape Range is one of the most outstanding examples in the world of an arid karst site with high biodiversity and examples of species originating from the Tethyan Ocean. Regarding the subterranean and anchialine environments of Cape Range, only two sites within the classic Dinaric karst of similar quality and integrity to the Cape Range exist – Postojna-Planina and Vjetrenica.

Integrity

The Ningaloo Coast nomination property satisfies the UNESCO conditions for integrity in the following ways:

1. The elements and the natural processes are highly intact and either relatively unaltered or capable of effective rehabilitation;
2. The natural threats to Ningaloo Reef or anthropogenic problems have generally been (or certainly could be) obviated by proper management practice;
3. However, impacts of petroleum and gas extraction, mining, pastoral grazing, feral animals, pest plants and recreation/tourism do exist; and
4. Regarding integrity, significant features and processes of the four natural criteria could be further enhanced and more fully contain superlative features, phenomenon and processes of outstanding universal value associated with the property as a World Heritage Site.

We have considered the aspect of "integrity" requiring a property to "contain all or most of the significant natural elements and processes". Although the current nomination boundaries undoubtedly contain many features and processes of World Heritage value and quality, some additional areas, features and processes that should be considered for inclusion or more extensive representation include:

- Exmouth Gulf and its areas of dugong and whale habitat;
- floodplain vegetation areas of the Exmouth Coast;
- seabird breeding islands of the Exmouth Coast;
- mangrove areas and lagoons of the Talandji/Tent Island Nature Reserve Areas;
- vegetation types identified by Beard (1990);
- sand dunes and plains geomorphological unit south of Cape Range National Park;
- the floodplains, alluvial fans and river valleys geomorphological unit (which has been completely excluded from the nominated property in the Learmonth area along the west coast of Exmouth Gulf);
- the entirety of the dissected anticlinal ranges unit and the karst cave and mesocavern system (of which approximately 50% lies outside the nominated boundary); and
- the complete groundwater system, including the entire freshwater lens, brackish intermediate water layer and seabed outflows.

In terms of integrity and infrastructure, the area must be:

- kept free from over-exploitation of the reef resources by sand mining, fishing and/or tourism industries or damage by boats associated with these industries; and
- protected from the collateral impacts of development, including clearing of vegetation, road construction, and hotel and marina construction.

The proposed boundaries do not fully comply with conditions of integrity as defined in the Operational Guidelines (UNESCO, 2008):

- particularly paragraphs 87-95, 99-107;
- no reference to a buffer zone. (In this regard, the Shark Bay World Heritage Site does not serve as an appropriate model.)

Review of the core zone and an appropriately regulated buffer zone is strongly recommended:

- In particular, we have concern regarding quarry areas existing to the east of Cape Range National Park that could potentially affect ground water quality, having a relay-effect on biological functions and creatures located in the Marine Park and Cape Range;
- The potential effects of pastoral leasehold grazing on the Marine Park south of Cape Range National Park are

also of concern due to what we regard as an inadequate 40 m onshore.

- The Exmouth Gulf area, or portions of it, should be considered for inclusion in order to take in the entire underground aquifer and freshwater lens, significant islands of the Gulf and the tidal and supertidal flats of Talandji (Giralia Bay to Yanrey Flats).

Although the important areas excluded at this time certainly do not diminish the universal outstanding value of those elements and processes that are included within the nominated property, they are of serious concern.

The current physical and functional integrity of the main geomorphic and physiographic elements and processes are exhibited within the nominated property and can generally be adequately conserved and monitored under joint World Heritage and regional authority co-operation.

Most coral reefs are seriously threatened (Cao and Caldeira, 2008; Walsh, 2008). Many are in poor condition in comparison to the near pristine condition of Ningaloo Reef. In addition, karst cave and mesocavern systems, such as those at Cape Range area, are extremely vulnerable to adverse human impacts. For these reasons, core area boundaries and buffer zones adequate to protect these resources should be the first step in ensuring appropriate protection and conservation management. Strong management is also vital to maintenance of positive health of coral reef systems.

Summary Conclusions

The nominated Ningaloo Coast property satisfies all four of the natural criteria for World Heritage inscription and compares highly with other similar karst and coral reef areas throughout the world.

However, there are important concerns about integrity and the inadequacy of the nominated property boundaries in terms of the core zone and the need for designated and regulated buffer zones as viewed within the context of the World Heritage Commission's (2008) Operational Guidelines.

Contacts

Key contacts regarding the Ningaloo Coast World Heritage nomination property include:

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Cango Caves - A Progress Report

Hein Gerstner

Cango Caves, South Africa.

Abstract

Africa is the cradle of humankind – from Australopithecus to the oldest modern humans to be discovered. Although virtually ever rock shelter overhang or shallow cave contains either pre-historical or historical remain (or both), proper cave systems are not that frequently found. Except Cango. This ancient pre-Cambrian limestone host one of the larger systems in Southern Africa and definitely boast the best developed show cave in the sub-Sahara. This paper is an attempt to firstly introduce this limestone cave and secondly describe the attempts made by the management to keep abreast with cave best practice models and appropriate applications as well as dealing with local politicians who often battle to understand the ethics and sensitivity of such unique non-renewable resources and heritage. This paper is our attempt to conserve, educate and taking up responsibility of managing an 'inherited' heritage for the next legacy (should we be so lucky that they realize the responsibility).

Introduction

Africa is the cradle of humankind. If it was not for the protective matrix of the Malmani (Transvaal) dolomites and the canopies of caves, the Australopithecus (Southern ape) fossils would have remained the missing link.

Sub-Saharan Africa is rather poor when it comes to carbonate rocks conducive for the formation of cave systems. It is nevertheless riddled with thousands of shallow caves or rock overhangs. The emphasis is however focused more on the contents of caves (archaeology and palaeontology) rather than the cave itself. The exception is Cango, a true limestone cave system and the biggest show cave operation in Africa.

"Cango" meaning "place of water between hills", is an ancient Khoi/san word. Cango Caves is situated in the Southern Cape Intermontane basin, called the Little Karoo. "Karoo" means dry, which it is, with an annual rainfall of 340mm p.a. The refill of underground water from the ring of surrounding mountain (the Swartberg, Kamanassie, Outeniqua and Red Mountain) retains the region as a "green" desert. The Swartberg Mountain, the range to the north, was recently declared an international Heritage site.

The depositional history of the Kango formation limestones date back to Pre-Cambrian times (100 million years go) when stromatolite deposits along a shallow shoreline formed the lowest member of the Cape Supergroup stratigraphy, known as the Kango member.

The presence of a well developed fault line that runs parallel to the Swartberg Mountain range caused the orogenetic pressure from the drifting Falkland plate to squeeze the limestone lense from the lower strata to the surface in a north/south tilted orientation. Numerous hot springs accompany the fault line and it is one of the reasons the effects of the 1969 great quake were felt in Oudtshoorn.

The limestone member lay submerged in the water table 15 million years ago, due to a period of exceptionally high rainfall. This resulted in a phreatic, low energy system of 7.2km of which the first 1.2km is designated tourist cave. Cango II was discovered in 1972 and remains pristine. It has been visited by the late Mr. Roy Skinner, the first non-South African and by Kent Henderson of ACKMA in 2008.

Wild Caves in the limestone belt tallies to 26 of which 2 are infrequently used by Adventure operators in the schools and teambuilding market. Significant is the adventure route option at Cango. It is probably one of a kind in the world and does quench the need for the adventure seeker, although it is pretty commercial.

A Dutch ensign, Isaac Schrijver entered the secret realm of the Little Karoo through a canyon like feature, the Attaqua's Kloof in 1689. His colonial presence halted the Later Stone Age in this region. A hundred years later, the Cango Caves were discovered by a certain Van Zyl, farmer and road builder. He was accompanied by a team of slaves. This colonial "discovery" could never be substantiated by archival evidence. Political

"disputes" often erupts over the naming of the Caves and some of its larger chambers. The archaeological evidence however, provides sufficient proof that Stone Age People occupied the twilight zone of the Cango as far as 80,000 years ago. The discovery is undisputedly their claim.

Cango is not the deepest or longest cave in Africa, but it is one of the oldest tourist attractions in South Africa. The sheer size of the caverns and it's massive speleothems (as well as the lack of competing caves around), was sufficient to be described as one of the wonders of Africa by Hedley Chilvers at the turn of the previous century. Some of the first protective legislation was passed, by the British government specifically for the conservation purposes of Cango. The first ever official and government remunerated guide was appointed at the Cango Caves.

Managing a show cave in Africa poses many challenges. Having local politicians as decision makers for cave policies often affecting operational procedures, together with the fact that the Municipality is becoming increasingly more dependant on cave income, ensures a threatening environment for the Cave. This affects staff appointments, conservation, ethics and often much needed funding for critical projects, e.g. LED lights. Solutions are never simple, often implying intense negotiations, arguments and threats of intervention by the Provincial Government. The latter is the appointed keeper of the Cango Caves. Sadly they also lack the capacity or drive to make a drastic change.

The Cave currently is receiving 230,000 visitors annually and the market is healthily split on a 50/50 basis between foreign (mainly German, Dutch and U.K.) and domestic.

Negative impacts are definitely the absence of an accepted Management plan and the (still) dormant scientific advisory body. Council still has not been in a position to approve the existing management plan and views the science committee as a threat and unnecessary expenditure.

Not all is doom and gloom.

We are currently running several worthwhile projects that we try and align with international best practice models, e.g. the LED light replacement programme, the construction of a new walkway to prevent dust pollution, the Radon protection programme and the environmental monitoring project.

Our current aim is to "ringfence" the cave as a recognised conservation Trust, run by an assembly of knowledgeable directors, to ensure the longevity and well-being of the caves as a non-renewable geo-asset and as the unique selling point of the Little Karoo. The future of Cango is doubtful under the prevailing situation.

The Next Stage in the Evolution of Management Models at Jenolan Caves, NSW, Australia

Peter Austen and Alan Griffin

Jenolan Caves Reserve Trust

Abstract

Our previous paper examined the impact of privatisation accommodation and the commercialisation of its cave tours. This was part of the Greiner Government's overall reform agenda which focussed on the application of New Public Management Principles.

It was concluded the business model adopted in 1989 at Jenolan, had more to do with the commercial issues at Jenolan than the introduction of New Public Management Principles. The lessons learnt from the initial foray into commercialisation of the Jenolan tourist operations is now aiding the development of long term management arrangements at Jenolan.

Since 2007, extensive work examining management options to best ensure the commercial and environmental sustainability of Jenolan has been undertaken. The experience gained by Government in its management of an integrated business at Jenolan since July 2006 has greatly assisted this work.

This paper presents the results of this recent work and examines two options; either of which might serve as the Jenolan business model for the short to medium term. The development of the options was complicated by three factors: the rapidly changing nature of regional tourism and competition for discretionary spending; the emergence of a holistic approach to geo-tourism and geo-management; and the impact of the current international financial environment.

The two options present a balanced approach to the objectives of commercial and environmental sustainability utilising the strengths and expertise of the public and private sectors.

Introduction

Jenolan Caves is situated approximately 120 kilometres west (as the crow flies) and 2.5 hours drive from Sydney on the western side of the Blue Mountains.

Since its discovery by Europeans in 1838, Jenolan Caves has remained one of Australia's iconic tourist locations and is known for its use of innovative strategies to protect the geological and heritage assets of the area.

However, its dual role as a popular tourist location with over 220,000 visitors a year and a site of geological and heritage significance, creates the possibility of conflicting management objectives. In order to balance these objectives, the NSW Government, in 1990, separated the responsibility for managing the hospitality services provided by Caves House from the management of the caves (both tourist and wild), and the reserve in general. At the same time the Government entered into a lease arrangement with the private sector to operate the hospitality services.

Due to issues arising from the separation of management responsibilities, these arrangements were modified in 1995 and the responsibility for managing the lease, the caves and the reserve was brought back into one entity the Jenolan Caves Reserve Trust (JCRT) reporting to the Minister for Environment.

However, the separation of delivering the hospitality services from the cave operations proved increasingly dysfunctional and, following a review, it was determined that the preferred option was to have one operator, managed by the Parks and Wildlife Division of the Department of Environment and Conservation, manage all services provided at Jenolan.

Having traversed a full circle, the Government is now considering new management arrangements at Jenolan. This paper examines

the influences that determined previous decisions regarding management of the reserve and identifies the lessons gleaned from the experience of alternative management arrangements at this popular tourist and strategically significant environmental location.

Historical Overview

The area we know as Jenolan Reserve and its caves were well known to the Gundungarra and Wiradjuri indigenous peoples who left many artefacts and other evidence of their use of the area.

European contact purportedly commenced around 1838 to 1839 with a runaway convict James McKeown using the area as a hideout. Around 1840 the pastoralist James Whalan made the first reported contact with the Caves. Over time visitation increased and with it damage from the souveniring of cave formations (speleothems). This resulted in the colonial government reserving the area to protect the natural features. The Fish River Caves Reserve was gazetted in 1866 preceding the establishment of Australia's first national park (the Royal) by 12 years and the world's first national park Yellowstone by 6 years. (Note: Yosemite was granted as a public trust in 1864).

Due to its natural and rich cultural heritage, in 2004 the whole reserve was placed on the State's Heritage Register and consideration is now being giving to placing it on the National Register. The reserve also forms part of the Greater Blue Mountains World Heritage Area.

Historic Management Arrangements

Prior to 1989 management of the Jenolan Reserve was undertaken within a mainstream government agency using cash flow accounting. It would appear Caves House was treated as a separate cost centre and there is also evidence that it was financially cross subsidised by revenue from the tourist cave operations.

With the election of the Greiner Government in 1988, Jenolan Caves was not immune from the ideologies of free market and New Public Management. In response to the Government's agenda, a decision was made to separate the hospitality services (accommodation, food and drink outlets) and the reserve management (including the tourist caves). In addition, it was decided that the private sector would be better placed to manage the hospitality services and accordingly a 99 year lease was granted over Caves House.

Administratively, the lease and the reserve and the caves were managed by the Jenolan Caves Reserve Trust (JCRT) along with Wombeyan, Abercrombie and Borenore Karst Conservation Reserves.

The Trust was to be self funding. This was compromised, however, by low visitation levels at the smaller reserves where, at best, Wombeyan broke even in cash flow terms, whilst the other two reserves required supplementation from the Jenolan businesses for their day to day management costs. Although Jenolan made a steady return, it did not return the profit needed to reinvest in essential cave and above ground infrastructure, let alone cross subsidise the other reserves or fund environmental programs.

2003 Review into the Management Arrangements

With the support of the Trust Board, the Hon Bob Debus, Minister for the Environment, initiated a special review of the Trust by the Council on the Cost and Quality of Government in 2003 (JCRT Special Review, 2003). The review found the Trust had been managing its finances without recourse to recurrent funding, despite long standing structural and commercial impediments caused by the business model established in 1989. It was determined that the business model was unsustainable. The Review recommended that the Trust be disbanded and the responsibilities for managing the reserves be transferred to the Parks and Wildlife Division within the Department of Climate Change (DECC) and the option of integrating the operations at Jenolan be investigated by an Administrator appointed to implement the Review's recommendations.

In adopting the recommendations of the Review and various studies, the Government established a State Karst Management Advisory Committee supported by a specialist Karst Conservation unit located within DECC. It also transferred the Wombeyan, Abercrombie, Borenore and Jenolan Reserves to DECC, with the Jenolan visitor zone to follow upon resolution of management issues relating to Caves House and the finalisation of

a new Plan of Management for the Jenolan Reserve.

Negotiations with the then lessee of Caves House to integrate the commercial businesses at Jenolan failed. The Government subsequently acquired the lease and issued an Expression of Interest for an operator to manage the businesses at Jenolan under a 21 year lease/licence arrangement. The investment required to upgrade Caves House to a contemporary standard, depressed regional tourism conditions and the cost required to undertake due diligence resulted in a poor response to the EOI. Since July 2006 the NSW Government has been managing an integrated business operation as an interim measure until a final decision is made on the long term management arrangements at Jenolan.

To date the Government has injected $2.9M into outstanding capital and maintenance works within the caves and above ground and some $3M to carrying out catch up maintenance within Caves House.

The Lessons Learnt from the Previous Commercialisation of Jenolan caves

There are a number of fundamental lessons to be learnt from the arrangements in place at Jenolan between 1989 to 2006. These are:

- The businesses at Jenolan have to be managed as an integrated operation irrespective of whether they are managed in-house by government, by a private sector operator or a combination through an alliance type of arrangement. Caves House, built originally to reflect the romantic and picturesque relationship with the caves and targeted towards wealthy travellers (Jenolan Caves Reserve Plan of Management, 1988), is economically unstainable on its own, as it is too large for a boutique operation and too small for a resort type facility.
- There is a need not only to achieve, but also be seen to achieve, a balanced approach towards conservation and commercial objectives. This requires a division of the day to day responsibilities for managing the commercial businesses and regulating compliance with conservation and heritage requirements. This division is required regardless of whether the businesses are being managed in-house by government or by a private sector operator.
- A strategic tourism development plan, including finance and implementation plans, is needed with clear role definition for the various stakeholders and government.
- A Board made up of various and disparate stakeholders is not regarded as best practice. A report from a 2003 review into governance boards discourages representational appointments to Boards of commercial entities as they "can fail to produce independent and objective views" (Uhrig, 2003). A key reason for the success of the JCRT Board despite significant challenges was the strong leadership qualities provided by its Chairs (JCRT Special Review, 2003).
- A small dedicated agency managing a reserve such as Jenolan is not efficient or financially viable. Small agency overheads as a percentage of turn over are double that of a large agency and access to financial, legal, marketing, information technology and human resource expertise is limited and more expensive given its limited buying power.
- The Trust was able to effectively develop a remarkable degree of expertise in cave management and science, however, its expertise in other areas (e.g. management of the above ground reserve) was compromised by the resources available to it.
- The future operation must meet both government and community expectations in respect of cultural, environmental, social and heritage standards. In addition, the needs of the various stakeholders at Jenolan must be considered.
- The most effective method of maintaining Caves House as a heritage asset is to use it. Deferred expenditure for a heritage asset is generally considerably higher when it is left idle for prolonged periods.
- Despite attracting on average around 220,000 visitors per annum over the last 6 years, the businesses at Jenolan have never been self sustaining to the point where

they are able to invest in long term major capital upgrades to infrastructure. Even with this level of visitation, it is probable Jenolan will always, to some extent, be dependent on government supplementation.

2008 Business Analysis

An assessment in 2007 looked at what was needed to complete the upgrade of cave infrastructure and bring the accommodation assets and above ground infrastructure to an acceptable level. It was estimated that some $10m was required over a three year period.

Given the estimated cost of the upgrade, the Government decided it required an independent review of the Trust's marketing, operational and financial plans. The review, carried out by Deloitte Touche Thomatsu (Deloitte Touche Tohmatsu, 2008) under the supervision of the Trust and the State Property Authority, was also to advise on future management options.

Essentially Deloitte's analysis confirmed the Trust's findings in that;

- The businesses should be run as an integrated operation.
- Governments are not well placed to directly manage hotels/ accommodation services.
- The private sector would unlikely be interested in managing Jenolan's accommodation services in their current state. In addition, given the current economic environment and tourism markets, the arrangement most likely to attract a private sector operator in the short to mid term would be a management agreement and not a lease arrangement.
- Given the current environment within the tourism sector there is limited revenue growth opportunities due to competition for discretionary spending (including home entertainment).

The Deloitte study did, however, provide valuable additional insights into a number of areas such as making greater use of internet solutions to increase market penetration, increasing operational efficiencies, streamlining operational and financial reporting and widening the range of key performance indicators to measure the performance of the various operations within the hotel.

The Challenges

Since the 2008 review, the economic climate has deteriorated even further exacerbating the challenges already being faced at Jenolan. The primary challenges, which are not unique to Jenolan but also relevant to other commercial caving operations and regional tourism, include:

General Challenges

1. *Visitation levels.* Empirical evidence is showing that domestic day visitor numbers for tourist attractions within a two to three drive of Sydney to date have not been seriously affected by current economic climate. However, overnight stays and international visitor numbers have declined markedly. The high fixed costs associated with accommodation assets such as Caves House means this is having a dramatic effect on revenue and cash flow.

2. *Increased competition for discretionary spend.* Recent government grants to the Australian tax payers and pensioners have resulted in increased spending on home entertainment including plasma screens, blue ray technology and electronic games. These are in direct competition to tourist attractions such as Jenolan. This position is worsening due to the availability of a myriad of choices for entertainment and tourism (domestic and international) available on the internet. Federal Tourism Minister, Martin Ferguson, in launching the development of a National Tourism Strategy (Ferguson, 2008) suggests that the tourism industry needs to keep abreast of and adapt to the changing needs of the marketplace

3. *Availability Government Funding.* The current economic stimulus packages are focused on mainstream government infrastructure such as education and health services. This further reduces the priority of funding for eco-tourist facilities. However, on the plus side, government is concerned with the state of the Australian Tourist Industry and money may become available from the Commonwealth and State for tourist infrastructure that can demonstrate

that it is critical to local regional economies.

Jenolan Specific Challenges

1. *Changing generational recreational patterns* Attractions such as Jenolan's guided show cave tours generally have little appeal for Generation Y who on average desire instant feedback and gratification. Adventure caving does hold appeal to this market segment but the need to protect the wild caves, limits the capacity to generate sufficient revenue from this source to allow long term sustainability.

2. *Suitable Business Models.* History has shown that for efficiency and financial reasons the various businesses at Jenolan should be managed as an integrated operation. However, at the same time managing a hotel such as Caves House is not a core function of government nor is it within the expertise of government. On the other hand, there are very few, if any, operators in the market place capable of managing a hotel and a sensitive and fragile cave environment; nor is it likely such an operator be interested in, what is in the wider sense, small scale operation such as Jenolan. This dilemma is causing some hesitancy within government in tackling the long term management issues at Jenolan with any sense of urgency.

3. *Invigorating Staff.* The process that Jenolan is now going through commenced in 2003 with the original Review. There have been a number of significant changes and more change is inevitable. For staff it has been a turbulent period and uncertainty has become a part of everyday life. It has to be said it is draining for the morale of staff across the organisation.

4. *Concealment of Passion.* The people of NSW and indeed Australians appear to have a deep and abiding affection for Jenolan. The Government recognises the need to protect the caves and the tourism industry see's Jenolan as a good opportunity. However, because of Jenolan's recent history, the risks associated with its infrastructure and its access challenges, the government prefers to opt for less risky projects. Jenolan has lacked a champion – an eminent person or an organisation who is generally perceived not to be motivated by self interest to unlock the passion. For many bureaucrats the lack of a champion might be considered an advantage but our experience is contrary to this view especially in competing for discretionary funding from either the public or private sectors.

The Way Forward

Government's priority is to manage Jenolan in a sustainable manner, protecting its indigenous and European heritage whilst maintaining public access (DECC, 2008). This includes protecting the caves and the karst landscape and at the same time minimising financial demands on government.

Securing private sector expertise to manage the hotel operations will depend on finding the right balance between environmental and heritage obligations and commercial sustainability. This will require an alternative delivery management model to that used in the past. Such a model will depend on true partnership between the public and private sectors based on:

- Transparent operational and financial reporting
- Development and acceptance by both parties of new revenue sources
- Clear understanding of the obligations and risk allocation associated with the sites heritage and environmental requirements
- Clear understanding of the commercial requirements of all parties which will be reflected in any agreement.

Prior to any arrangement being finalised there are a number of pre-requisites to address, including the need to upgrade the accommodation assets and streamlining the operating structure currently functioning within the limitations of government requirements. In addition, an environmental regulator will be required to oversight those functions which are separate from the day to day management of the site.

Based on the work to date the only possible options available for the short to medium term future management of Jenolan appear to be:

1. *Management by Government*

   This arrangement preserves the status quo with government managing both aspects of the businesses at Jenolan. The advantages of this scenario include the continuance of an integrated commercial operation and retention of government's core expertise in managing sensitive environmental sites. The disadvantages are that management of hotel and leisure facilities is not a core function of government and there are inherent inefficiencies in managing a commercial operation within a government framework.

2. *Management Agreement with a private sector operator to manage the accommodation assets*

   Under this arrangement the overall management responsibilities will remain with government and a private sector operator will manage the hotel. Marketing for both cave tours and accommodation can be contracted to the private sector operator and a form of profit sharing and revenue incentives based on an open book approach entered into by both parties. This option allows both the private and public sector to play to their strengths – putting management of the hotel and marketing with the private sector and keeping conservation and interpretation with government.

3. *Management by the Private Sector of all commercial operations under a management agreement.*

   As noted above it is expected that the number of private sector operators capable of managing the accommodation assets is expected to be limited. However, this option must still be investigated as it could bring increased efficiencies to the administration of Jenolan Again this approach will need to be based on an open book approach but will require tight environmental controls to protect the show caves.

Conclusion

The search for a suitable management model for Jenolan is reaching its final stages. The journey has been prolonged and difficult due to the industry wide challenges and the issues particular to Jenolan.

The challenges include the current world economic downturn, changing recreational needs particularly of the Y generation, the declining Australian Tourist Industry and the disparate nature of the commercial and environmental requirements at Jenolan.

Will the new management model succeed? Only time will tell as it will rely on a truly collegiate approach by the public and private sectors both bringing their core expertise to the adopted arrangement.

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Winds of Change – A Karst Management Database

Rauleigh Webb

Abstract

The Australian Speleological Federation (ASF) created the Australian Karst Index in 1985. Today cave managers have little more than that 1985 karst index on which to base management decisions.

What is required is a Karst Management Database that is designed to hold not only the basic information about a cave or karst feature such as cave length, depth etc but also to hold details of everything relating to every karst feature that they manage. The database should hold ALL research information that has ever been undertaken for every cave and karst feature. The database should also classify this information so that at any time a Cave Management Prescription for any cave or karst feature can be generated by the database using ALL of the management information that is available at the time of generation.

Such a Karst Management Database is being designed to collate all fields of research including geology, archaeology, palaeontology, aboriginal heritage and site information etc It would also contain general data such as maps, photographs, videos etc, all related to one or more karst features. This paper outlines the design of the database and how it will be build to simplify a cave managers job of collecting the varied data that is required to make informed decisions about the caves and karst features that they manage.

Do we Need a Karst Management Database (KMD)?

The concept of a Karst Management Database (KMD) is one that has built over time. More and more information relating to caves and karst features is being discovered by researchers, speleologists and managers. This large quantity of knowledge is required by cave managers if they are to make knowledgeable decisions about the present and ongoing management of caves and karst features. Unfortunately unless this quantity of knowledge can be harnessed by an appropriately crafted database, decisions relating to the ongoing management of caves and karst are likely to be made on the basis of "best available local knowledge" or the results of extensive literature surveys. This has been the case for all current cave managers in Australasia for over 30 years. Other countries appear to have similar problems, as a search of the internet returned zero results for "Karst Management Database".

Examining the "databases" on the http://www.karstportal.org website shows NO databases containing karst management data. These databases generally contain basic information such as the caves location, name, length, depth and short description. The most extensive online database in the world appears to be the Australian Karst Index Database (KID) based on the 1985 dataset. Fleury *et al* (2007) describes the Karst Information Portal as

> " the integration of karst knowledge by providing a comprehensive, community-driven central repository of this knowledge, including gray literature, raw data, and published journal articles."

Unfortunately this portal does not provide a database that cave managers need to adequately manage their caves.

The lack of a KMD appears to be a global problem so the development of such a database could see it used on a global scale. Certainly it has the prospect of being used Australasia wide.

What Information should be in a KMD?

It is clear that a KMD should provide cave managers with a tool that can access data relating to every aspect of cave and karst management. So here is some of the data that I think should be in the KMD.

The Basic Information

The basic cave information is the basic dataset that is currently stored in the Australian KID. Information such as the cave Name, Number, Length, Depth, water flow etc. This level of information provides little to cave managers

that they could base management decisions upon.

So the next level of detail which should be considered basic cave management information is at least the following:-

- Hazard Information with ratings
- Visitation rates per/week and/or per month or year
- Maximum and Minimum Party Size
- Booking Information (AM/PM/DAY)
- Cave Classification
- GPS Location information

Examining this basic level of cave management information it provides managers with the basis of a permit system that will allow them to make decisions about controlling access to caves and karst features. Managers will still need to use "local knowledge" to determine many of these critical values which all have the possibility of badly affecting caves if they provide excessive access to caves. As managers if you are unsure on visitation rates or party sizes always err on the side of lower numbers and provide caves with lower impacts.

Hazard Information with ratings

One of the items in this basic information is Hazard Information. Any potentially known hazardous sites within a cave need to be assessed and rated. A simple rating system should be used such as that shown in Table 1. This example uses a range of numbers to rate the stability of a rockfall with 1 being the most stable and 10 being the most unstable. Only those hazards that are thought to pose a risk should be rated with other rockfalls in the cave falling into the 1-2 rating which specifies that care is required at all times on rockfalls.

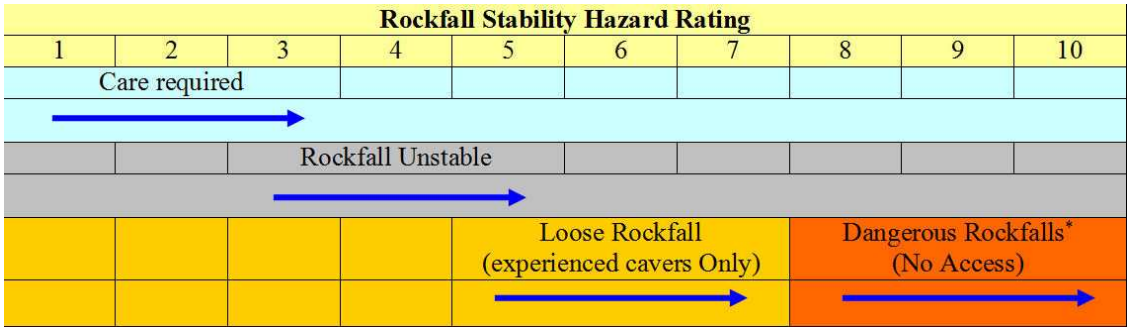

Table 1 * - No Access – These Dangerous areas should only be accessed to be re-assessed by appropriate Staff or Consultants.

By developing simple hazard ratings for all cave hazards and then rating those hazards for each cave the KMD could be used to provide cave permits that could easily list the hazards, with ratings, on each cave permit. The generation of cave management prescriptions (Webb, 1999) could also be automated using the KMD containing this level of data.

Kowallis (2009) provides a methodology for "rating a cave" by identifying the hazards in a cave, giving the hazard a rating (in the form of a range) and then "estimating" the "possibility of occurrence Factor" to determine an overall "Hazard Rating" for the cave. This system provides a method of determining the overall risk rating for the entire cave by taking all of the known hazards in the cave into account. This system could provide overall Hazard Ratings for each cave in a KMD. However Kowallis's hazard rating does rely on the "possibility of occurrence Factor" which is purely an estimate based on one or more persons "local knowledge" and "gut feeling" on how bad a particular hazard is? In some cases this may have some statistical basis, such as flooding where it may be based on the number and size of past flood events but this will not always be possible.

The …LOGICAL information

This set of data is the largest set of those proposed for the KMD. Some parts of this dataset are currently in the ASF KID database but they are poorly represented. The …Logical information refers to the many fields of science that relate to caves and karst that end in the suffix –logical, and some that don't. Table 2 lists the –logical data areas that relate to caves and karst.

Dataset
Geological Feature data
Biospeleological data
Hydrological data
Archaeological data
Palaeontological data
Meteorological data
Microbiological data
Cultural Heritage data
Cave Inventory data (Speleological)

Table 2

All of these datasets would require rating information similar to that specified in Table 1 for rating Rockfall Stability Hazards. However for the datasets in Table 2 the ratings would relate to the rarity of the cave feature, cave animal, hydrological feature, fossil, etc. The suggested rarity ratings for cave and karst features are shown in Table 3.

In order to fully specify the importance of a feature it would be preferable to specify the rarity on a State, Country and Global scale. By using all three rating levels, it would be possible to specify all of the features in caves and karst for an area at the State, Country and Worldwide levels. This method of scaling would highlight the importance of features in caves and karst from all perspectives and would ensure that managers could readily highlight the critical features in their area which would require higher levels of protection. These features could also be readily highlighted when Cave Management Plans and prescriptions are prepared. This level of rating would also be highly valuable when documenting caves and karst for major submissions such as World Heritage listing.

Rarity Rating of Features									
1	2	3	4	5	6	7	8	9	10
Common		Average	Uncommon	Scarce		Rare		Very Rare	

Table 3

The actual data fields that would be stored for all of these datasets would clearly be different with different information requirements for each dataset. The database design would readily allow for the different data fields for each dataset and would allow other, as yet unspecified datasets, to be added to the database at any time.

Infrastructure Info

Other types of data could also be added to the database that would greatly assist cave managers in maintaining the infrastructure within, on or nearby caves or karst features. Infrastructure tables could be maintained that recorded infrastructure details such as:-

1. **Tourist Cave Infrastructure – Stairs, Platforms, Lighting, Gates etc**
2. **Non-Tourist Caves – Bollards, Abseiling structures, hardened walkways, signs, track or route marking, ladders, etc**
3. **Scientific Equipment**
4. **Buildings – Toilets, Water Tanks, Generators**
5. **Car Parks, Interpretive Centres etc**

Details such as Location, Size, Materials, Date Constructed, Cost, Supplier, Warranty, Maintenance Schedule, Damage or Wear and Tear notes etc could all be stored in the database. This would allow cave managers to generate comprehensive maintenance reports and schedules on all of the infrastructure that they need to maintain. The database would also accommodate any other infrastructure items that cave managers may need to add and maintain.

Permit Information

Currently cave permit software called TripMan has been developed and is operational at Yarrangabilly in New South Wales. The TripMan software allows cave managers to store the basic information required to generate cave permits for cave leaders who

have the required access levels to visit caves under their management. Managers can ensure that the visitation levels they require are enforced via the TripMan software. This software also allows leaders to request their permits online with appropriate authorisation being supplied by management staff.

A KMD would have the ability to store considerably more information about all of the different types of permits that cave managers are required to issue in relation to a variety of cave and karst activities. Table 4 lists a number of different types of permits that managers would be expected to deal with in respect to the caves they manage. All managers may not require all of these permit types but many of them apply to most managers at some time.

Permits for Cave and Karst
1.Permits to collect cave fauna by cave, karst area or state?
2.Permits to visit caves – (Current TripMan system)
3.Permits to conduct experiments in caves
4.Permits to perform digs to enter or extend caves
5.Permits to perform Palaeontological or Archaeological digs in caves
6.Permits to collect speleothems and other deposits from caves
7.Permits to dive in caves

Table 4

The list in Table 4 is by no means comprehensive but the KMD should readily accommodate any type of permit that you may wish to authorise. Each type of permit could be defined in the database and then the permits could be issued at any time by the appropriate staff. The database would maintain an ongoing record of all permits provided along with any conditions that were applied to any permits.

Fire Information

Another area of management that would benefit from a KMD is fire information in karst areas. The generation of maps showing known cavernous areas is very important when planning firebreaks and in emergencies, where new fire fighting breaks can be placed, while ensuring the safety of dozer operators. Keeping heavy equipment away from known cavernous areas is sometimes not possible but if appropriate planning has been undertaken then the risk to operators of heavy equipment can be minimised.

Use of the KMD in conjunction with GIS mapping software would readily allow the generation of sensitive cavernous areas for use in fire planning. It would also allow the generation of definite "no go" areas for heavy equipment. Highly sensitive sites that may be vulnerable to fire, could also be identified in the KMD so that special planning requirements are applied to these sensitive karst sites.

Maps showing known cavernous areas could also be extrapolated using known hydrological information to include "possible" cavernous hazards that would only be entered with heavy equipment in cases of emergency.

The KMD would store information about sensitive sites and areas along with a sensitivity rating similar to the "rarity" rating shown in Table 3. These ratings could then be used to highlight those areas or sites with the highest sensitivity and ensure that the most sensitive sites received the highest level of protection.

What is the Extended KID?

In Australia the ASF KID database is currently the database with the most basic information available. Other databases have been created such as the South Australian KIDSA database of the Nullarbor which contains many more data items than the current ASF KID. The WA KID database also extends the data stored by the ASF KID by also providing fields that store the information listed in Table 5.

Extended KID Data
Cave Maps in Image form
Cave Images
Cave Videos
Trip Reports
Fossil Data
Environmental Data

Table 5

All of these data objects and more could readily be added to the KMD which would make this database the most comprehensive karst database ever built.

Database Design and Software

Without entering into extensive detail of how the database would be designed and operated the overall design for the development of the KMD will be described.

An SQL server database would be used as the major data store for all of the information in the KMD. The exact "flavour" of the SQL server software is not considered critical but would almost certainly be either Microsoft SQL server (2008 at present), Oracle (11g at present) or MYSQL (5.1 at present). All of these products provide a database which would ensure that the KMD could grow rapidly over a 10-15 year period with only maintenance and upgrades to consider.

The development of the web based application would be the heart of the KMD. To ensure that the application is robust and can be maintained in a corporate environment, the appropriate development environment is Microsoft's ASP.Net.

The database table design would be based on objects, which are in fact the field names and types that make up the design for a specific object type. The object would be the Basic Cave information or the Geological feature data, and the objects would have a relationship table which would allow objects to be related to each other in any number of ways. The forms that allow users to input and change data in the database would be stored in the database as an XML field. The XML form would be read from the database when a form needs to be loaded and the data displayed to users in a web browser.

This design would allow new objects to be easily added to the KMD at any time with minimal or no input required from programmers.

Who Would Use a KMD?

The users of a KMD would be wide and varied but the main list of user groups are specified in Table 6. All of these groups have an interest in caves and karst. Their interests may vary wildly but they all require the same thing and that is information about caves or karst features in a particular area or region. They may be proposing a development on karst and need to know how to avoid caves and karst features, or they may be looking for a cave to undertake specific research. No matter what purpose the group has they need up to date and accurate information on caves and karst. The KMD software will allow cave managers to provide different online levels of access to the KMD. Different views of the data can be provided to each user group or even individual users.

This would allow cave managers to ensure that the data could be secured while still giving appropriate levels of access to a large variety of user groups.

KMD User Groups
Cave and Karst Managers
Researchers in Cave and Karst
Speleologists
Government Departments
Cave Rescue Organisations
Property Developers
Mining Companies
Telecommunication Companies

Table 6

What Would they Access?

The importance of security over access to the database cannot be overemphasised but using the current software tools it is relatively easy to provide access to a very wide range of views of the KMD without compromising the data.

Researchers could easily be provided with update access to their relevant areas of expertise without compromising the overall integrity of the KMD. Speleologists could be given access to the KMD to allow them to provide cave surveys, inventories, images, Trip Reports, or any other data area that cave managers deemed appropriate.

Overall the levels of access would be created, specified and managed by the cave manager ensuring that data access would be provided to user groups to ensure that it was used or updated in a timely and appropriate manner. If required the KMD could be configured to ensure that cave managers reviewed updates before they were applied to the KMD.

What Cave Managers Could Produce

Cave managers have requirements to produce a range of different reports relating to the karst areas that they manage. A range of possible reporting requirements for the KMD are outlined in Table 7 but many more are possible and could be defined in the development process.

With built in configurable logic the automated generation of Cave Management Prescriptions would allow cave managers to generate up-to-date prescriptions at any time. As new information is added to the KMD prescriptions would automatically change as critical information changed.

The levels of reporting would need to be highly flexible so that additional reports could be generated by cave managers without reverting to the need for programmers to generate new reports.

Reporting Requirements
Visitation Data for Caves and Karst Areas – Daily, Monthly, Annual
Vital Cave and Karst Information for regional management plans
Cave Management Prescriptions (automated)
Cave Maintenance Work flows (automated)
Fire and Rescue planning data
Permit Renewal data
Details of outstanding data not entered
GIS details of caves and karst areas

Table 7

Who Would Enter the Data?

Initially a significant quantity of basic cave data could be imported from existing data sources such as the ASF KID and other databases and spreadsheets held by speleological groups. However a major portion of the data is currently held in research organisations such as Universities, Museums and private companies. The developer of the KMD would need to liaise with these organisations to request access to the data they hold, to allow importing into the KMD. Reciprocal arrangements with these organisations should see them access to the KMD to extract information, as well as, to update their specific areas of research or knowledge.

Where cave managers have provided access to caves for researchers or speleologists they should be required by the permit they are given to place the results of their research into the KMD. Where the research is sensitive or confidential researchers should be able to request a caveat be placed on access to the information by the cave manager. This form of cooperation should ensure that important data that may affect the management of a cave or even a site within a cave is not overlooked because the information is not available to the cave manager.

Permit applications could be entered ,via the Internet, by those requesting/renewing a permit but all permits would be authorised by appropriate staff. This process could be fully electronic or involve the generation of hard copy permits if required.

Who Should Manage the KMD?

Management of the KMD should be the responsibility of the government agency managing the caves and karst. In Australia there are about 20 or more agencies/organisations/private companies that are currently managing caves. However of these bodies the one that has more karst and more caves than any other to manage in DEC in Western Australia. With the majority of the Nullarbor, Cape Range and the Kimberley providing over 8000 caves and karst features it is imperative that DEC starts to collate the large quantity of data that is required to manage these significant cave and karst resources. The creation of a KMD should become a priority for DEC as the first of these areas moves towards World Heritage listing.

Once the KMD has been built its use could readily be extended to other cave managers and karst areas throughout Australasia and hopefully the world. No such database currently exists but it should. If cave managers are to truly manage the caves they are custodians for they need extensive up to date information. The way to bring this information to cave managers is with a comprehensive KMD.

Conclusion

The paper describes a comprehensive KMD that would provide cave managers with the ultimate data store for cave and karst information. The database would be flexible enough to allow any data items relating to caves and karst to be defined, stored and retrieved by the database.

If DEC in Western Australia were to build such a KMD then it is very likely that other cave managers would be interested in using the database to store the data relating to the caves and karst that they need. Besides interest from Australasia it is very likely that other countries cave and karst management authorities would also be highly interested in utilising such a KMD.

Let's plan for the future and build a KMD that will ensure caves and karst will have a database that will provide cave managers with the best chance of making informed management decisions. Hence they will be able to make those decisions because they have the best information available.

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List of Abbreviations:

Abbreviation	Meaning
ASF	Australian Speleological Federation
ASP.Net	Active Server Page.NET – Development environment for WWW pages.
ACKMA	Australasian Cave and Karst Management Association
DEC	Department of Environment and Conservation (Western Australia)
GIS	Geographic Information Systems
KMD	Karst Management Database
KID	Karst Index Database
SQL	Structured Query Language
XML	Extensible Markup Language – used to share structured data.

Interim Management Guidelines For The Nullarbor Caves And Selected Karst Features

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Abstract

The Nullarbor Karst is the largest karst area in Australia (200,000 km2) and the largest contiguous karst formation in the world. The Nullarbor is globally unique due to its simple and youthful geologic history, its saline hydrology within a carbonate aquifer, its extensive crystal weathering. Karst processes are active and unlike other desert caves of the world, the Nullarbor underground is being hollowed out at observable rates. The Nullarbor is the only arid or semi-arid karst that has undergone a short period of sub-aerial weathering and limestone digenesis, but has vast caves and limitless underground water. The arid nature of the Nullarbor Karst is highly significant in terms of the type and variety of speleothems and other karst features within the caves. The area may potentially have 50,000 karst features, including dongas, blowholes, rockholes, dolines and caves of various types with dry and unique underwater sections exist. However, only 3500 karst features have been examined and recorded. The area supports a wide range of "at risk" rare, endangered, vulnerable and/or endemic flora and fauna species on the ground surface areas. Within the soils, regolith and cave passages, a wide range fauna exist, including troglofauna, stygofauna, guanofauna, edaphobites, bat species and bird species. Some of these features are contained within existing conservation reserves, but many are located in off-reserve properties. Despite the Nullarbor's world significance and being revered in Australian folklore and contemporary romantic images of the Australian Outback and wilderness, the complex geomorphological and hydrologic processes of the area are poorly understood. Recently prepared Interim Management Guidelines provide a framework for management of the area's resources and various land use threats. However, dryness, remoteness and current economic barrenness seem to conspire against appropriate levels of protection, research and management of this karst area of world significance.

Article

Project Background and Objectives

The report "Interim Management Guidelines for the Nullarbor Caves and Selected Karst Features" (Geoscene International, 2009) was prepared for the Rangelands NRM Co-ordinating Group and the Western Australian Dept. of Environment & Conservation. It was funded as a "desktop study" through the Biodiversity Conservation Initiative – Save Our Species Program. The 12-month project was completed during March, 2009 with assistance from the Steering Committee, including:

- Department of Environment and Conservation, WA;
- Australian Government Natural Resource Management Team;
- Rangelands NRM Team;
- Department of Indigenous Affairs, WA;
- Goldfields Land and Sea Council;
- Western Australia Museum;
- Pastoralists;
- Speleologists, Cave Divers & Cave Researchers.

The principal objectives were to prepare Interim Management Guidelines (IMGs) for the caves, blowholes, dolines and key

associated biological features of the Nullarbor Karst System. The primary audience consists of those management and stakeholder groups represented on the Steering Committee, as well as other Local and State Government bodies.

Although the study initially sought to cover the entire Nullarbor Plain area within Western Australia, however, was re-scoped to focus on the caves and selected karst features located primarily south of the Trans Australian Railway.

Land Tenure and Land Uses

Land tenure is shown in Figure 1 for the broader Nullarbor region within Western Australia. Pastoral grazing (primarily sheep) on Crown Lands (Pastoral Leasehold properties) dominates much of the area. Nuytsland Nature Reserve and Eucla National Park are located along the coast. The Great Victoria Desert and Plumridge Lakes Nature Reserves are located in the northern portion of the broader karst region. The Trans Australia Railway and the Princes Highway cut across the area from east to west. A number of mining leases or mining exploration leases exist in the area for the extraction of limestone, mineral sands, etc. Water bores are also licensed for the extraction of groundwater which usually has relatively high salinity levels. Tourism facilities are limited to the occasional roadhouses/motels along the highway and the Eyre Bird Observatory.

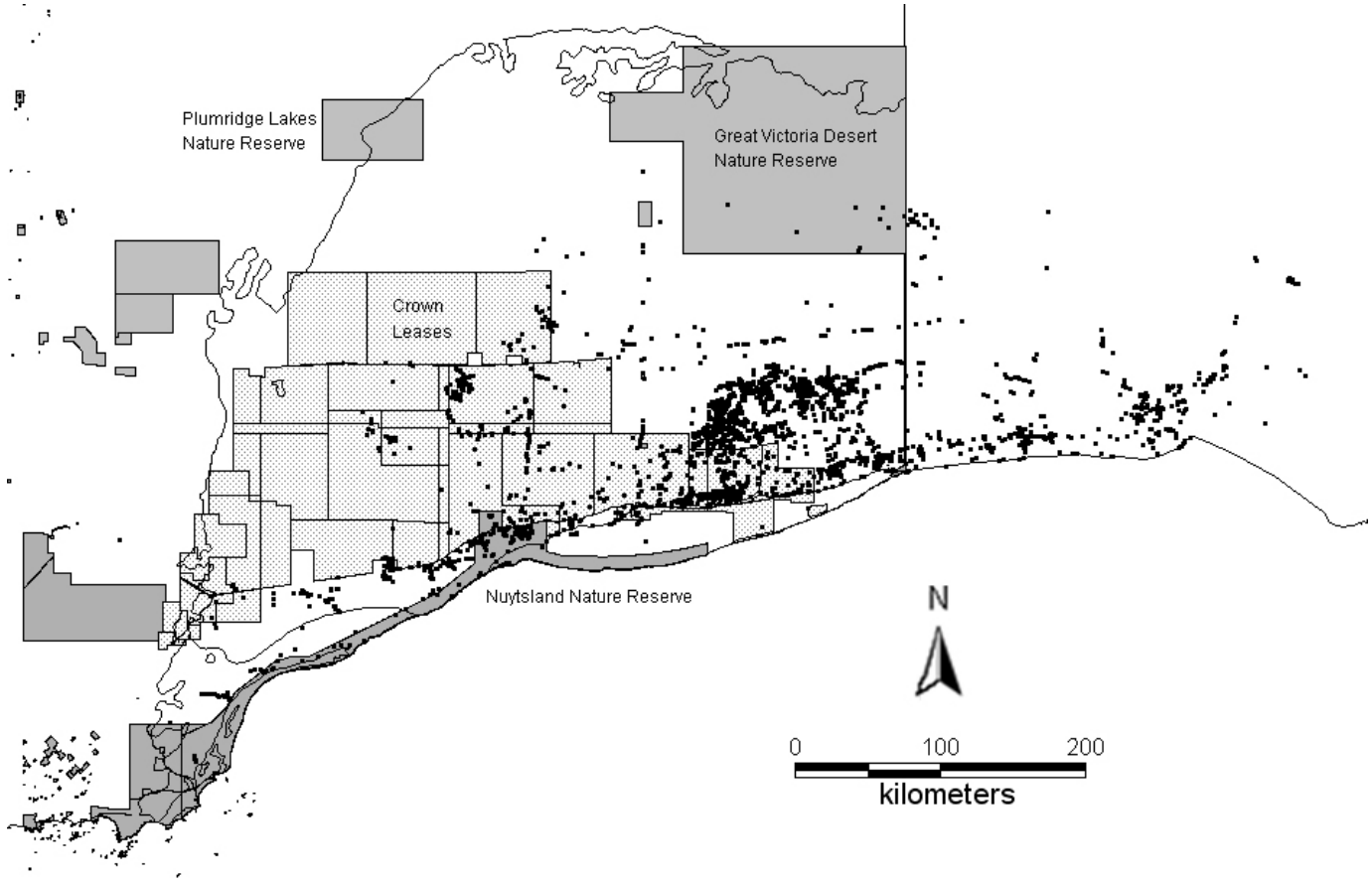

Figure 1Land Tenure
(Source: Adapted from Subterranean Ecology, 2007 p. 20 – Figure 4-4.)

Figure 46 PHYSIOGRAPHIC/VEGETATIONAL UNITS AND COLLECTION SITES – See table 16 and appendix VI

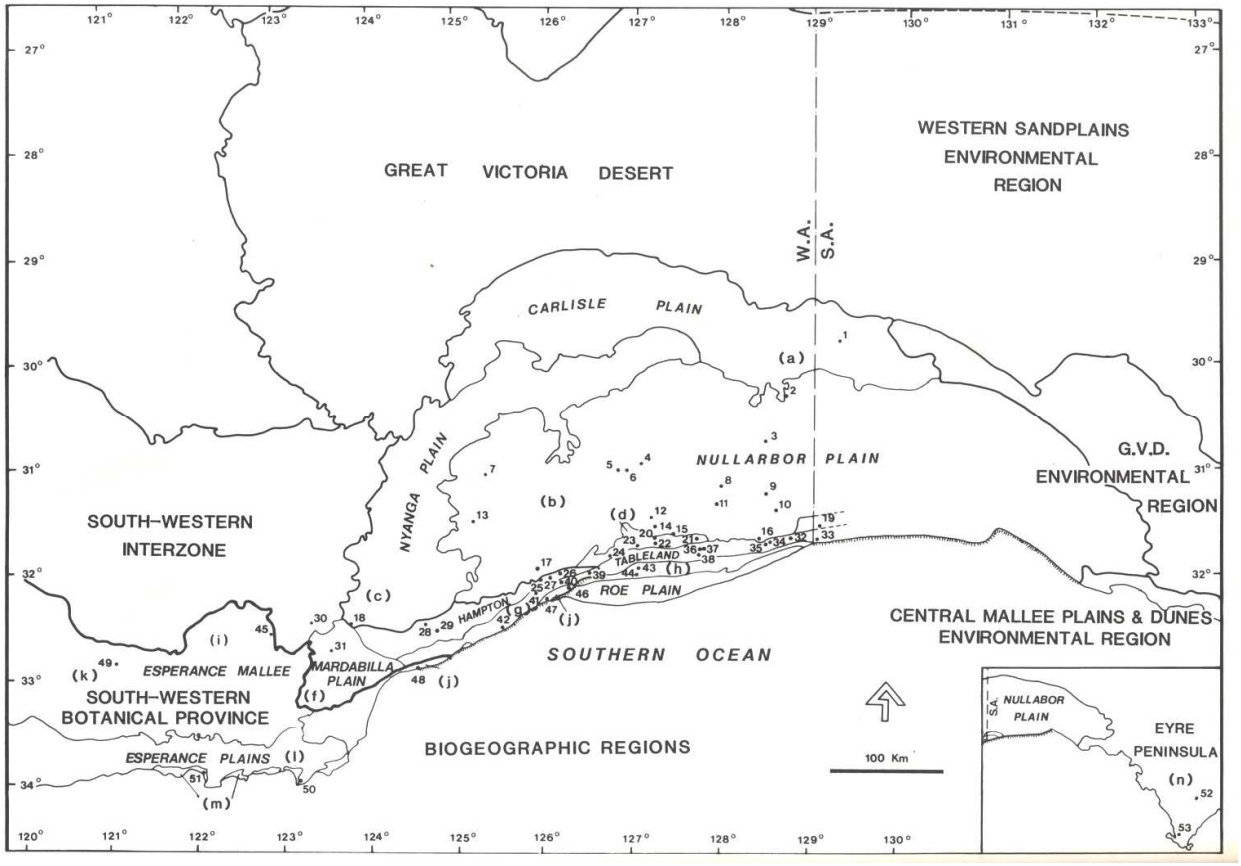

Figure 2Beard's (1975) Biogeographic Regions
(Source: Tille, 2006, Soil-landscapes of Western Australia's Rangelands and Arid Interior)

Biogeographic Regions and Climate

The focus area includes four biogeographic regions as shown in Figure 2, each displaying distinctive characteristics or features as follows:

Nullarbor Plain

- flat, treeless plain;
- dongas;
- ridge & corridor terrain;
- south end of palaeochannels;
- scattered caves/karst features (solution pans, rockholes, collapse dolines & blowholes);
- Bluebush – Saltbush steppes;
- low Acacia woodlands over Bluebush.

Hampton Tableland

- south of Nullarbor plain;
- denudated limestone formation revealing underlying Abrakurrie limestone;
- most of the known caves and dolines;
- ridge & corridor terrain dominates;
- scattered Acacia &/or Mallee Eucalypts in Chenopod shrubland;
- karren restricted to coastal cliffs & former coastal escarpments adjacent to dolines & cave entrances;
- rounded pocketing and perforation of the limestone, which occurs by solution beneath the soil, has been exposed in many places by subsequent deflation;
- most important area of the region for the development of a range of surface and subsurface karst features;
- various mallee communities dominate the limestone scree slopes and pavements, as well as the sandy surfaces;
- alluvial and calcareous plains below the scarp support Eucalypt woodlands and Myall open low woodlands.

Roe Plain

- depositional surface formed on Pliocene to Pleistocene roe calcarenite;
- emerging sea floor with beach ridges & coastal dunes;
- active modern and older dune ridges;
- some caves with different style to those of Bunda Plateau;
- Eucalypt woodlands and Myall open low woodlands on alluvial and calcareous plains below the scarp.

Mardabilla Plain

- southwest portion of Bunda Plateau, south of Nyanga Plain;
- flat & soil covered with numerous inliers of basement rocks;
- shallow moats 3 – 10m deep & 50 – 150m across often ring basement rocks;
- Mallee and shrublands on sandplains associated with laterite uplands, playas and granite outcrops;
- diverse woodlands rich in endemic Eucalypts on low greenstone hills, valley alluvials and broad plains of calcareous earths.

Climatically Peter Tille's (2006) Soil-landscapes of Western Australia's Rangelands and Arid Interior follows Beard (1990) in describing the bioclimate of the Nullarbor soil-landscape province of the Central Southern soil-landscape region as "mainly Eremaean". Much of the inland area commonly has 12 dry months a year, making it akin to a dessert. Mean rainfall is mostly 150-250 mm (dropping to 100 mm in the north) with no seasonal tendencies. The south of the province extends into a "Sub-Eremaen" bioclimate zone, a Mediterranean semi-desert with 9-11 dry months and rainfall rising to 300 mm on the Great Australian Bight. In the southwest (near Israelite Bay) the bioclimate tends toward "Thermoxeric", extra dry to dry Mediterranean with 6-8 dry

months and up to 400 mm of winter-dominant rainfall..

Significance and Key Values

The entire Nullarbor Karst System is of national and world significance. Aside from the main karst features noted above, the area supports a wide range of "at risk" rare, endangered, vulnerable and/or endemic flora and fauna species on ground surface areas. Within the soils, regolith and cave passages a wide range of fauna exist, including troglofauna, stygofauna, guanofauna, edaphobites, bat species and bird species.

A high degree of endemism exists for many of these species. The caves and dolines play a refugia role for many of the species. Many of the species are distinctive and highly diverse and representative examples of relictual subterranean fauna are found in the caves of Roe Plain and the Hampton Tableland.

The presence of microbial mantles are considered to be rare and recommended for high priority protection. Specially protected fauna (Schedule 1 of the Wildlife Conservation Notice 1998) considered rare or likely to become extinct as a result of identified threatening processes include *Troglodiplura lowryi* and *Tartarus mullamullangensis* and the Pannikin Plains Cave Isopod (*Abebaioscia troglodytes* Vandel). Other localised troglobitic species include *Tartarus nurinensis* and *Speothalpius grayi*, *Speozuphium poulteri*, among others.

The caves of the Nullarbor also offer significant palaeontological resources providing evidence of megafauna (e.g., marsupial lion, short-faced kangaroos, giant wombat, etc.) and the presence of the Thylocene (Tasmanian Tiger) on mainland Australia.

Aside from the values directly associated with the karst features, a range of other highly significant values exist under the areas of:

- paleoenvironmental evidence and history;
- archaeological features;
- surface ecosystems, flora and fauna;
- cultural heritage places, sites and features (Indigenous and non-Indigenous);
- natural heritage places, sites and features;
- scenic resources;
- tourism, recreation and wilderness features, facilities, activities and values;
- Indigenous tourism ventures; and
- scientific research and education.

Culturally, the Nullarbor Karst System has been home to Aboriginal groups for tens of thousands of years. The area is significant for its anthropological values and for its archaeological values with some evidence of Aboriginal cave paintings and rockhole modifications. Historically, the area is important to Indigenous Australians and non-Indigenous Australians alike. The Nullarbor karst supports some large pastoral leasehold properties that are iconic representations of life on the Australian Outback.

Some of the above geologic, flora and fauna areas are contained within existing conservation reserves, but many are located in off-reserve properties.

The report provides a detailed summation of the full range of natural, cultural and scientific values of the area.

Framing the Guidelines

What is Karst?

In framing the IMGs, it was important to establish a common understanding of karst processes, characteristics and implications, as many people are not familiar with the term "karst" or have a limited understanding of it being associated primarily with limestone geology. Here, we have used the following definition offered by Watson *et al.* (Eds., 1997) in the IUCN publication, Guidelines for Cave and Karst Protection:

> *"The term karst denotes a distinctive style of terrain which is characterised by individual landform types and landscapes that in large measure are the product of rock material having been dissolved by natural waters to a greater degree than is the norm in most landscapes. In a narrow sense,*

the word refers to any area which has been shaped by solution processes. More broadly, it is an integrated, yet dynamic system of landforms, life, energy, water, gases, soils and bedrock. Perturbation of any one of these will impact upon the rest of the system….Caves and other typical karst features may also result from other processes, and give rise to the phenomenon known as pseudokarst – land systems which contain karst-like features such as caves and surface collapses which are not formed by solution".

Key Focus Attributes and Assets Addressed

The key attributes and assets addressed in the study include:

- caves and interior cave features;
- blowholes; collapse dolines, and;
- key subterranean ecosystems, flora and fauna associated with the above features.

The discovery of these features has increased steadily over the years, as illustrated in the comparison between Figure 3 and Figure 4. Currently, the Karst Index Database – South Australia (KIDSA) have recorded just over 3500 karst features, including 684 caves, 1,169 blowholes, 926 dolines, 533 rockholes and rock shelters, and 255 other karst features. Subterranean Ecology (2007) estimated that only 7% of the total potential caves have been recorded to date. It is estimated that over 50,000 caves and karst features are likely to exist in the Nullarbor region.

Closely associated attributes and assets include:

- geology, landforms and soils;
- catchments and karst sub-catchments;
- karst aquifers and groundwater quality;
- native plants and plant communities;
- ecological communities;
- native fauna (terrestrial and subterranean);
- indigenous heritage;
- non-indigenous heritage; and
- other human values.

Potential Uses Considered

Potential land uses addressed by the IMGs include:

- tourism and visitor activities;
- indigenous and cultural activities;
- pastoral activities;
- mining activities;
- cave rescue and emergency services training;
- water extraction; and
- research.

Key Management Issues

Given the combination of high environmental and cultural values and the mix of land tenure and management vestings there are a very wide range of management issues. Figure 5 provides an overview of this range of issues.

In reviewing these issues, it is useful to recognise that the purpose of this report is to prepare Interim Management Guidelines for implementation over the next five years in order that essential field operations and management decisions can be carried out while a full management plan is in waiting. In addition, the focus is on the protection and management of the caves, dolines and blowholes and their immediate surrounds.

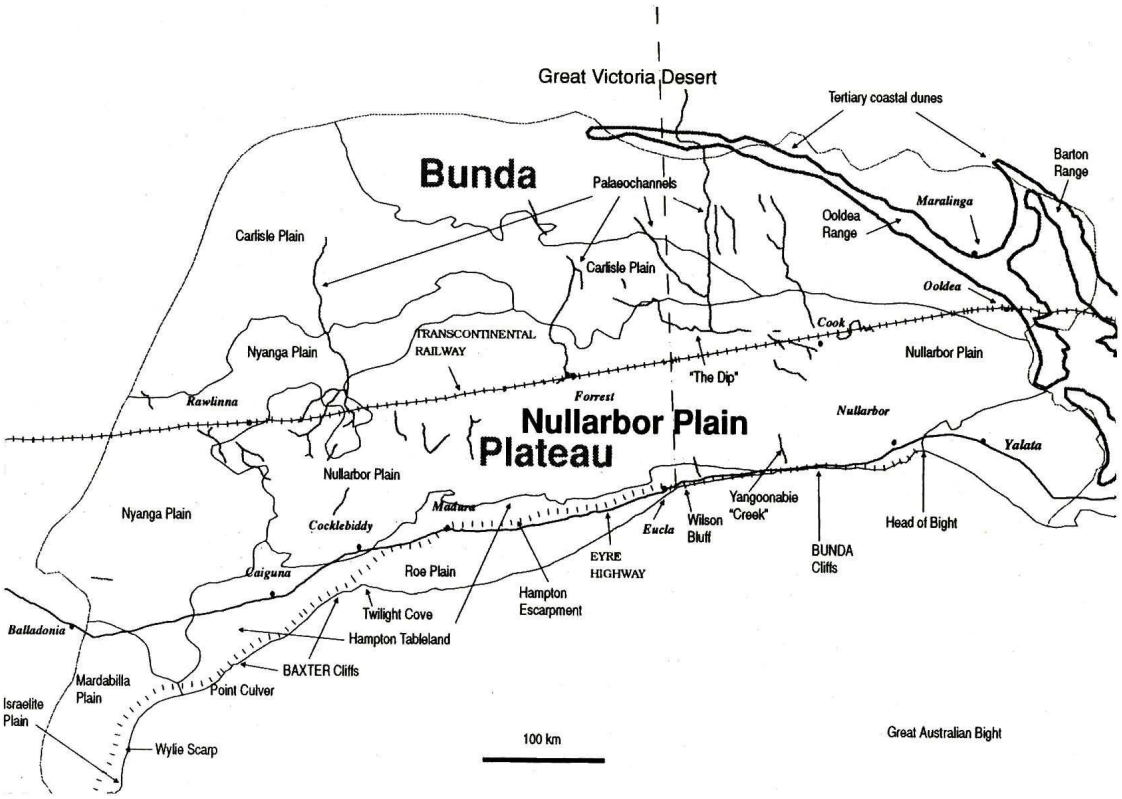

Figure 3 Cave and Karst Features Known During 1982
(Source: Davey *et al.*, 1992, Figure 2 – Physiography of the Nullarbor region: after D.C. Lowry 1970, Lowry & Jennings 1974 and Benbow 1990)

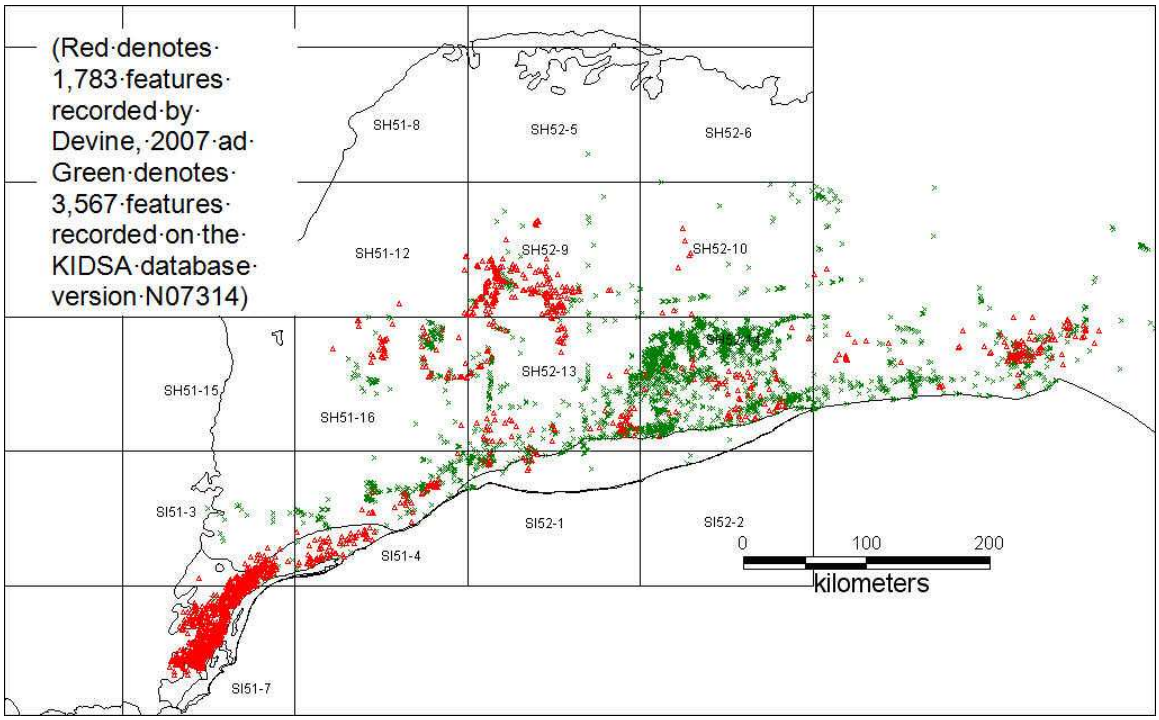

Figure 4 Cave and Karst Features Known During 2007
(Source: Subterranean Ecology, 2007 – Figure 4.3, p.

18)

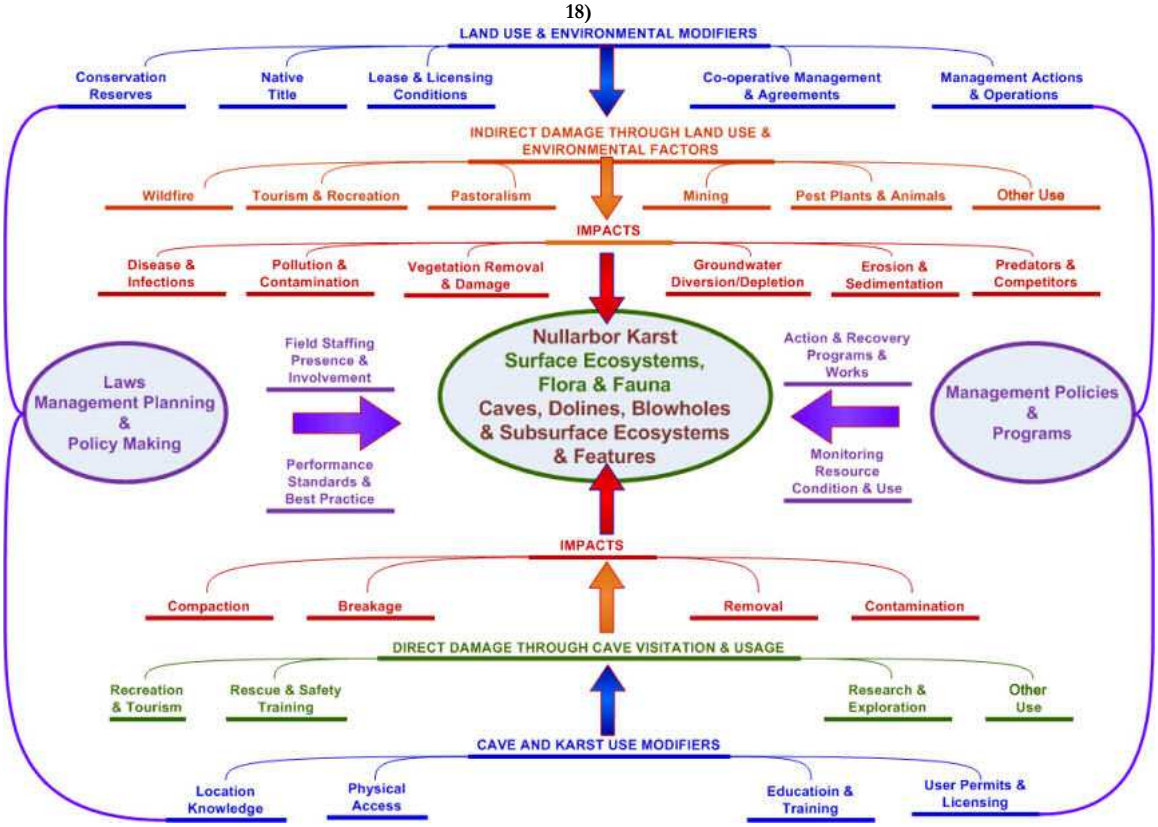

Figure 5 Overview of Management Issues Regarding the Nullarbor Caves, Dolines, Blowholes and Associated Karst Features (Source: Geoscene International, 2009. Copyright, Scenic Spectrums Pty Ltd, 2009.)

The report takes a significant step towards some form of agreed, united on-ground management by a number of key stakeholders around the cave and karst areas that we believe are currently under potential existing threat. Maintenance and protection of the caves, dolines and blowholes (and where necessary recovery or rehabilitation), along with the associated surface ecosystems, flora and fauna are the central focus of the guidelines. Minimisation and protection of the resources from either direct or indirect damage by cave visitation and usage (for recreational or research purposes) or by land use activities and other environmental factors should be the primary objective.

Addressing all of the various issues raised by the flow chart in Figure 5 would certainly require a full management plan. For the purposes of the IMGs, the following are the key issue areas have been addressed:

1. the use of caves and potential impacts on caves associated with:
    - recreation & tourism uses;
    - research & exploration uses; and
    - rescue & safety training uses;
2. ecosystem, flora and fauna issues;
3. pastoral uses and potential impacts on caves;
4. mining uses and potential impacts on caves;
5. transport and communications infrastructure and associated impacts on caves;
6. issues related to indigenous cultural heritage and aboriginal recognition and co-operation;
7. fire control and management;
8. safety and liability issues; and
9. consideration of enhanced management frameworks.

Several other uses with potential impacts are relatively well-addressed by existing regulations, guidelines and practices, including:

- Indigenous use, including protocols for co-operative Aboriginal access and management under current land tenure arrangements. (Until current Native Title claims are resolved, it is difficult to add to the guidelines and agreed arrangements already in place.);
- Wildfire or bushfire regulations and response guidelines;
- Pest plant and animal controls, along with protective measures for flora and fauna species declared under the EPBC Act, the Conservation and Land Management Act 1984 or the Wildlife Conservation Act 1950;
- Road and railway construction;
- Pastoral and mining uses. However, specific aspects of these should be reviewed in light of the focus issues of this report and recent adjustments to tenure and reserve allocations. The issues addressed will consider options regarding the range of land use and impact modifiers noted in Figure 5, including the application where appropriate of: Conservation Reserves; co-operative management and agreements; lease and licensing conditions, and management actions and operations.

Principal Findings, Recommendations and Conclusions

Principal Findings

- The findings of the report are too extensive to completely summarise in this paper. However, the principal findings of essential importance include:
- the Nullarbor caves and associated features play a critical role in a much larger karst system that is without question of world and national significance for a range of natural and cultural resources (e.g. geologic, palaeontological, archeological, biological etc. and in terms of indigenous and non-indigenous cultural heritage);
- the area receives relatively low visitor numbers due to remoteness, but is extremely fragile and vulnerable, even to the level of use currently received;
- management co-ordination, presence, activity and control over the caves and karst features is inadequate given the high conservation values and vulnerability of the area;
- the current Cave Access Permit System is inconsistently applied and unenforceable, primarily due to a lack of public knowledge/co-operation and no field checks on usage;
- there are significant public safety and liability issues;
- there are many untapped opportunities for presentation and interpretation of the outstanding features of the area to the public and for enhanced conservation measures and research.

Priority Guidelines

Twenty-four Interim Management Guidelines have been recommended, covering a full range of Nullarbor values and issues. The key IMG recommendations are summarised as follows:

1. review and consideration of alternatives for field-based conservation officers, either as trained volunteers, paid staff or some combination, including incentives for assistance from pastoral leaseholders;
2. application of the Cave Management Classification System to determine which caves should be managed as Tourist Caves, Adventure Caves or Restricted Access Caves with more

consistent and rigorous application of the Cave Access Permit System (maintaining positive relations with and involvement of Pastoralists and appropriate Aboriginal communities or Traditional Owners);

3. conduct assessments of cave risks to visitors for selected caves on a priority basis;
4. consider vesting the overall management of all Government department (e.g. Cave and Karst Management Advisory Committee representing other key government departments and stakeholders;
5. consider fencing, gating and locking critically significant and fragile caves, dolines and blowholes where practical (along with new cave reserves set aside in the recent 2015 Pastoral Lease agreements with pastoralists);
6. continue priority ecosystem, flora and fauna protection and recovery programs and weed and pest animal controls on a targeted basis;
7. survey and fence ground-surface footprints of significant cave passages on pastoral leasehold properties and Unallocated Crown Lands for safety and conservation purposes;
8. provide visitor information, safety and interpretive facilities and programs on a selected and priority basis as indicated by feasibility assessments and specified works plans;
9. consider enhancement of management frameworks and improved co-ordination of key management agencies and stakeholders;
10. involve Traditional Owners in future ownership and management initiatives.

Summary Conclusions

In summary, the following concluding comments regarding the report and guidelines are made:

- Although the first four priority guidelines (field staff, cave classification, risk assessment & single agency) are broader policy and administrative concerns, they greatly influence the capability to implement effective and efficient field operations during the interim period of the next five years;
- There is potential for funding under periodic Federal Government grant programs (e.g., Caring for Our Country). Other significant resource assessment, planning and research projects have been identified;
- A preliminary review of potential protected area management frameworks that might be suitable for the future conservation of the Nullarbor's natural and cultural estate is encouraged;
- The information collected on the significant values and management issues of the Nullarbor caves and associated karst features should be shared with the community, key stakeholders and government land managers;
- Further review, comment and suggestions from the key stakeholders and the general public should be sought;
- The IMG report and the continuing dialogue will provide a short-term sense of direction as we look ahead.

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VISITOR MONITORING NEEDS WITHIN THE AUSTRALIAN FOSSIL MAMMAL SITES (RIVERSLEIGH/NARACOORTE) WORLD HERITAGE AREA

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Abstract

The Australian Fossil Mammal Sites World Heritage Area consists of two distinct fossil sites, Riversleigh and Naracoorte, over 2,000 km apart and located within two different Australian States, Queensland and South Australia. Each site is managed by their respective State government agencies. Monitoring is an essential part of protected area management and has traditionally concentrated on the biological and physical components of sites. The systematic collection of visitor data has been an area generally overlooked by protected area managers who have instead relied on more ad hoc approaches. This paper reviews the available visitor data at Riversleigh and Naracoorte and identifies issues and gaps in visitor data collection at each site. The paper concludes a visitor data collection system should be implemented across the two sites for planning and management purposes and encourages the development of systematic visitor monitoring across all of Australia's World Heritage Areas.

Keywords: World Heritage (Area), Australian Fossil Mammal Sites (Riversleigh/Naracoorte), visitor monitoring, tourism planning and management, Queensland

Introduction

World Heritage listed properties are places of such outstanding universal values that they must be conserved and passed on intact to future generations (UNESCOa, 2009). Most World Heritage Areas are important tourism draw cards, creating local and regional income and employment opportunities, and are a source of national pride (Australian Government Department of Environment & Heritage [DEH], 2006). Some of the most iconic and well known World Heritage Areas are found in Australia. Uluru, Kakadu and the Great Barrier Reef instantly convey a series of compelling images to both Australian and international tourists. In fact, nearly 13 million domestic and 2.3 million international tourists visited World Heritage Areas, National parks and State parks in 2007 (Tourism Research Australia, 2008)

It is essential that World Heritage Areas are sustainably managed so they may be appreciated by future generations. A key element in any sustainable management planning is visitor monitoring (Wardell & Moore, 2004). Visitor monitoring is the systematic gathering and analysis of visitor data over time (Newsome, Moore & Dowling, 2002). This paper reports on the status of visitor monitoring within the Australian Fossil Mammal Sites (Riversleigh/Naracoorte) and identifies issues and gaps in visitor data collection at each site. The paper calls for the systematic monitoring of visitors at both sites. The paper concludes by encouraging regular visitor monitoring across all of Australia's World Heritage Areas using the same core questions in order to compare visitor findings throughout Australia.

Visitor Monitoring in Protected Areas

Monitoring is an essential element of protected area management (Pitts & Smith, 1993; Eagles, McCool & Haynes, 2002; Newsome *et al*, 2002; Wardell & Moore, 2004) and consists of the systematic and periodic gathering, analysis of information of both the natural environment and visitors over time (Eagles *et al*, 2002; Newsome *et al*, 2002). Historically monitoring has concentrated on biophysical aspects of the environment (Pitts & Smith, 1993), while the systematic collection of visitor data by protected area managers, if collected at all, have utilized more ad hoc methods (Muhar, Amberger & Brandenburg, 2002).

Four specific types of visitor monitoring data have been compiled by Newsome *et al* (2002, pp. 259-260) for planning and management purposes and are listed below:

- "Park use: total visitor numbers, point of entry and mode of transport to the park;
- Site use: sites visited, group size and use, seasonal use, frequency of visits, types of visit (day use vs. overnight) and activities undertaken while in the park;
- Visitor characteristics (profiling): demographic and socioeconomic information, motivations, expectations, perceptions, knowledge and information needs; and,
- Visitor outcomes: satisfactions, complaints, recommendations, comments."

Reasons for Visitor Data Collection.

Visitor monitoring provides information useful for management and planning, resource allocation and leverage, agency performance reporting, interpretative communications, marketing, and public accountability (Newsome *et al*, 2002). "Without effective monitoring and review it is difficult to see how managers can make informed decisions" (Reynolds & Elson, 1996). However, monitoring is only effective if it is done regularly, otherwise its usefulness is severely limited (Eagles *et al*, 2002; Pederson, 2002). Wardell and Moore (2004) note recognition of the lack of adequate visitor data for World Heritage management in Australia dates back to the early 1980's Sheppard (1982, cited in Wardell & Moore, 2004) summarizes four categories of issues that occur when park managers do not have current and relevant information about their visitors:

- Actions by management tend to be based on personal intuition that can be easily influenced by external pressures such as department finances and staffing constraints.
- There is no systematic basis for the allocation of resources between parks or sites within a park.
- Without baseline information, there is nothing to mark the effectiveness of management actions or revisions of planning documents.
- Without visitor feedback, there is no information on recreation preferences, values or behaviour to use as a basis for identifying the consequences of alternative management actions.

Visitor monitoring does require resource commitment in the form of sufficient funding, trained personnel to carry it out, access to data bases over time and sufficient time to design and implement the programme (Eagles *et al*, 2002).

Case Study: The Australian Fossil Mammal Sites

The Australian Fossil Mammal Sites World Heritage Area consists of two distinct fossil sites, Riversleigh and Naracoorte, over 2,000km apart and contained within two different Australian States, Queensland and South Australia. A serial nomination, the Riversleigh portion of Boodjamulla (Lawn Hill) National Park and Naracoorte Caves National Park were jointly inscribed in 1994 after meeting rigorous World Heritage Convention criteria, based on their mutual outstanding universal natural heritage values, as outstanding examples representing major stages of the earth's evolutionary history; and, significant ongoing ecological and biological evolution (IUCN/WCMC, 1994). Together the two sites are among the world's ten greatest fossil sites (UNESCOb, 2009).

Riversleigh

The 10,000ha Riversleigh fossil fields are located 250km northwest of Mt Isa and 200km south of the Gulf of Carpentaria in the northwestern part of Queensland within the southern most segment of the much larger 282,000ha Boodjamulla/Lawn Hill National Park (Queensland Parks & Wildlife Service, 2002). The park is owned and managed by Queensland Parks and Wildlife (Queensland Government Environmental Protection Agency, 2004). The rich variety and astonishing quality of the Riversleigh fossils has dramatically changed the understanding of Australian mammal assemblages during the time of greatest biological diversity in Australia's evolutionary history as well as

significantly increased understanding of the environmental conditions in which these animals lived (Luly & Valentine, 1998). Most of the Riversleigh World Heritage Area is closed to the general public; however, a small area known as D Site, is open to tourism. This area has a gravel parking lot, an orientation board, a small artificial 'cave' interpretive room and a few small interpretive signs posted along a 15 minute circuit track around the area. The survey site was located inside the interpretive artificial 'cave' at D Site.

Naracoorte

The 600ha Naracoorte Caves National Park World Heritage Area is located 11 km south-east of the Naracoorte township within the southeastern part of South Australia. The park is owned and managed by the Department for Environment and Heritage. The 26 caves within the park contain the fossil remains of tens of thousands of vertebrate animals making it one of the richest deposits of Pleistocene vertebrate fossils in the world (Reed & Bourne, 2000). Over 118 species (DEH, 2006) of amphibians, reptiles, birds and mammals have been discovered. The caves "illustrate faunal changes spanning several ice ages, highlighting the impacts of both climate change and humankind on Australia's mammals from at least 500,000 years ago" (DEH, 2006, p. 10). However, the site is most famous for the giant Megafauna fossils, including a giant Tasmanian devil, giant kangaroos, a marsupial lion, a giant echidna and a giant python (South Australian Department of Environment and Heritage, 2001).

Status of Monitoring Activities

Riversleigh: Visitor monitoring activities are not conducted by Queensland Parks and Wildlife within the Riversleigh section of the Australian Fossil Mammal Sites. Nor are there ongoing visitor monitoring efforts by others at this time.

Naracoorte: Total visitor numbers to Naracoorte have been kept since 1970 . Accurate numbers of visitors prior to 2005 are difficult to ascertain as only cave visits were recorded; thus, a visitor participating in multiple tours would count as more than one visitor. Visitation has been around 40,000 for the past four years (Steven Bourne, pers.comm.). In 2002 (Steven Bourne, pers. Comm) and 2006 (Market Equity, 2006), comprehensive visitor surveys were conducted (however, the sample size was quite small for a year long study and many questions lacked needed depth).

Discussion

Data on visitor preferences and demand for any World Heritage Area is essential for establishing and benchmarking management objectives (Pederson, 2002) Information on the number of visitors and their likes, dislikes, motivations and expectations help the World Heritage planners divide visitors into subgroups of people with similar characteristics, wants and needs. This information is useful in setting objectives for infrastructure, personnel needs and education and interpretation programmes. Combined with data on tourism markets, the information can be used to develop objectives for attracting preferred types of tourists to a site (Pederson, 2002).

Queensland Parks and Wildlife (QPW) and the South Australian Department for Environment and Heritage are charged with the preservation, conservation and management of the Australian Fossil Mammal Sites. The absence of accurate total visitor numbers for the Riversleigh section has resulted in highly inflated visitor numbers. For example, a Wet Tropics Management Authority booklet (n.d., but probably published in 2003-2004) states the number of visitors to Riversleigh is estimated to be 22,000. A 2008 World Heritage Economic Activity Report conducted via desktop research places the number at 35,000 visitors. King and Prideaux (2009), in an independent study, monitored visitors on-site at Riversleigh over a four month period between 1 April - 30 July which included periods of high and low visitation, as well as contacting commercial tour companies for the number of clients they took to the World Heritage Area and found that between 3,000 - 5,000 tourists visited the site in 2008. Park management personnel who have spent time at Riversleigh will know that the visitor numbers offered by King and Prideaux (2009) are more in the realm of reality. However, without regular visitor monitoring all total visitor numbers can potentially be, and should be, questioned.

The implications for the absence of such basic visitor statistics are actually quite profound. As Eagles *et al* (2002, p. 2) notes "public use data of protected areas are important to all stakeholders." Case in point, the 2008 Economic Activity Report for Australia's World Heritage Areas contains erroneous total visitor numbers for the Australian Fossil Mammal Sites (Riversleigh) which could potentially exclude the Riversleigh region from economic stimulus grants and other types of opportunities. Other government agencies may use the erroneous figure in their evaluations, in a 'ripple effect' with unknown economic and socio-cultural results. Thus, it is the duty of QPW to collect visitor information accurately so other agencies and institutions, as well as themselves, may have it available for a variety of purposes.

For Naracoorte, the use of cave visits rather than numbers of park visitors has led to over-inflated visitation often quoted for the park. This exaggerated number has implications for investors establishing new businesses relying on park visitation. Number of visitors and their place of origin are now routinely collated providing park management with basic information. Motivation for visiting, source of information, demographics, how visitors use the park and visitor satisfaction levels are all critical factors only partially investigated with two surveys with a small sample size.

Visitor monitoring requires a standardized approach. This is the only way can there be assurance of comparable data between protected areas over time (Eagles *et al*, 2002). However, as Reynolds and Elson (1996, p. 573) observe:

> …procedures for monitoring visitor use and characteristics are weak and unstructured on many sites. Monitoring is of most use where it can detect changes from baseline. Such processes… are vital for decisions about the sustainable use of sites… and the limits of acceptable change.

The Australian Fossil Mammal Sites are just one example of the weak and unstructured nature of visitor monitoring within Australia's World Heritage Areas. While World Heritage sites such as the Great Barrier Reef and the Wet Tropics of Queensland have strong visitor monitoring programs, other World Heritage Areas, such as the Australian Fossil Mammal Sites, the Gondwana Rainforests of Australia, and the Willandra Lakes Region lack such processes. Australia should implement a comparable, systematic and periodic visitor monitoring program across all of its World Heritage Areas. Both the visitor and park management would benefit from such a program.

Conclusion

The Australian Fossil Mammal Sites World Heritage Area consists of two distinct fossil sites, Riversleigh and Naracoorte, over 2,000km apart and contained within two different Australian States, Queensland and South Australia. Each site is managed by their respective State government agencies. Monitoring is an essential part of protected area management and has traditionally concentrated on the biological and physical components of sites. The systematic collection of visitor data has been an area generally overlooked by protected area managers who have instead relied on more ad hoc approaches. This paper reviewed the available visitor data at Riversleigh and Naracoorte and provided examples of issues and gaps in visitor data collection at each site. Partnering with various commercial enterprises, academic institutions or interested organisations is one way to potentially address the visitor monitoring issue.

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The Cave Divers Association of Australia (CDAA) - Linking Landowners to End-Users

Peter Buzzacott and Warrick McDonald

Abstract

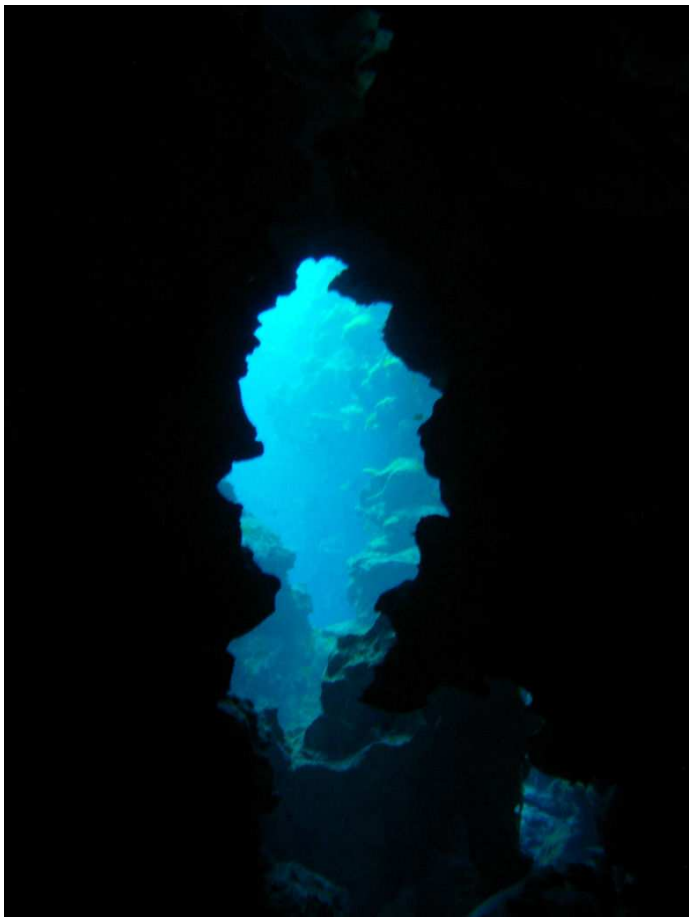
The Cave Diver's Association of Australia (CDAA) formed in 1973 in response to a number of high-profile cave diving deaths and today has nearly 700 members and a safety record that is second to none. Land owners and managers entrust CDAA with ensuring the safety of divers through training, access conditions and equipment requirements. Often land owners impose site-specific caveats and entrust the CDAA to enforce those access rule, which they do through a range of measures including the punishment of offences with suspensions, fines and/or, in the extreme, expulsion from the Association.

Benefits to landowners include that they have a single point of contact (a site manager), day-to-day enquires regarding access are dealt with on their behalf, and over time the CDAA often install and maintain infrastructure such as steps, ladders and benches. Benefits to members include that high-quality training is available in Australia, access is negotiated for and arranged on their behalf, a network is available to locate appropriately experienced guides, and there are many sites now with infrastructure such as a gantry for lowering gear and kitting-up benches.

Background

Jacques Cousteau and his team made the world's first open-circuit cave dives at the Fontaine de Vaucluse near Avignon in 1946.[1] Soon after, the first compressed-air dives in an Australian cave were made at Jenolan Cave's Imperial Sumps in 1952. Piccaninnie Ponds was explored in 1961 and the now famous Shaft followed in 1964, so named for the spectacular shaft of light that penetrates the dark like a giant laser.[2] By then, the winds of change were sweeping our world. Television brought adventurous pursuits into people's homes and a wealthier, more mobile generation of Australians took to scuba diving. The sport blossomed. The water in many caves is reliably clearer than a diver is likely to ever find in the sea, and the prospect of being lowered down to the water is, in itself, attractive to some adventurous types so it was only a matter of time before cave-diving gained popularity. The first cave-diving fatality in Australia occurred in 1969, followed in short order by a further ten deaths in flooded caves near Mount Gambier by mid-1973.[3] The worst of these took four lives from a single dive group and almost a year passed before the last body was located. There were calls to ban diving in caves, many land-managers did close off access to diving, one cave was even re-named "Death Cave" and a steel lockable lid was put over it, with little regard for the resident flora and fauna. Something needed to be done so the Government of the day agreed to consider voluntary regulation of the sport before treading down the legislative path.

Photograph 1: A diver enters the cavernous Piccaninnie Ponds

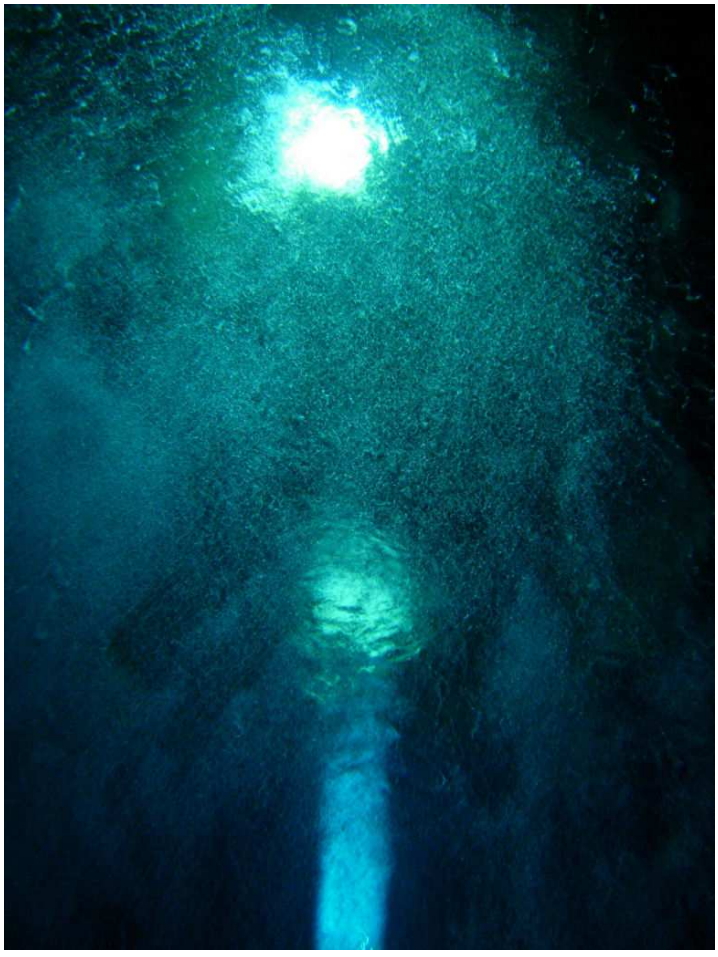


Photograph 2: The view from inside Piccaninnie Ponds

Photograph 3: A diver exits the ponds after another great dive

Photograph 4: The manhole-like entrance to the shaft

Photograph 5: A diver's view whilst being lowered to the water



Photograph 6: The famous laser-like shaft of light cuts through the dark

The Cave Divers Association of Australia (CDAA) was conceived on 29th September 1973 in the Allendale East Public Hall, when a group of divers met to elect the first committee, draw-up a constitution and agree a set of standards for cave diving in the Mount Gambier region.[4] A year later the constitution was ratified and, having explored cave diver training and procedures in the USA and the UK, the group presented their recommendations to a meeting of 71 divers. A new system of categorizing caves and testing divers was described, printed safety information distributed and the latest cave diving equipment shown around.

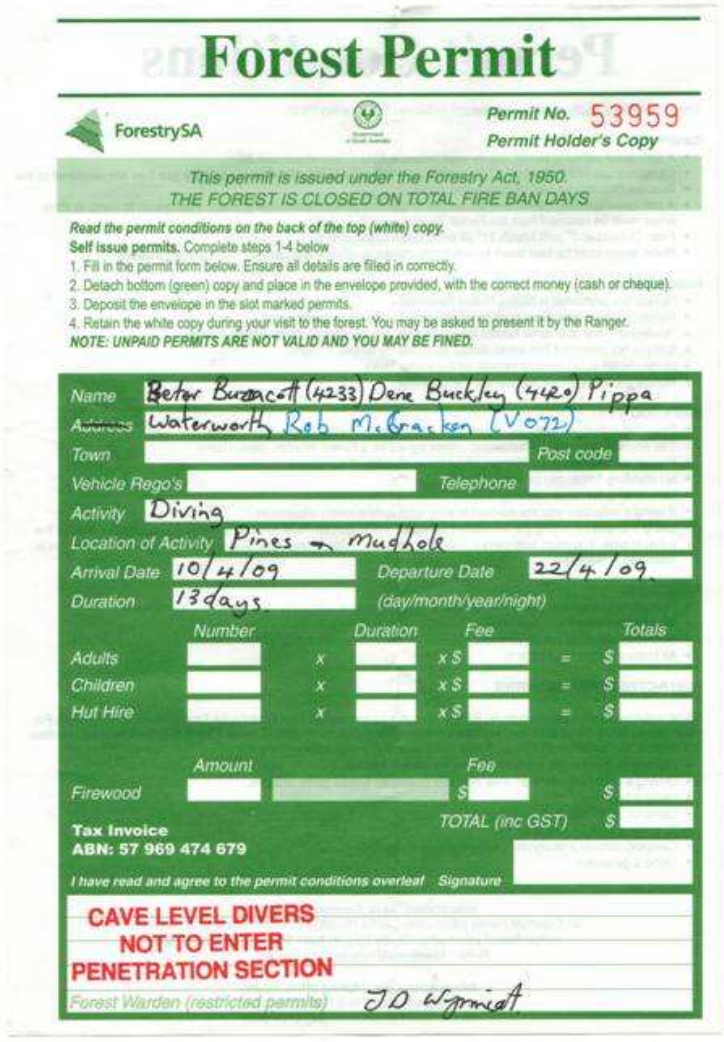
Dive clubs were invited to nominate club testers with prior experience in cave diving and the first examinations of club testers were carried out as soon as October 1973, and again in February 1974. Though some experienced cave divers may have objected to being tested in order to continue the sport they had experience in already, the CDAA gained widespread acceptance by Government, dive clubs and land owners, and some of the popular caves re-opened to cave-diving.

Mount Gambier lies near the South Australia/Victoria border and the CDAA was initially split between these states in two separate groups. Category 1 and 2 caverns and sinkholes afforded suitably tested divers access to a dark zone, frequently up to 40m deep, but full cave diving had been on hold until the first Category 3 test held at Piccaninnie Ponds in May 1975. Divers from Victoria were tested by the South Australian Group, and South Australian divers by Victorian testers, a practice that continued for some years.

With the continued growth of recreational diving, and since the arrival in Australia in 1972 of the Professional Association of Diving Instructors (PADI), the diving 'industry' grew and Australia's own training agency, the Federation of Australian Underwater Instructors (FAUI) grew with it. Demand for diver testing outgrew the limited availability of testing weekends so, after robust debate, FAUI instructors who were also rated Category 3 divers were accepted to train and test prospective CDAA members.

Photograph 7: The drop to the water at Hell's Hole is not for the faint hearted

By 1978 the CDAA was continuing to forge strong alliances with land managers and Government, establishing itself as the peak body in Australia for cave diving. The Woods and Forest Department of South Australia granted legal access to qualified CDAA divers to visit the caves known as Pines and Hell's Hole. For the first time since 1973 divers could obtain permits to dive these caves, and this permit system has worked successfully over the 31 years since. Even today, any current member of the CDAA who wants to dive either cave simply telephones the staff at the Forestry SA office in Mount Gambier, requests a permit, and it is available to be collected from a collection box outside soon after. The permit is a legal document and access is granted provided certain conditions are met, for example to dive Hell's Hole the group needs to be no smaller than four divers, one of whom must have dived there at least once before. If a group of divers were to surface from a dive and find the ranger ready to check if permit conditions are being met, (and it is quite common to find the rangers just so engaged), then breaking an access condition would certainly result in some form of penalty, ranging from an 'in-house' punishment for a minor breach (like suspension from the CDAA), right up to prosecution, and divers have actually been prosecuted by the Government for breaching access conditions. Put simply, there will always be members in any community who test their boundaries, but breaking the rules threatens continued access for divers and land managers know the CDAA vigorously investigate every reported breach. Thankfully, by far the majority of the CDAA membership not only follow the rules but are somewhat also self-policing by their intolerance of inappropriate attitudes.



Forest Permit

ForestrySA

Permit No. 53959
Permit Holder's Copy

This permit is issued under the Forestry Act, 1950.
THE FOREST IS CLOSED ON TOTAL FIRE BAN DAYS

Read the permit conditions on the back of the top (white) copy.
Self issue permits. Complete steps 1-4 below
1. Fill in the permit form below. Ensure all details are filled in correctly.
2. Detach bottom (green) copy and place in the envelope provided, with the correct money (cash or cheque).
3. Deposit the envelope in the slot marked permits.
4. Retain the white copy during your visit to the forest. You may be asked to present it by the Ranger.
NOTE: UNPAID PERMITS ARE NOT VALID AND YOU MAY BE FINED.

Name Peter Burracott (4233) Dene Buckley (4420) Pippa
Address Waterworth Rob McCracken (V072)
Town Post code
Vehicle Rego's Telephone
Activity Diving
Location of Activity Pines → mudhole
Arrival Date 10/4/09 Departure Date 22/4/09
Duration 13days (day/month/year/night)

	Number		Duration		Fee		Totals
Adults		x		x $		=	$
Children		x		x $		=	$
Hut Hire		x		x $		=	$

	Amount		Fee	
Firewood		$		$
			TOTAL (inc GST)	$

Tax Invoice
ABN: 57 969 474 679

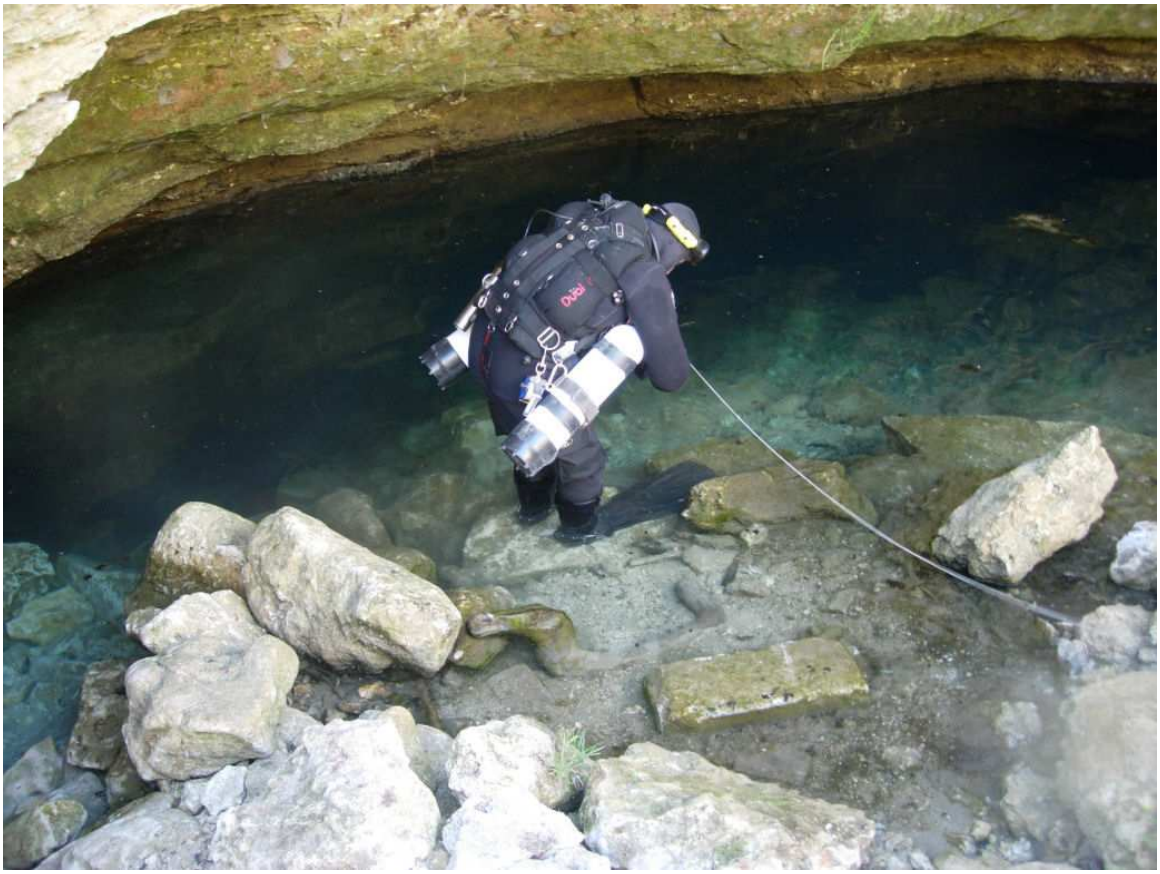
I have read and agree to the permit conditions overleaf Signature

CAVE LEVEL DIVERS
NOT TO ENTER
PENETRATION SECTION

Forest Warden (restricted permits) JD Wyrmat

Photograph 8: Firstly, a diver applies for a permit

Photograph 9: Restrictions are signposted at the cave



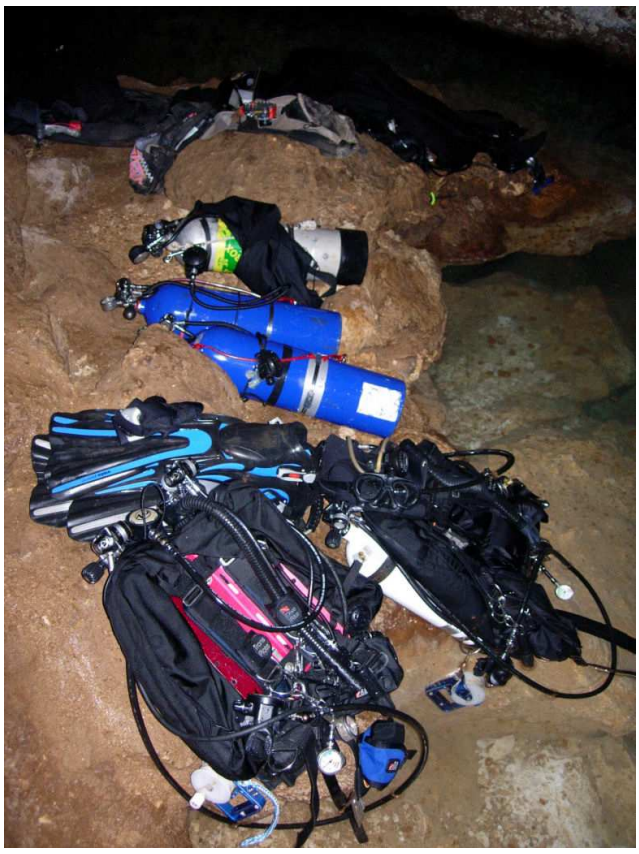
Photograph 10: Access conditions all met, a diver prepares for adventure

Photograph 11: Even inside the cave access conditions are restricted. Here is the limit that cave divers can reach; passed this point is reserved for penetration qualified divers only. There is no excuse – if you are caught sneaking a peek then you'll be punished.

Photograph 12: The Nullarbor is not for the ill-prepared.

Photograph 13: Getting to the water requires the right equipment

Photograph 14: Carpet is used to protect the cave in the tightest sections



Photograph 15: Finally, the water is reached and the gear assembled

That same year the CDAA formed a policy on cave-diving in the Nullarbor and required members intending to visit the area to supply detailed trip plans at least four weeks ahead of the proposed trip, including contact details and certification levels for all divers, the intended purpose of the trip, first-aid provisions, and roping or other relevant skills within the group. The policy was a timely response to the increasing interest being shown in exploring Cocklebiddy cave.

The category 1 and 2 courses were combined in 1978-79, in 1980 senior CDAA office-bearers Ian Lewis and Peter Stace published the book "Cave Diving in Australia" and by 1982 CDAA cave diving courses and examinations were on offer in four states, including now also by PADI instructors rated to category 3.[5]

In 1983 the CDAA had in place its first formal access agreement with a show cave, being Englebrecht's Cave in the town of Mount Gambier itself.[6] Initially a five-year agreement, the relationship has blossomed and grown over nearly 30 years and today the CDAA are again upgrading the cave diving display at Englebrechts, supplying posters and up-to-date video-footage for visitors, and the future looks bright for continued mutually beneficial collaboration between the cave managers and cave divers.

By then a largely Australian team had reached Toad Hall the year before and ABC News announced a French Team were intent on further exploration, thus setting an Australian record, perhaps even a world record. For those unaware of the now legendary Toad Hall, here is a brief description of the adventure. Firstly, divers need to travel to a spot near the Eyre Highway 440 kms east of Norseman, in Western Australia, amidst beautiful wilderness that appears limitless. Unpolluted by civilization, the night sky too is a marvel that has to be experienced to be believed and there, in this rugged, barren landscape sits the collapse doline of Cocklebiddy Cave. Clambering over boulders beneath the 10m sheer drop at the entrance, divers carry their heavy gear 100m down into the earth away from the ever-shrinking circle of light framed by the entrance. There, far below the scorching plain above, lies a crystal-clear lake a further 100m wide. The chamber is huge but the roof gradually angles down to the water and disappears beneath the surface at the far side. Divers swim across this lake, start breathing on scuba and follow the roof underwater, swimming near the roof of a 'railway tunnel sized' passage, with fossils and coloured bands embedded in the limestone walls. Cocklebiddy is a majestic cave and the visibility is endless, so clear at times that without the bubbles visitors would look as though they were floating in air. Early explorations set new cave diving distance records until a large air chamber was discovered at nearly 1 km's distance from the cave entrance. Exploration continued, the record was set a further 1.5kms beyond this air chamber, and the Australian team later returned with the goal of exploring even further. The mission was a huge success – a second massive air chamber was discovered 2.5kms beyond the first air chamber.[7] This chamber was named "Toad Hall" and a part of the sled used to carry the dive cylinders was dedicated to recording the names of visiting divers. The inscription reads "Many have wondered, but few will ever know…" and thereafter is written the reason the chamber is named Toad Hall. Last year 650 people reached the summit of Everest yet in total, less than fifty divers have their name on the visitor record in Toad Hall. It remains a pinnacle of Australian cave diving. Climbing over the rockpile in this new chamber, the divers were delighted to find yet another lake on the other side: there was more passage to explore and more diving to be done. They would train for nearly a full year before returning.

Photograph 16: The water is clear and the walls pale, conditions are excellent

Photograph 17: Here a diver visits an "air" chamber, with high CO2 levels so he keeps breathing from his scuba unit

Photograph 18: A high degree of physical stamina is required to dive the Nullarbor caves

Photograph 19: Dive teams need to be self-sufficient in every respect.

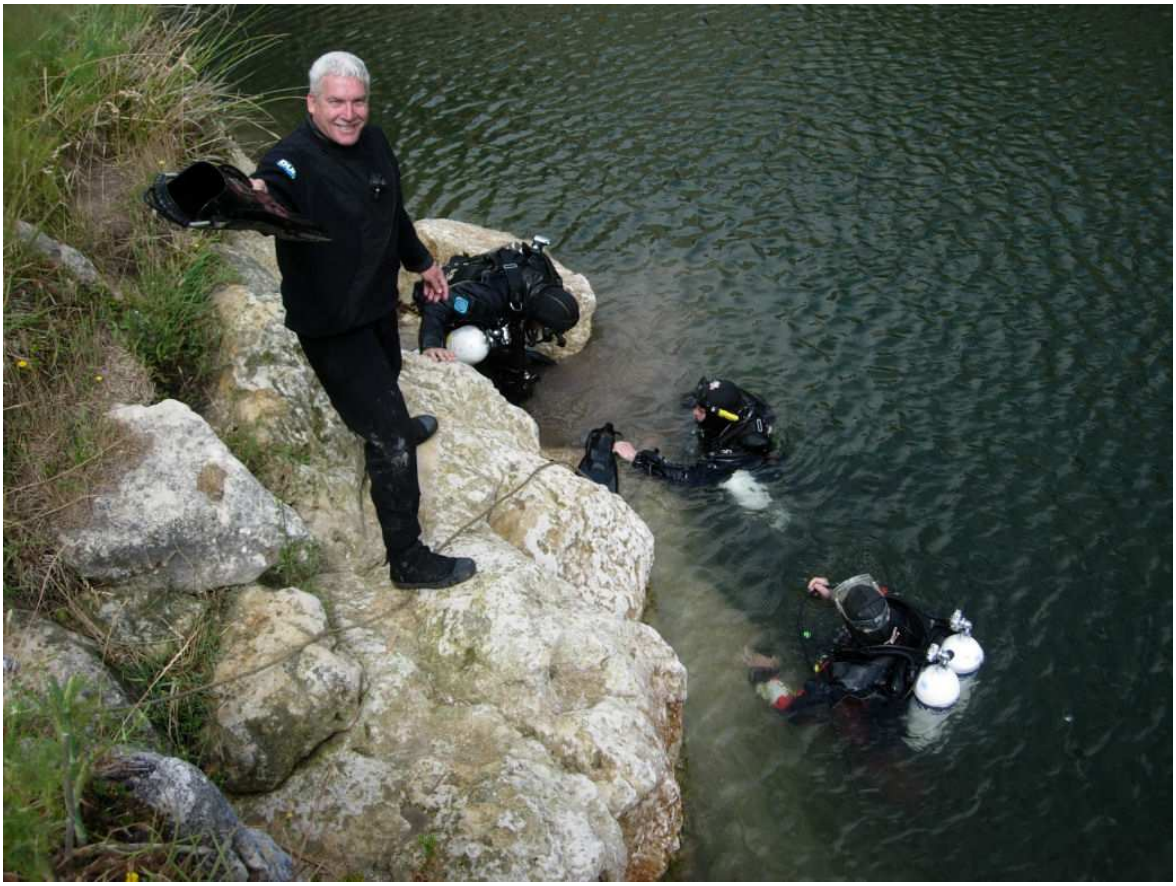
Before they could, a French team did indeed set a new record, by adding a further 1.9kms of explored passage beyond the 4.1kms record previously set by the Australian team. The French team wore triple-tank systems and it was hoped by the Australians that even further might be explored using smaller cylinders, generously pressurized. The number of air cylinders required was growing beyond the team's available resources. To address this Hugh Morrison, one of the owners of Perth Diving Academy, advertised free tank testing for anyone who would lend him their dive tank. Then, as today, an annual test (required by Australian Standards) cost about the same as a new Top Ten record (these days, a Top Ten CD). Then, again just as it is today, divers generously supported large expeditions and so the team left Perth in a truck loaded to the roof with borrowed dive tanks. Supported by many CDAA members, Ron Allum, Peter Rogers and Hugh Morrison planned to explore further than any diver before them. Using smaller tanks worked in the Australian's favour and Hugh explored a further 240m. It is worth noting that in the quarter of a century since, this distance has been extended, albeit rarely, and the record re-broken as recently as March this year, by another team of CDAA members.

Photograph 20: Few people will ever see these fossils, far from the surface

Photograph 21: A fossilised sea-urchin embedded in the wall as divers swim by

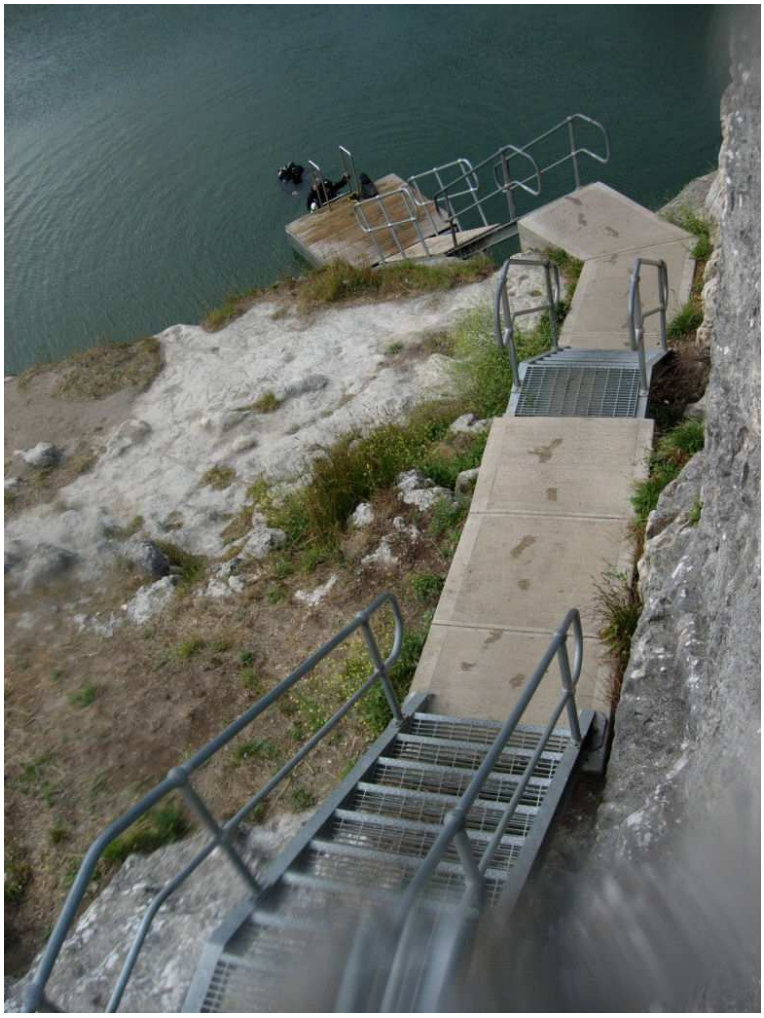
The fantastic diving in Mount Gambier then landed squarely on the world stage in 1984 with a 15-page David Doubilet feature in National Geographic.[8] Having already published several books on skin diving, American Hillary Hauser's accompanying story began "I was exhilarated beyond anything I have ever known." (p.129). Membership plateaued after this time to around 700 members current at any time, out of more than 1,200 that had so far been tested and certified.

Photograph 22: Cave diving requires considerable investment in time and money



Photograph 23: Cave divers are gregarious and develop strong camaraderie

Photograph 24: Cave divers are independently equipped with two of everything, but practice supporting each other underwater as an additional contingency



Photograph 25: The path to adventure is steep, as is the learning curve en route`

In 1989 the two state-based branches amalgamated, the unified CDAA we have today was cemented and the current organisational structure adopted. In 1990 an agreement was brokered between the CDAA and the WA Government's Conservation and Land Management (CALM) (with none other than Dr John Watson) and an extensive training program was conducted in Weebubbie Lake, where the instructor candidates 'taught' previously qualified and experienced divers, and Simon Jones, (another co-owner of Perth Diving Academy), became WA's first trained and certified "penetration" diver, still today Australia's highest cave diver rating.

The CDAA today

Today the CDAA's 840 members include many mature professionals such as doctors, management, academics, etc. Instructors run courses in six states and these courses are recognized worldwide by international cave diver training organisations, which is increasingly necessary because our members are travelling internationally more frequently. To afford international cave divers access to Australian caves, the CDAA administer a special visitors permit system with a raft of access conditions such as the requirement to be accompanied by a current member of the CDAA, to be sponsored by a current member, to submit copies of (and carry) recognised international certification and to abide by each site's access conditions. In this way more than seventy international cave divers have safely visited and dived Australian caves, assisted by the CDAA. Whilst many sporting clubs and associations have struggled to stay viable during the last 35 years, especially during tough economic times, the CDAA currently retains in excess of $360,000 in an investment account, which is in addition to our day-to-day "working fund" in a cheque account. Land managers need not worry that time invested in establishing a working relationship with the CDAA may be time wasted; the CDAA has a large, stable membership base and is financially secure.

Photograph 26: The CDAA is built on a solid foundation; its membership

Keeping abreast of the rapidly changing world, our diver training courses are continually being revised, training materials upgraded and a close eye is kept on the changes being made overseas, as other agencies continually strive to improve. The CDAA publishes a full-colour quarterly journal called *Guidelines*, maintains an extremely active web site with sometimes dozens of e-mails reaching hundreds of divers each day as topics are discussed and news breaks. A separate, larger e-mail list is maintained for "official" news, meaning when there is a high fire-danger near a popular cave, or maintenance is being carried out, or any other event that affects access to a cave then the majority of the membership are made aware almost instantly. The CDAA supports and regularly attends related conferences, so far this year OZTeK in Sydney, the biennial ASF conference in Sale (the CDAA was a sponsor) and, of course, ACKMA in Margaret River. For our own AGMs held each year in October we have, on occasion, flown-in international speakers, last year from Germany and this year from America. In addition to hearing from some of the world's leading explorers, often there is a scientific focus and this year we are also looking forward to a presentation by Associate Professor John Webb on the geology and hydrogeology of Mount Gambier. Since its earliest days the CDAA has enjoyed scientific collaboration with academic institutions and government. The University of South Australia, for example, recently conducted water quality sampling in four flooded caves with the help of CDAA cave divers.[9] Indeed, in the latest issue there is a call for nominations for the position of CDAA Science Officer. This position, like every position in the CDAA, will be voluntary.

The association is administered by volunteers, including five Directors, each with a number of Office Bearers reporting to them. Today the CDAA has three levels of diver qualifications, *Deep Cavern, Cave* and *Penetration (*soon to be *Advanced Cave)* and rates sites for landowners under the following headings: *Cavern, Sinkhole, Cave* and *Penetration*.

The future

Technology is changing so rapidly the CDAA is, by necessity, a dynamic organisation. Indeed, often the bringers of new methods or machinery into Australia are some of the CDAA's leading divers. Diver Propulsion Vehicles (DPVs) are now being powered by lithium polymer batteries, rebreathers are being used to the furthest reaches of our deepest and longest flooded caves, decompression computers have replaced the old "dive tables" and divers now get minute-by-minute updates on their remaining air and decompression obligations. LED torches have pushed back the limits of how long a diver can illuminate the way (in Florida cave divers have made 27-hour dives), heated vests are allowing CDAA divers to brave the harshest of caves (the Australasian depth record was set in New Zealand by a CDAA member) and drysuits are the standard now, with "comfort" valves for males and females alike. So far this year the CDAA has called for submissions from the membership, formed sub-committees, and subsequently published policies on the use of rebreathers and DPVs in caves.

Photograph 27: The CDAA is always looking for new partnerships, to access new caves and to assist worthwhile endeavours

We are looking for more caves to dive, cementing relationships with the wider caving community, finalising and offering recognised roping courses, supporting more grass-roots activity outside of South Australia-Victoria such as state meetings and workshops in NSW, QLD and WA, we have appointed a cave diving historian and are looking to bolster our scientific endeavours. Contact us if cave divers can assist with your scientific research – many of our members are scientists themselves.

Conclusion

The Cave Divers Association of Australia is Australia's peak cave-diving organisation. With members spread throughout Australia it is one of the largest in the world and has a safety record second to none. Our members add value to caves in many ways, for example by conducting regular clean-ups, installing and maintaining infrastructure, engaging positively with the curious public, reporting changes in water quality or water levels and, indeed, by maintaining close ties with speleo groups Australia-wide. It is only natural for cave divers to join their local caving group and the CDAA encourages this. Membership of the local speleo group is how the CDAA expects their membership to develop dry caving skills, in the same way as many speleo groups expect their own members to learn cave diving techniques through the CDAA. We encourage any office bearers of an Australian caving club reading this to circulate it within their own club with an open invitation to all cavers (who already scuba dive) to contact a CDAA instructor for information about taking that next step, to see beyond the sump. Courses are regularly advertised at www.cavedivers.com.au Likewise, the CDAA would like to hear from any caving group looking for new members and we will happily circulate membership invitations from caving clubs. Find your local state rep at:

State/Region	Representative	Email Address
ACT	(Heike Apps)	actrep@cavedivers.com.au
NSW	(Mark Jobbins)	nswrep@cavedivers.com.au
NT	(Jeff Swann)	ntrep@cavedivers.com.au
QLD	(Tim Featonby)	qldrep@cavedivers.com.au
SA	(Ken Smith)	sarep@cavedivers.com.au
SE-SA	(Grant Pearce)	sesarep@cavedivers.com.au
WA	(Peter Buzzacott)	warep@cavedivers.com.au
VIC	(Ian Taylor)	vicrep@cavedivers.com.au

Tasmania has some of the very best cave diving in Australia and the CDAA looks forward to seeing you all there at the 19th ACKMA conference, 2011.

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The Need For International Collaboration To Achieve Sustainable Development In Show Caves

David Summers

President, International Show Caves Association

Abstract

Sustainable development means that the environment meets the needs of the present without compromising the ability of future generations to meet their own needs. In response to the importance of the need to achieve sustainable development the International Show Caves Association (ISCA) has established the International Commission on Sustainable Development in Show Caves to consider ways and means by which show caves can achieve sustainable development, to propose long term plans by which the world's show cave community can deal more effectively with the achievement of sustainable development and to recommend ways that the concern for the achievement of sustainable development in show caves can be translated into recognition and greater co-operation among the different countries of the world. To achieve these goals there is a fundamental need for international collaboration.

Introduction

We need to rally all of the people involved in the world of show caves to the cause of achieving sustainable development in show caves. Our goals for the development and operation of show caves must be defined in terms of sustainability in all countries - developed or developing, market orientated or centrally planned.

The world first really heard the message of sustainable development from the United Nations World Commission on Environment and Development created in 1983, a full twenty-five years ago. Not last year - but a quarter of a century ago. To put this time period into relative comprehendible terms, it is one eightieth since the time that the Romans extended their empire into England. It is a hundredth of the time since construction of the Great Wall of China was commenced, not finished.

The World Commission on Environment and Development presented their report to the United Nations Assembly in 1987. Somehow, it has taken the world time to react to this farsighted report. Maybe, it was a shock of harsh reality for the wealthier northern states. Maybe it came as a surprise to the poorer southern states. Whatever it was, the world has only now started to mobilise to the call of sustainable development.

Sustainable development means that the environment meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable development means meeting the basic needs of all. The "environment" is where we all live and "development" is what we all do in an attempt to improve our lives within that abode.

After 25 years of virtual standstill and deterioration, our brave new world starts to move forward. It is time for change. It is time for global cooperation to move forward. It is particularly important in light of the present global financial downturn for the nations of the world to collaborate to achieve sustainable development.

The world of show caves has its own United Nations Organisation of show caves - it is called the International Show Caves Association. ISCA can provide the necessary link between the scientists and the public. Public interest in the scientific world is growing. The media is accelerating this.

The Need For Sustainability

The challenge for us in the world of show caves is to ensure that our caves are sustainable. Our number one enemy is environmental degradation. We must fulfil our responsibilities towards global sustainable development.

We need to grow closer to each other. We need to collaborate and share our experiences.

We need to share our successes and, even more importantly, we need to share our failures. Do we want to have another Lascaux tragedy on our hands? The answer is a resounding - no. We need to collaborate more.

There is a global need for sustainable development of show caves. There is a need for international collaboration to achieve sustainable development of show caves. We need worldwide solidarity to achieve this critical goal.

Let's start at the very beginning of the term sustainable development. In many ways our subterranean worlds are sensory monitors of what is occurring above ground. Even our entry into these natural systems can be intervention.

In any show cave, environmental matters must rank as the highest consideration. The often touted need for economical profit pales against environmental considerations. If the environment of the cave is not good, then its economic future will not be good. Conversely, of course, if the economics of the show cave are not good, then the environmental quality will suffer.

Where do we start? Clearly the item that must always be at the top of the list is the protection of the cave. This must always be in the highest echelon of the priorities of a show cave. It will be futile to implement any new methods of operating or developing a cave if the foremost obligation of protecting the cave is not achieved.

Vandals, with senseless malicious intent, can cause immeasurable damage to any cave - damage that can take thousands of years to overcome, if ever. In considering time spans in the life of a cave, it must always be borne in mind that the time since caves were first developed for showing to the public can be equated to the blink of the eye compared to the time taken to create a cave.

Protection of a show cave must fundamentally prevent entry into the cave by unauthorised people. It is pointless to rely on methods of discovering the identity of the intruder in order to punish them. We must protect the cave against the vandalisation that can occur through unauthorised entry. Cameras simply will not protect the cave.

Proper gating of a show cave can consequently be considered the first step in pursuing the sustainable development of a show cave.

Another critical component of developing and operating a show cave is the protection of the formations from the prying fingers of the visitors. All too frequently we hear of renowned formations that are irretrievably lost through this type of vandalism. Consequently, protection of the cave can be considered a fundamental in sustainable development.

The Natural Resource Of A Show Cave

After the cave is protected, the next question that must be answered is - what is the purpose of the show cave? The fundamental purpose of a show cave has to be education, be it academic education or enlightenment of the public.

Show caves are where the public needs to be directed in order to enable them to see the incredible underground spectacle that exists in our underworld. The general public does not belong in wild and unimproved caves. Caves are inherently dangerous places if the lay visitor is not properly trained and equipped.

In accepting the general visitor into their caves, the show cave operator must be aware that the average visitor is becoming more educated and will also have a greater awareness and appreciation for the environment.

A show cave is an incredibly valuable natural resource. Providing we protect it and preserve it, we can achieve sustainability. Nowhere are the words - the environment is both physical and social - more applicable than in a show cave.

The show cave owner/operator has a clear responsibility to ensure that their guides are well trained and have ongoing education. The responsibility of the guides is to ensure that they are providing a good educational tour. They are not the star of the visit - the cave is.

A show cave is the absolute best medium to let the public see and understand the wonders of the underground. Without this opportunity to physically witness the interior of a cave, it is predictable that the public will not be as concerned about the need to preserve and conserve caves. We must all work to ensure that the old notion that a cave is simply a hole in the ground, with its best use being a dumping ground, is no longer prevalent.

Sustainability Of Show Caves

The ongoing need to promote and educate the public is a global need. This very same credo is the same in every continent of the world.

International collaboration is fundamental to the achievement of these objectives. We cannot expect to achieve this in isolation as individuals.

In assessing these objectives, it is important to bear in mind that not every cave needs to be a show cave. Show caves are an incredibly small percentage of the total number of caves in the world. We, as owners and operators of show caves, have a responsibility to ensure that show caves are operated with the absolute highest environmental standards.

The matter of need becomes fundamental. In assessing "need", the economic impact that a show cave can have on a locale must always be remembered. Not only are the more obvious economic advantages arising from direct benefits to be considered, but also the less obvious benefits arising from a show cave must also be taken into account.

The notion that a show cave must be economically successful, in order to support the environmentally sound practices, is alive and well. Find a cave that is not performing well economically, and it will follow that there are insufficient funds available to support the environmental needs.

While I believe that the owners and operators of show caves are generally working hand in hand with the environment, there clearly is a need to be cognisant that this can always be improved. We must be vigilant and remain on the cutting edge of environmental matters. To do this the clear benefits of international collaboration must be enhanced and utilized more.

We have the ability to ensure that our show caves are sustainable. The future need not be threatened as long as we are vigilant and ensure that we are not promoting interlocking crises that can happen with indiscriminate economies and ecology.

Sustainable means that we must avoid using up natural resources. We must be in harmony with the productive potential of the ecosystem. In the end, sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are made consistent with the future as well as present needs.

There is an overwhelming need to make informed choices. The need to adopt sound sustainable development practices is upon us. The transition to sustainable development can be achieved.

Part of our environmental management practices must be focussed on after the fact repairs of damage and restoration of natural habitats. We must accept that change will happen. We must produce more with less.

Global Collaboration

There is a clear challenge facing the world of show caves. We must protect, conserve and preserve our incredible displays of the earth's natural systems. Show caves are not simply curiosities, but very important vehicles to aid and promote public awareness. The last component that we must meet is the need to remain viable.

After a period of stagnation, we are finally waking up. We have made an important start. We must now enter into serious collaboration on a global basis.

We have established the International Commission on Sustainable Development in Show Caves. Now this body must start its deliberations. These deliberations will extend around the globe and cover every continent. We need countries in every continent to support the essential objectives of sustainable development.

We are charged with a very fragile and delicate world, a world that requires a co-joining of economy and science. This is what the International Show Caves Association is all about.

In addition to establishing the International Commission on Sustainable Development in Show Caves, ISCA is currently preparing Management Guidelines for Show Caves. These guidelines will be practical and even if a given show cave does not comply with them they will provide guidelines that show caves can work towards.

We do not have a resource that we can rebuild, if it is damaged, within periods of time that are less than thousands of years into the future. We are all aware that once something in a show cave is lost, it is effectively lost forever.

The future need not be threatened if we collaborate, collaborate and collaborate.

International Guidelines on Cave and Karst Protection & Urbanisation Issues

John Watson

Co-editor and author 1997 IUCN Guidelines for Cave and Karst Protection

Planning and Urbanisation in Karst Lands Workshop

This morning I gave a talk on the draft Department of Environment & Conservation (DEC) policy on Caves and Karst. This afternoon I have been asked to give a brief presentation on the 1997 IUCN *Guidelines for Cave and Karst Protection* (Watson *et al* Eds, 1997) in the context of urbanisation of karst. I am speaking here as lead editor of that publication and not in my role as a DEC officer. However, there are some interesting similarities with current work in another rapidly expanding urban centre where I live, namely Albany, and where we have pressure to clear more and more remnant native vegetation for future urban housing. I will use that non-karst example to suggest a number of possible strategies that also may be relevant in addressing the urbanisation of karst on the Swan Coastal Plain.

The IUCN *Guidelines for Cave and Karst Protection* were drawn up after I was involved in preparing a similar set of international guidelines for mountain protected areas in 1991 (Poore, 1992). Having established the IUCN Working Group on Cave and Karst Protection (now the Caves and Karst Task Force) at the 1992 World Parks Congress in Venezuela, I felt that a sister publication to the *Guidelines for Mountain Protected Areas* would be a valuable addition to the IUCN literature. Whereas the IUCN (the World Conservation Union) had specialist commissions or theme groups such as Marine, Mountains, Forests, World Heritage, threatened species *etc*, there was no similar group within the membership focusing on caves and karst. The primary aim of the guidelines was to raise awareness of the special needs of caves and karst *within IUCN itself and also within protected area agencies around the world.*

We must have done a reasonable job as the guidelines are still being used (for example, someone thought them relevant to today's workshop !) and although I believe some progress has been made on an update, no revision has yet appeared. As well as targeting *agencies,* the guidelines also targeted planners. A clear message was given that the guidelines were pitched at a very broad generic level and needed to form the basis of more specific locally written guidelines around the world.

So, it is pleasing that in Western Australia, for example, we now have:

- significant progress towards a draft set of cave and karst policy objectives across all aspects of DEC's role Statewide,
- an excellent set of guidelines already produced by the Environmental Protection Authority (EPA) (EPA, 2008) which is focused more at the area or sub-regional level,
- and more localised management guidelines at the individual site level such as for the tourist caves in this area.

However, a few fundamentals first…

- Karst boundaries are notoriously hard to determine as we are dealing with both surface catchments and underground catchments, both of which generally extend beyond the surface karst occurrence itself. I am sure many planners continue to overlook this.
- Principles of wetland protection and management are perhaps the best comparison we can use to raise awareness of karst issues with such people. However, for many people caves are 'out of sight/out of mind'…unlike wetlands and mountains which are very visible.
- Over a quarter of the world's population live on karst – my guess is that an even higher proportion of the population in Western Australia do especially in the expanding suburbs of Perth and elsewhere along the Swan Coastal Plain.

The guidelines suggest a range of threats to karst from total destruction to less obvious and more subtle susceptibility to pollution and other discharges. They also stress the range of resilience to threats as being largely determined by the water input and associated energy levels. This is similar to the principles of dealing with marine oil spills – wave action on high energy coastlines rapidly disperses the oil whereas in low energy inlets and mangroves the vegetation and fauna may remain impacted by oil for months if not years. In urban Western Australia we are dealing mainly with low energy hydrological systems and hence there is great potential susceptibility to threatening processes.

Population data for 2004-2006 for a number of country centres in Western Australia and for the Perth Metropolitan Area, show exceptionally rapid growth in Ravensthorpe and Albany. This reflects the anticipated operation of a nickel mine near Ravensthorpe and a magnetite mine near Albany. The Ravensthorpe population growth has now reversed due to BHP Billeton closing the new Ravensthorpe mine in January 2009. However, the rapid demand for housing in Albany continues and has created environmental impacts of another kind in an area that is renowned for its high biodiversity (Myers *et al,* 2000*).*

Indeed the Albany hinterland contains a huge range of threatened flora and fauna species. These species are located throughout the landscape in so called 'remnant vegetation', much of which is privately owned and already targeted for future urban growth. Such areas often retain valuable habitat as well as landscape vegetation connectivity through corridor linkages. In order to assist planning authorities and the EPA in assessing proposals for release of more land for urban growth, a regional vegetation survey is now in progress basically to identify remnant vegetation that is particularly important in a sub-regional context and not well represented elsewhere in the region. Areas with populations of threatened species are also being identified and some areas noted for their vegetation connectivity function.

The Albany Regional Vegetation Survey may provide some useful precedents for dealing with and prioritising the urbanisation of karst. In Table 1 I have listed some key points of the Albany survey in the left column and suggested some equivalent actions or strategies for addressing pressure on urban karst in the right hand column. Whether we like it or not, urban expansion will continue and the challenge we face is to minimise the overall impacts, protect the especially unique and get the planners to think globally *(i.e.* catchment wide) and not locally in the context of karst. However, to reinforce this we will need to present a strong *economic business case* for planners and developers to sensitively consider 'living with karst' and thereby minimise future building and infrastructure management and maintenance costs.

So to conclude

- Millions of people world wide already live on 'urbanised karst'
- Thousands more will do so in our own lifetimes, especially in Western Australia
- We need to convince planners to think more strategically with regard to urban expansion impacts on karst values
- Both environmental *and business cases* will be needed to maximise optimum outcomes for karst with a win/win outcome.

Table 1

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Abstracts only

Ringing in the changes in Cave Tourism

Dr. Julia James.

In keeping with the conference theme "Winds of Change" this presentation will briefly give an overview of some of the recent changes in cave tourism.

Examples will be taken from caves on six out of the seven continents and include:

- New caves opened and old caves re-opened for tourism.
- Refurbishing of existing tourist caves.
- The ever-growing variety of tours.
- World heritage caves.

All changes will be assessed by the speaker and given a bell rating from 10 to 0, rankings that will definitely be open to debate.

Setting the Scene – Syngenetic Karsts in the Southwest of Western Australia

Ken Grimes

Western and Southern Australia have many karst areas developed on soft sandy limestones (calcarenites) which are quite differing to the traditional 'hard-rock' limestones found elsewhere.

These are the syngenetic karsts of the youthful Quaternary dune limestones and related soft-rock karsts of the Tertiary limestones (which also show some syngenetic features).

In syngenetic karst speleogenesis and lithogenesis are concurrent: caves and karst features are forming at the same time as the loose sediment is being cemented into a soft, porous rock.

The distinctive features of syngenetic karst are: shallow horizontal cave systems; a general lack of directed conduits (low irregular chambers occur instead); clustering of caves at the margins of topographic highs or along the coast; paleosoil horizons; vertical solution pipes which locally form dense fields; extensive breakdown and subsidence to form collapse-dominated cave systems; a variety of surface and subsurface breccias and locally large collapse dolines and cenotes; and limited surface sculpturing (karren).

In the southwest of WA syngenetic karst occurs in the coastal dune calcarenites of the Tamala Limestone.

Many features are similar to those seen in Eastern Australia and elsewhere, however there are some interesting differences also.

North from Perth, there is a long belt of Quaternary dune limestones that continues all the way to Cape Range (which is mainly Tertiary limestone). Within this the most interesting karst areas are the Nambung Pinnacles and the Yanchep area.

At Yanchep dune limestone overlies a quartz sand aquifer and aggressive water enters from below to dissolve caves at the base of the limestone.

South from Perth there are a few caves and springs where the Swan and other rivers cut through the dune ridges. In the Leeuwin-Naturaliste region a belt of dune limestone up to 6 km wide contains numerous caves (see conference Field Guide for details). Early work by speleologists (e.g. Bain and Bastian) in this area contributed to the concept of syngenetic karst. The special aspect of this area is the shallow impermeable basement, which can guide the water flow through the dune sand above. The caves are best developed in the older more-cemented dunes and are of three types: *linear caves* formed by cave streams which follow buried valleys above the impermeable basement; *breakdown* systems, including the 'inclined fissure' type, which modify and can completely replace, earlier solutional caves; and the horizontal watertable *maze caves* of the Augusta area – the last are relatively rare in the Leeuwin-Naturaliste region but common elsewhere. Water tracing has mapped some conduit flows from stream sinks at the inland margin of the dunes, through intermediate through-flow caves to springs on the coast, but much of the underground water flow seems to be lost offshore.

Synergy driving innovation in Cave Lighting.

Dan Cove, David Head and David Rowling

There have been enormous advances made in recent years in the field of cave lighting. These advances have been made in lighting technology, most importantly the evolution of high intensity LEDs, in automation and control, efficient uninterruptable power supply and also in the overall underlying lighting design philosophy. It is important to realise the multi-disciplinary nature of the challenge presented when considering a new cave lighting project, as these advances are being made by individuals in potentially quite disparate areas.

The recent experience of relighting the *Orient* at Jenolan Caves NSW, highlights the necessity of a collaborative effort, as innovation in all areas was driven by a dynamic process of technology influencing design, but also of design philosophy forcing the continued development of available technology. The ultimate result of this synergy is a far superior cave experience than would have been achievable otherwise, and also provides a most conducive situation for the growth and development of the individuals involved.

Jewel Cave Redevelopment

Lindsay Hatcher

The Augusta Margaret River Tourism Association (AMRTA) recently received over whelming support from its membership, to undertake the well needed Jewel Cave Preservation and Redevelopment Project. The AMRTA, managers of Jewel Cave, are extremely excited about the project and are committed to cave management and tourism within the region contributing $1.1 million of its own funds to the $3.1million project.

The Jewel Cave project looks at eco-sensitive buildings and infrastructure that will compliment the natural environment, upgrading 50 year old wiring and lighting, creating an interpretive centre and cafe to increase education and visitor amenities and the re-vegetation (with endemic plants to the site) of the existing site to help recharge the water table and preserve site integrity.

Margaret River architects, Willcox and Associates have been awarded the contract to design and build the interpretative centre and café at the Jewel Cave site as part of the upgrade of the facilities. The Willcox and Associates concept was in keeping with our brief and in particular answered our requirement for environmentally sustainable features through its attention to passive solar design, natural ventilation, solar

water heating, insulation, water storage and efficiency, minimal artificial light and waste management systems.

It is anticipated that the whole project, including the new car parks, the building and the work within the cave will take approximately two years to complete. The full plans and working drawings are available to view at the ACKMA 2009 conference and the AMRTA is excited to be able to walk delegates through the project. This project has been at least twenty years in the development and the AMRTA would like to thank past managers and committee for having the foresight and commitment to ensure the stunning Jewel Cave is preserved and protected.

Filling the Gap – the role of a non-government karst conservation organisation in Australia

Jay Anderson and Alan Briggs

This presentation outlines the development of a new Conservation Group in WA. The Caves and Karst Conservation Foundation is set up under the WA National Trust, specifically to protect and conserve caves and karst areas. To use the American terminology, the Foundation is effectively a 'Conservancy'.

The National Trust has many attributes that set it aside from other public and private organisations. The National Trust is set up under a State Act of Parliament, and has approval under the Australian Taxation Office to operate as a charity bringing with it tax deductibility for donations of land and money. The National Trust is an active organisation with an impressive list of credits and is well respected internationally. The National Trust (WA) is involved in a range projects and outcomes regarding conservation and interpretation of the State's natural heritage.

The National Trust has the ability to establish conservation appeals for a range of natural heritage projects. In this case we are establishing an appeal for cave conservation. The appeal will be managed by a

committee established under the Council of the National Trust of Australia (WA). The Purpose of the Appeal is to receive donations of land and money to conserve the values of caves and karst and to educate the community for the protection of these values. The Appeal is referred to as the 'Caves and Karst Conservation Foundation Appeal'.

The Appeal is operated by the Caves and Karst Conservation Foundation committee – a separate group of people who also manage The Caves and Karst Conservation Foundation. The key constitutional objectives of the Foundation are:

- To conserve and protect caves and karst systems as natural assets.
- To interpret caves and karst systems.
- To educate the community about caves and karst systems and their values.
- To provide leadership in environmental management and natural heritage management of caves and karst systems.
- To facilitate the increase of scientific knowledge about caves/karst

This new organisation will fill the gap between the ASF, ACKMA and state Conservation Agencies. The Foundation will be active in project management – seeking to raise funds to put back into cave and karst management. The Foundation will be in a position to provide support to private land managers and non-government cave managers. The Caves and Karst Conservation Foundation will bring 'caves' to the general public, fostering a desire for people (other than speleo's) to be involved in the conservation and interpretation of caves and karst systems.

Woodvale Swimming Pool Collapse

Ross Anderson

Caves and Karst are some of the most vulnerable ecosystems in the world. The Karst Landscape on the Swan Coastal Plain (including Yanchep National Park) represents an important part of the earth's geological diversity. The limestone in this area of Western Australia exhibits unique characteristics due to the nature of its development.

The geology of the northern suburbs of Perth comprises, in part, a large area of coastal Aeolian limestone (also known as: Tamala limestone and Aeolian calcarenite), observed as a series of distinct landforms roughly parallel to the coast. Several authors have recognized three main units that occur from east to west: The Bassendean Dune system, the Spearwood Dune system and the Quindalup Dune System

During March 2007, a sinkhole developed in a backyard of a residential property in Woodvale. This resulted in the collapse of a swimming pool and the loss of around 44,000 Litres of water overnight. During the months that followed, local and State Government agencies and other service companies assessed the situation without resolution.

In July 2007, Ross Anderson of Dissolved Rock Pty Ltd, contacted Mike and Sonja Pilkington to make the offer of assistance in the investigation of subsurface conditions and possible remedial actions that could be undertaken to stabilise the sinkhole that was evident in the rear north western corner of their property.

The offer entailed a site visit to the property to undertake on ground investigations using Ground Penetrating Radar (GPR), downhole camera equipment and a surface inspection of the property and surrounding neighbourhood.

It was assessed that the connection to the ground surface displayed in the backyard of the property was most likely a solution tube rising from a cavity at or near watertable level. The Perth Ground water atlas estimates that the ground water in the Woodvale area is approximately 15.5 metres AHD. Using available information and cave data an estimate of limestone thickness was made.

Two reports were submitted to the land owners and parliament member Judy Hughes. In the following months the property was bought by the government and remedial works undertaken to fill the depression.

The property was then sold by the government with a notification on the title and restriction of use for the rear northern section of the property. Acknowledgements: Lex Bastian, Ian McCann, Jay Anderson, and Greg Joyce.

Urbanisation and Karst Systems – living with karst in Western Australia

Ross and Jay Anderson

Urban development and its associated impacts is one of the major karst management issues within south-west Western Australia.

The unique karst system that runs along the WA coastline faces many issues: water abstraction, catchment vegetation, impacts by development, visitation and management impacts. Protecting the karst system from current development and the impact of Perth's expanding population is a huge task.

There have been a range of karst issues and outcomes to date. In some areas, speleologists have been able to work with landowners, developers or the local Government to assess a proposed subdivision for caves and karst features. Speleologists are sometimes not involved or are not allowed access to land to make appropriate comment on potential impacts to caves and karst or advice is disregarded.

A lack of timely consultation with specialists or a lack of understanding of the complexity of karst, can result in environmental damage. It is important that all who are involved in management and planning decisions within karst systems, are aware of the IUCN Guidelines for Cave and Karst Protection. Likewise, the EPA have Guidance Document 33 – for Planning and Development – including a significant chapter on karst.

This paper discusses two case studies within the karst system. One locality has had significant impacts on karst features, despite the features being identified by speleologists.

Plans for part of this area include installing a road that will bisect land with a large number of caves and karst features – and the karst system that exists in native Tuart bushland is at risk. In the other locality, speleologists have been able to contribute to the protection of the karst in a proposed subdivision. As a result, the part that contains karst may be either incorporated into a bushland reserve or be purchased by the Government to add to the National Park.

The Speleological groups are working with numerous local groups and Government agencies to improve recognition of environmental management and safety issues associated with karst in the area.

The paper reviews the outcomes and considers the key issues. As Perth's population increases, subdivision and development will continue to occur. Karst impacts will continue unless there is a change in attitudes regarding the importance of karst and karst features, and their management. A collaborative approach is essential to achieve appropriate management of karst in this area. This paper will propose some options for successful outcomes.

A Snapshot and History of the Leeuwin Ridge

Brian Combley

A series of Photographs of the area and the caves both historic and current with a broad overview of historical events affecting the Leeuwin Ridge Karst Area. The photos include aerial photos of icons of the area such as Cape Naturaliste Margaret River and Cape Leeuwin along with historic locations such as Caves House, Ellensbrook and Wallcliffe House.

When to Turn the Tap Off

Brenton Knott

The climate operating over the south-west of Western Australia is changing, notably with reduction in rainfall. Concomitant with this, there is increased pressure of land-use, some of it showing remarkably little ecological wisdom. One of the major regional aquifers is the Gnangara Mound between the Swan and Moore rivers. The Mound reached an elevation of about 70 m asl and, on its western slope, assisted in the formation of caves in the area of Yanchep National Park with cave streams lined by tuart (*Eucalyptus gomphocephala*) tree root mats. This reliable food supply supported a diverse, abundant and zoologically important groundwater fauna.

In the summer of 2000/2001, the streams dried, and the government response has been to remediate the situation – by restoring local mounds within selected caves. I will review briefly the fauna, the history of the remediation, and suggest that it is all futile given that it is not possible to predict reliably future climate of the region.

Climate Change and Karst

Andy Spate

Karst and their dependent environments have been around for a long time. Consequently they have been exposed to much climatic change through time. Taking just the last 66 million years through Tertiary and Quaternary times we have had much hotter, wetter, drier and colder conditions. These have shaped karst environments, their processes, biota, sediments and so on. What we have today has survived these climatic swings plus, perhaps the impacts of environmental change brought about by a number of human invasions.

Global warming, whether produced by natural processes or humans inputting greenhouse gases such as carbon dioxide and methane, will produce climate changes. These may not produce warmer weather in region x or y. The pulls, pushes and interrelationships of atmospheric and oceanic circulation make understanding the impact on terrestrial environments where we live extraordinarily complex. It may mean that some places are colder and/or wetter rather than just warmer.

If it is difficult to say what happens in regions x and y, it is going to be difficult to even more complicated to predict or understand what will happen to karst processes. These processes produce and maintain the karst environments we manage, research and enjoy today. This paper explores some impacts of climatic factor change on karst processes.

Bioluminescence in cave glow-worms: signs of altered circadian rhythmicity

David Merritt & Arthur Clarke

Glow-worms emit light from cells in the malpighian tubules to attract prey into their webs. They are found in suitable wet caves as well as in rainforest settings. Forest glow-worms cease glowing on exposure to light so they glow only at night. They possess a circadian rhythm of light output, demonstrated in the laboratory through their ability to maintain cyclical glowing for many weeks in constant darkness. Because glow-worms reach high population levels in caves where they do not receive strong daily resetting stimuli, we investigated whether cave glow-worms are rhythmically bioluminescent. We developed a remote time-lapse digital imaging setup to record light output levels at 10 minute intervals for up to 5 days. Analysis of light output of the Tasmanian glow-worm, *Arachnocampa tasmaniensis*, and the New Zealand glow-worm, *A. luminosa*, in wild caves established that both species maintain strong rhythmic light output. The time of peak light output is different to forest glow-worms: cave populations glow most brightly when it is daylight outside the cave and most weakly during the night: they are completely out of phase with adjacent rainforest populations. We discuss the possible basis of the phase-shift and synchronization within caves.

Conference acknowledgements and introduction

Welcome to the Conference

A very warm welcome to the 18th Australasian Cave and Karst Management Conference. This is the third ACKMA Conference to be held in the south west corner of Western Australia, the first held in 1981 at Yallingup was attended by 24 delegates, the second at Margaret River in 1991 was attended by 47 delegates, and this, the third, is expected to be attended by over 90 delegates (though *please* don't ask me the final number until after the conference!)

The Leeuwin-Naturaliste area in the South-west of Western Australia is an area of great natural charm and beauty. A stunning coastline of white sandy beaches interspersed with rocky headlands is fringed by limestone reefs and world class surf. Other natural features are the majestic forests, the south west's largest river, the Blackwood, and of course, the caves.

Caves were the first 'tourist attractions' in the region, and indeed within the south west of W.A., with many being opened for tours in the early years of the 20th Century. The earliest reserves (part of the present day Leeuwin-Naturaliste National Park) were put aside for '*protection of caves and flora health and pleasure resort'*.

Today the caves remain a great attraction, though now the region is known for much, much more. Vineyards producing world acclaimed wines, boutique breweries, fine dining, arts and crafts, chocolate, cheeses, and olives are just some of the attractions.

The Leeuwin-Naturaliste National Park, stretching 110km between Cape Naturaliste in the north and Cape Leeuwin in the south encompasses most of the remaining forested areas and includes much of the limestone in the area.

Four small enclaves within the National Park are vested in the two local tourism associations and contain the major show caves – Ngilgi, Mammoth, Lake and Jewel.

The conference hosts are the Department of Environment and Conservation, the agency that manages Western Australia's National Parks and the 100's of caves and karst features within them, including Calgardup, Giants, Crystal (Yanchep National Park); the Augusta Margaret River Tourism Association, manager of Caveworks, Mammoth, Lake and Jewel Caves; and Geographe Bay Tourism Association, manager of Ngilgi Cave.

Those of us fortunate enough to make this place our home proudly welcome you to this beautiful part of the world.

Anne Wood

Conference Convenor

Anne Wood. Photo: Kent Henderson

Acknowledgements

Thanks must go to the conference organizing committee comprising Jay Anderson, Ross Anderson, Renee Mouritz, Tracey Robins, Neil Taylor, Rauleigh Webb, Candace Williams and Peter Wood for their valuable time and input. Thanks must also go to Jayme Hatcher for her work in the initial stages of conference organisation.

I would like to make special mention of Jay Anderson for all her work organizing the pre and post conference trips, Rauleigh Webb and Ken Grimes for producing the Conference Field Guide, Kent Henderson for producing the Conference Handbook and providing ongoing advice and support (and harassment!), Ross Anderson for organizing the workshop for Wednesday afternoon, and Peter Wood for his support and assistance in many ways too numerous to list (feel welcome to ask Peter for details).

Thanks also to the many members of the caving fraternity for their help during the conference and to Molloy Island Volunteer Bush Fire Brigade for the use of their laptop and projector for the presentation of papers.

Sponsors

The Department of Environment and Conservation (DEC) is the major sponsor of the Conference, contributing resources, staff time and coordination of volunteers to organize and manage the event. DEC also provided funding for the conference satchel, and DEC publications – *The Caves of Western Australia* and *Discovering the Leeuwin-Naturaliste National Park*. Thanks also to DEC for the venue of some conference events, Wharncliffe Eco Discovery Centre, and entry into Calgardup Cave, Giants Cave, Golgotha Cave and other caves of the Leeuwin-Naturaliste National Park. DEC has also provided entry to Yanchep National Park and Crystal Cave during the pre-conference study tour.

The Augusta Margaret River Tourism Association has contributed staff time, the *Caveworks* centre, Lake Cave and staff for the opening event and entry to Mammoth, Lake and Jewel Caves. AMRTA has provided the venue and refreshments for the interpretation workshop, which is being held prior to the commencement of the conference.

Geographe Bay Tourism Association has provided staff time and entry into Ngilgi Cave.
Stella Bella Wine has provided wine for the welcome BBQ and two other evenings.
Christian Fletcher Photo Images has provided a print to the value of $550 and cards for each delegate.
This assistance is of all these organisations and supporters is gratefully acknowledged.

Yours in Cave and Karst Management,

Anne Wood,
Conference Convenor.

Caveworks, Margaret River .Photo – Kent Henderson

Interpretation at Calgardup Cave. Photo – Kent Henderson

Conference Photo, Margaret River, Western Australia (R. Webb. photo)

List of delegates

(alphabetically arranged)

1. Jay Anderson
2. Ross Anderson
3. Ann Augusteyn
4. Peter Austen
5. Dr. Claire Baker
6. Steven Bourne
7. John Brush
8. David Butler
9. Dale Calnin
10. Peter Buzzacott
11. Deborah Carden
12. Peter Chandler
13. Libby Chandler
14. Brian Clark
15. Arthur Clarke
16. Marjorie Coggan
17. Julia Coggins
18. Brian Combley
19. Travis Cross
20. Daniel Cove
21. Brett Dalzell
22. Geoff Deer
23. Trish Deer
24. Kirsty Dixon
25. Brett Farquharson
26. Rob Foulds
27. Hein-Jacques Gerstner
28. Dr. Grant Gartrell
29. Alan Griffin
30. Peter Grills
31. Ken Grimes
32. Lindsay Hatcher
33. David Hay
34. Nic Haygarth
35. David Head
36. Nicholas Heath
37. Kent Henderson
38. Dr. Julia James
39. Cassandra Jury
40. Geoff Kell
41. Rob Klok
42. Sasa Kennedy
43. Lisa King
44. Moira Lipyeat
45. Greg Martin
46. Derek Mason
47. Mary Mccabe
48. Will Mccutcheon
49. Mandy Mclauchan-Andrews
50. Timothy Moulds
51. Dr. David Merritt
52. Renee Mouritz
53. Jeff Murray
54. Patrick Nykiel
55. Rhonda Oshanek
56. Meegan Overstone
57. Carolina Paice
58. Barry Richard
59. Tracey Robins
60. David Rowling
61. Bian Rumei
62. Catherine Sellars
63. Chester Shaw
64. Jeffry Simun
65. Andy Spate
66. David Summers
67. Robert Susac
68. Simon Taylor
69. Dianne Vavryn
70. Dr. John Watson
71. Van Watson
72. Rauleigh Webb
73. Mike Winn
74. Anne Wood
75. Peter Wood
76. Philip Wood
77. Barbara Zakrzewska

Part Time Attendees

78. Sophie Bishop
79. Alan Briggs
80. Shane Downes
81. Jared Drummond
82. Brett Huntly
83. Gary Hunton
84. Clint Kirkham
85. Dawn Klok
86. Dr. Brenton Knott
87. Sonia Lamond
88. Christie Mahony
89. Robyn Mcbeath
90. Phil Mcguigan
91. Drew Mckenzie
92. Paul Morton
93. Inga Price
94. Alison Prichard
95. Judy Shaw
96. Jenny Tattam
97. Sharon Thwaites
98. Candace Williams
99. Dennis Williamson
100. Brett Woodroffe
101. Renata Zelinova