



Ecosystems at Risk:

Limestone Caves

Riverina Environmental Education Centre

" They are severely disadvantaged by quite minor disturbances. Thus they have low resilience in the face of a change to the cave ecosystem..... conserving cave biota is a major challenge for ... management." D. Gillieson. 1996

1. Ecosystem Functioning in General

An ecosystem is any given space where animals and plants interact with each other and the physical environment. In a typical terrestrial ecosystem such as a woodland, various plants grow and support an animal population by providing food and shelter. The environment provides the plants with water, nutrients from the soil and energy from the sun which they need to grow and reproduce. Plants in turn become the food of herbivores which obtain their energy and nutrient requirements by eating

plants. Likewise, carnivores obtain their energy and nutrient needs by eating other animals. This dependence or linking of plants and animals to each other via food chains and also to the physical environment which provides air, water, energy, nutrients and a place to live is called an ecosystem.

Organisms, plants and animals, evolve over long periods of time to become adapted to survive in particular environments called habitats. An adaptation is a characteristic of an organism, either a structure, function or behaviour which makes it better able to survive and reproduce in a particular habitat. Many organisms have very specific adaptations to specific characteristics of their habitat. If the habitat is changed just a little the organisms may not be able to survive the new conditions.

All organisms require energy and plants obtain their energy needs by converting sunlight energy into chemical energy by the process of photosynthesis. The flow of this energy from sun to plant to herbivore to carnivore is the food chain. As a general rule, the more plants an ecosystem has, the more animals it can support. Plants will grow better in some places than others.

Plant biomass can be recorded as the dry weight of plants per square metre and gives an indication of the productivity of an ecosystem and the size of the plant and animal communities supported. Biomass figures are a convenient way of comparing different ecosystems.

Ecosystem Biomass (world average)

tropical rainforests 45 kg/m ²	woodland 6 kg/m ²
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alpine 0.6 kg/m²dark caves 0.002 kg/m²

There is very little in the way of animals and no plants in dark caves.

2. Cave Ecosystems

Our any given space in this case is caves which have particular physical characteristics. Deep inside caves there is usually no light, the air is cool and very humid, nearly saturated with water vapour. Carbon dioxide levels may be high if there is little air movement. The climate is very stable, it does not change much, there are few or almost no diurnal or seasonal fluctuations.

Not all parts of a cave are the same. There are three major zones: entrance, twilight and dark based on a reduction of light intensity from the surface down. Each has a different physical environment and a different community of organisms. Each can be treated as a different ecosystem and generally they increase in fragility away from the surface. The absence of light deprives organisms of their major source of energy and the production of biomass by photosynthesis of green plants is limited to near the entrance.

In deep caves there is little to no light, so the food chain has no direct source of energy and the cool temperatures also limit growth. The cave ecosystem depends very much on energy (food) brought into the cave from the surface environment. Food may be brought in by creatures such as bats, which leave their droppings and their dead as food for other organisms. Air currents may bring in pollen and small insects or floods in caves with streams which may wash in debris such as wood and leaves to be eaten by scavengers. The penetration of tree roots into cave passages may also be a very important source of food.

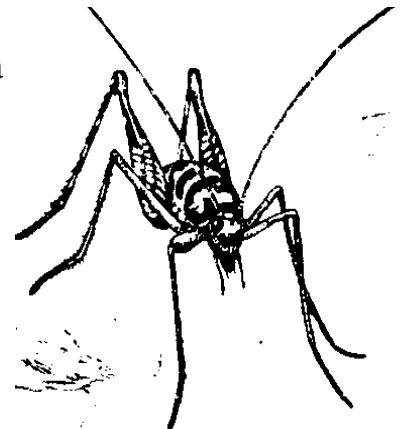
With the absence of plants, most organisms are either detritavores or carnivores. This limited productivity means that the total biomass of organisms is low and cave organisms are never numerous. Dark caves have two distinct but linked communities. The roof community may have bats and swiftlets and the parasites which feed on them. This community relies on journeys to the surface for feeding.

The cave floor community is more complex but relies upon the roof community for much of its food. The organic layer on the floor is composed of the waste products and corpses of animals from the roof as well as the floor. Woodlice, flies, beetles and moth larvae will feed on guano of insectivorous bats. The softer guano of fruit bats is consumed by cave crickets and cockroaches. The carnivores then feed on the guano eaters. These include spiders, assassin bugs, ants and centipedes.

Organisms have evolved very specialised adaptations, often quite bizarre, to the very stable, unchanging cave environment. General adaptations include a loss of pigmentation, partial or total loss of eyes, extension of sensory hairs or antennae and elongated legs.

3. Why Cave Ecosystems are Fragile

During their long evolutionary history, cave animals have reduced their capacity to withstand environmental changes. They have become very specialised to live in a habitat which is very stable. Through evolution, they have lost resistance to survive an environment which changes. There are no daily or seasonal climate variations and it is always dark. It's a bit like living inside an insulated box.



Many animals cannot withstand desiccation or temperature fluctuations. Hence the fauna is at risk of environmental changes which may appear to be very small changes to us. A study of adult cave beetles and cave cricket eggs found that as cave soil dried from 100% relative humidity to 99%, the mortality increased from near zero to almost 100%. (2) Just by making an entrance passage a little wider to allow easier entry we allow more air to circulate perhaps lowering the cave humidity and drying it out. A few footsteps may crush the few organisms living in the detritus of the cave floor or make it no longer suitable for the inhabitants.

Caves have very low animal population numbers to start with, there are not many of them. Again the biomass of animals may be 0.002 kg/m² in a tropical cave floor ecosystem which is extremely low but may be much lower again in the Yarrangobilly cave system.

When compared with the size of other ecosystems, cave ecosystems are very small. Many cave animals are known from one site only (endemic). Caves are "island" communities with few if any links to other caves so if organisms become extinct in one cave system, they cannot be recolonised from other caves.

4. Human Impacts

Caves ecosystems are based on a very small quantity of energy which can only support very few animals as shown by the biomass figures. It only takes a very small change to the quantity of energy to upset the balance of the ecosystem. Perhaps changes to the catchment upstream such as from the clearing of vegetation causing siltation of the cave stream bed or the diversion of water reduces the input of detritus washed in (food). Perhaps tourists to the cave drop a few crumbs from a Mars bar thus dramatically increasing the amount of energy for organisms, even a few microscopic flakes of human skin, which we are always shedding, will change the energy base of the cave ecosystem.

Increased foot traffic near entrances may accelerate the inwashing of fine sediments which covers former floor habitats. Lighting systems in tourist caves are an artificial source of energy which encourages the growth of algae which will impact on the food chain introducing more food to particular points along the path causing a redistribution of animals. A single person in a cave releases heat at a rate of between 82 and 116 watts. At Remouchamps cave in Belgium a single party of 87 tourists raised cave air temperature by 1.5 °C during a five minute visit. This rise in temperature creates a large change in humidity since warm air can hold more water vapour than cold hence the relative humidity falls dramatically, drying the cave atmosphere. Even the exhaling of carbon dioxide by tourists can have a serious effect.

Human impacts outside of the cave can have dramatic impacts inside. Agricultural activities in karst catchments contribute non-point source sediments, pesticides, herbicides, animal wastes and bacterial loads to cave streams. Point source spills occur along major roads in the United States of America where approximately 22% of the country has karst landscapes. Spills include cyanide, ink, diesel fuel and paint.

Vegetation clearing for grazing or controlled burning may reduce food sources for bats causing them to move to different caves if available. Bats have nursery chambers for rearing young. Just a few tourists may cause the bats to relocate to another cave. The original floor ecosystem relying on bat guano will no longer have an energy base for its food web. Many cave areas have been mined for limestone either destroying the whole system or opening it up to air movement and other disturbance.

Problems with urban development in karst catchments include sewage, landfill waste disposal and leakage from various underground pipes and storage tanks.(3)

Tourism does not stop with walks through caves. Caves are connected to the surface through cracks through which air and water move. There are many indirect effects caused by the need for infrastructure. This includes toilet facilities, roads, car parks, noise, buildings, electricity supply and changed surface drainage all of which will impact on the fragile cave ecosystem. The feedwater for stalactites may be drastically reduced as surface drainage is altered.

5. Management

Two areas need to be considered. Management of the cave itself and management of the whole catchment above the cave.

Surface water flows are critical. The catchment/cave water cycle is connected and caves depend on water. Creeks which start on the surface then flow underground are a link to the surface. The cave system relies on this for much of the food and energy brought into caves and the water quality. Changes to the water cycle such as the diversion of surface water for irrigation, urban use or roadside drainage may have a big impact. Water quality needs to be maintained. Pollution can have a big impact on cave aquatic ecosystems. The release of fertilisers and herbicides from agricultural activities can endanger cave ecosystems. Catchment vegetation is important. Vegetation intercepts rainwater which effects the quantity and quality of feed water available for caves.

Identifying the carrying capacity, or how many visitors a cave can take over a period of time before it suffers unacceptable levels of damage, is important. To minimise the impact of large numbers of people, standard rules in a show cave are no smoking or littering and no touching or breaking of cave features.

The number of visitors allowed on guided cave tours depends on individual caves but a maximum of 30 people has been suggested so all visitors can hear the guides and see what was being shown, and so that the guides could see and control their visitors. Each cave needs to be assessed on its own merits though and for safety or the protection of very fragile or rare formations visitor numbers may be restricted to 10 or less. (4)

An important cave management issue is the modification of cave entrances, either to widen them to assist entry or put gates or doors on them to restrict the entry of vandals or the entry of feral animals. The size of entrances, passage diameter, volume of cave beyond the entrance and the location of other entrances will all influence cave microclimate.(5)

The NSW National Parks and Wildlife Service categorises caves into the following:

Category 1. Public Access; caves in open areas which have been developed as public inspection caves either with a ranger or as a self guided tour.

Category 2.1 Special Purpose; caves managed to keep them as unmodified as possible consistent with some recreational use. At Yarrangobilly 2 caves have been set aside as scientific reference caves to protect their faunal communities. Access to these will be by bona fide scientific researches holding NPWS Scientific Consents. Other caves will only be entered in the company of Service staff. Levels of visits will be closely monitored.

Category 2.2. Outstanding Natural Value; also subject to limitations on numbers and frequencies of

visits but not as strict as 2.1 caves. Parts of category 2.2 caves may be classified as 2.1.

Category 2.3 Dangerous; No caves at Yarrangobilly have been classified as 2.3. Several entrances to the Glory Holes caves have been classified as 2.3 to avoid dangers to tourists from cavers above.

Category 3.1 Wild Caves; there are about 120 wild caves at Yarrangobilly which require permits from NPWS to enter.

Category 3.2 Unclassified Caves; these are closed while awaiting classification.

Plan of Management, Kosciusko National Park Yarrangobilly Management Unit

Objectives:

- * protect the cave systems from disturbance
- * protect the cave and stream biota and special plant communities
- * allowing public access for recreation (tourism)

The NP&WS has a dilemma in that it must protect the caves but at the same time allowing public access to this extremely fragile ecosystem. It is an ecosystem where people visitation is very concentrated in the one confined space, the cave. In other ecosystems visitor impact is spread over a larger area.

Yarrangobilly's visitation pattern is also very concentrated in time with over 25% of visitation occurring over the Easter break.

Cave Management practices include:

- * limiting access to only a few caves
- * restricting use to guided tours except for one self-guided cave
- * educating the public on cave fragility

Catchment Management Practices include:

- * not allowing camping near the caves and moving the present camping site at the old Yarrangobilly Village to an area outside of the caves karst catchment.
- * retaining the existing buildings and infrastructure of car parks, picnic areas and toilets due to their historic value
- * relocate the diesel generator out of the catchment.

* In the Yarrangobilly catchment, native eucalypt forest was cleared and replaced with pine plantations. Caves underlying the pine forests were found to have a high root biomass and were relatively dry. The pine plantation has now been cleared and the area partially regenerated with native forest and some cave formations have reactivated with additional moisture entering the system.

Cooleman Plain Management Unit

(Karst catchment upstream of Yarrangobilly.)

'Management of the Cooleman Plain area will take into account the vulnerability of the caves to disturbance, the complex drainage network of the caves and karst area, the sensitivity of the soils and plant communities to damage, the outstanding value of the Aboriginal sites and historic places (Cooleman Homestead) and the desire of considerable numbers of people to use the area for recreation.'

In the one area there are a number of separate features which we place value on which making management a complex task.

* To protect the caves, each cave is classified according to the Six Group Scheme and managed accordingly.

* There is an interpretive (educational) program to provide visitors with an awareness of the caves system.

* A priority list of management works required to protect or rehabilitate the site.

* Two new camping areas have been provided near the caves but out of their catchment because of the disturbance caused by the present campsite close to the caves (toilets, erosion, vegetation disturbance).

* Present car access will be replaced by walking tracks and the present car park rehabilitated.

Student Exercises

1. What is plant biomass and how do world averages compare between tropical rainforests and caves?
2. List some of the physical characteristics of caves.
3. What are the three major cave zones?
4. Why is energy important to an ecosystem and how does energy enter a cave ecosystem?
5. Name the two major animal communities in dark caves.
6. Name some adaptations of animals to the cave environment.
7. What has happened to cave animals through evolution which makes the ecosystem very fragile?
8. How may humans impact on cave communities?
9. Why is it important to manage the surface catchment over caves?
10. List management methods of the caves themselves.
11. List the 6 categories of caves according to the NP&WS.

More information on cave management can be found at :

* **National Speleological Society, (USA) see Cave Management Section <http://www.caves.org/>**

*** Management of the Karst and Groundwater - Mt Gambier**
<http://www.netserv.net.au/cwork/ackma99/grimes/manage.html>

Acknowledgement

1. The book "Caves-Processes, Development and Management", 1997 by David Gillieson is highly recommended and can be ordered from Allen & Unwin, P.O. Box 8500 St Leonards. 2065 (Aust), Fax: 02 99062218. Price \$45
2. R. Buecher, Monitoring the Cave Environment, 1995
3. T. Poulson, Research Aimed at Management Problems Should be Hypothesis Driven: Case studies in the Mammoth Cave Region, 1995
4. Ibid
5. E. Vale. 1995. Patterns of Visitation at Odonga Cave and Their Management Implications.