

## **PRINCIPLES OF KARST MANAGEMENT**

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### **INTRODUCTION**

The New South Wales National Parks and Wildlife Service (NPWS) is responsible for managing a number of areas that contain karst features. Nearly all of these areas are confined to steeply-dipping Palaeozoic rocks of the Southern Highlands, and are, typically, small lenses of limestone within valleys and gorges.

This paper deals with the management of these small karst areas by discussing their importance, defining the objectives of management, and outlining a systematic planning process that will enable management to achieve the objectives. The paper is condensed from "A Manual for Karst Management", which is aimed at providing the NPWS local on-site land manager with enough information and guidance to ensure the effective and responsible management of karst areas. The spectrum of zoning, cave classification and cave access parameters are documented to provide a basis from which managers can identify and define appropriate management for their specific localities.

### **A BASIS FOR MANAGEMENT**

Karst resources need to be managed because of:-

- \* their relative rarity;
- \* the high recreational demands placed on the limited resources, which include camping, bushwalking, guided cave tours, speleologist caving, rockclimbing and car access;
- \* the fragility and vulnerability of many of the features found in karst areas;
- \* the importance of the resource in terms of geological and biological features, archaeological, sub-fossil and fossil remains, and the role that these play in our understanding of the natural history and prehistory of the Australian continent.

### **OBJECTIVES OF MANAGEMENT**

The primary objective of management for karst resources administered by the NSW National Parks and Wildlife Service are:

1. to provide for the preservation of the natural features and natural ecosystems of karst areas;
2. to ensure that natural dynamic processes associated with karst areas are not unduly modified;

Secondary to these objectives are:-

3. to provide the opportunity for scientific study and research of the karst areas consistent with 1 and 2 above;

4. to provide opportunities for the appropriate recreational use of the karst resource, consistent with 1 and 2 above;

5. to provide opportunities for visitors to increase their understanding of the scientific and educational values of the karst resource, consistent with 1 and 2 above:

## **BASIC PRINCIPLES OF MANAGEMENT**

One of the major constraints of karst resource management is the vulnerability of subterranean cave systems to damage arising from developments or land use practices on the surface, and from inappropriate visitation practices. It is recognised that the surface and subsurface environments are intimately related and cannot be viewed in isolation from each other.

The constraints on management can be expressed as a series of principles which must be followed in order to achieve the Objectives of Management. They are related to a broad, ecological approach to karst area management.

They are:-

### **1. The Hydrological Principle**

Wherever possible, those systems that influence a karst area must be managed so that their natural flow regime and catchment are maintained in a pristine condition. No potential source of pollution or disturbance must be located upstream from, or within, the karst area. The free movement of surface run off water, infiltration, and the underground movement of water must be maintained in a natural state, and must not be influenced by contaminants.

### **2. The Meteorological Principle**

Air movement within caves, the "breathing" of caves, and the relative proportions of gases within caves must be maintained in as near to a natural state as is possible. The cave atmosphere must be protected from sources of pollution.

### **3. The Geological Principle**

Natural rates of sedimentation, weathering, erosion and landform evolution must be maintained so that the natural dynamic quality of the karst resource is retained. The geological record and the geomorphological features present must be protected from human interference.

### **4. The Biological Principle**

All components of the natural system must be managed so that the biological resources of the karst area are maintained in as natural a state as is possible.

## **MANAGEMENT PLANNING - A PREPARATION OF A SPECIFIC MANAGEMENT PLAN**

Faced with the responsibility of caring for an area of karst, the manager, apart from the daily administrative, supervisory and practical duties, is required to formulate a sound and reasoned

approach to protecting the resource. Planning, based on firm objectives, is recognised as the critical step in this process. For all karst areas under the control of the NPWS, a specific management plan will ultimately be prepared. A strategy, which will guide the preparation of the management plan is set out below as a series of steps.

They are:

1. Study of Karst Resources
2. Karst Resource Inventory
3. Assessment of Relative Function
4. Definition of objectives
5. Delineation of Constraints
6. Zoning
- 7 Identification of Conflicts
8. Identification of Management practices
9. Scheme of operations
10. Review

The planning strategy proposed is documented in detail below.

### 1. **Study of Karst Resources**

We have recognised that karst resources need to be managed, and that they are both special and fragile. No-one should presume to manage karst resources without first having obtained a sound and complete knowledge of their special nature and their special management requirements.

Failure to do so can only perpetuate the type of unsound and ad-hoc decision-making that has plagued cave "Management" for a very long time.

### 2. **Karst Resource Inventory**

All of the available resource data known for the karst area must be collected and catalogued, and The information used to identify scientifically important, representative or sensitive parts of the resource.

By reproducing important resource information in a readily interpretable manner such as an overlay system, the manager can quickly pinpoint sensitive or important localities and areas.

Data to be documented for the karst resource includes:-

- \* Geology
- \* Geomorphology

- \* Palaeontology
- \* Archaeology
- \* Sub-Fossils
- \* Flora
- \* Fauna
- \* Catchment Hydrology
- \* Visitor Use Patterns
- \* Climate (including cave Meteorology)
- \* Fire History
- \* Scientific Research (current)
- \* Exotic Species
- \* History
- \* Developments present
- \* Vandalism and Damage

In addition, for each cave in the area, the following should be assessed: -

- \* Potential gate sites
- \* Minimum equipment required to visit the cave
- \* Maximum/minimum numbers in visiting groups
- \* Recommended frequency of visits
- \* Recommended ratio of experienced to inexperienced visitors

Managers should not hesitate to utilise specialists or consultants (e.g. the Australian Speleological Federation) for this vital phase of data collection. The collection of resource data is considered to be an on-going, never completed process. Because of this, managers may have to make some decisions "by the seat of their pants" but these should, at least, be based on all of the available data. Interim management statements may be produced where little data is available for decision - making.

### 3. **Assessment of Relative Function**

After all the available information has been collected and collated, an evaluation of the relative importance and function of the particular karst resource is essential. This should be evaluated on a number of levels.

This is, at a:

- \* National and State Level
- \* Service Estate Level
- \* Service Area Level

and should include all the factors listed in 2 above.

#### (a) **National and state Level**

To fully appreciate the importance and function of the local karst resource, the manager must place it in perspective by relating it to all other karst areas in the Nation and State. Individual karst areas may then be managed within an overall strategy plan, which should have the potential for:

- \* identification of the most scientifically important karst resources;
- \* identification of the areas of greatest recreational pressure;
- \* an understanding of inter-relationships of karst areas (e.g. bat breeding and movement);
- \* closer liaison with other karst management authorities;
- \* the possibility of uniform or consistent karst and management principles being applied throughout the State.

(b) **Service Estate Level**

By considering the relationship of the karst area to all others within the Service Estate, the manager may strike a balance of preservation, conservation and recreation relative to the importance of the resources and the degree of protection afforded to those karst areas outside the service Estate. This step will also allow assessment of the adequacy of the service's sampling of cavernous areas, and application of uniform management policies and permit Systems for karst areas throughout the Estate.

(c) **Service Area Level**

Where there is more than one karst area within the boundaries of a National Park or Nature Reserve, subtle variations in management between these areas may achieve a satisfactory balance between the recreational demands and the priority objectives of management. These variations would reflect the relative importance and individual nature of each karst area within the Service Area.

4. **Definition of Objectives**

For each karst area, the objectives of Management will be determined based on the overall objectives of karst management within service Estate.

The Management of specific areas will reflect the analysis of the karst areas relative importance and function (see 3 above) in the preservation, Conservation and Recreation spectrum within which the service has to operate. However, the primary objectives will still hold for all karst areas controlled by the Service.

5. **Zoning of the Karst Area**

A zone is an expression of the objectives of Management over a defined geographic area.

To reflect the variability of management requirements throughout the karst area it needs to be zoned on a number of levels:

- (a) Surface Level;
- (b) Cave Level;
- (c) Within-Cave Level.

(a) **Surface Level**

The inclusion of the karst area within a Nature Reserve will generally provide adequate protection without special zoning's, whereas karst areas within National Parks will usually be placed within a Wilderness Area, Outstanding Natural Area, Strict Natural Area or (rarely) Natural Area or Development Area.

These are conventional zoning's currently used by the NPWS and they represent management's recognition of the importance of the resource within the Service Area. It is to be hoped that in National Parks most karst areas and their entire catchment will be afforded the protection of outstanding Natural, Strict Natural or Wilderness Area zoning's.

But as useful as conventional surface zoning's are, all they do to protect the karst resource is to influence access to and development on the surface - they cannot fully account for the variability and vulnerability of karst features. For example, caves of immense scientific importance may stand in the midst of caves being used for active tourism, which impart to the surface area the zoning of Development Area. The surface zoning, in such a case, does little to protect the isolated scientific gems.

Likewise, the karst area and its entire catchment may be zoned as Outstanding Natural, but there may be particularly vulnerable bat breeding sites within that zone that are not afforded adequate protection by the zoning. It becomes clear that further levels of zoning are required for more complex karst areas.

To overcome many of the limitations of conventional zoning's in relation to karst areas, a number of surface classifications have been proposed.

They are:

1. Closed
2. Restricted Access
3. Semi Restricted Access
4. Open.

These classifications are intended to allow the manager to define acceptable access and use of discrete areas, within the broad-area zoning, which require special management attention. To use the example cited above, a particularly vulnerable bat-breeding site may be identified on the basis of available data as an area which should be closed to visitors. It thus becomes a Closed cavernous area within an outstanding Natural Area.

For many karst areas, this level of classification may never be necessary, as long as protection of the surface, be it by Nature Reserve or a restrictive zone within a National Park, is adequate to protect the cave resources. However, this level of classification can be of great assistance to the manager in deciding (for example) on the desirability or location of access roads, walking trails, and other visitor facilities, or the desirability or nature of promotion and publicity given to the resources.

It is envisaged that most karst areas in Service Estate will fall within the semi-Restricted Access classification, allowing access to authorised speleological visitors only, and these areas, as a consequence, would not be promoted and would not be furnished with many visitor facilities. Promotion and facilities would generally be limited to areas deemed to be Open cavernous areas, due to low scientific importance or low vulnerability, or due to existing or proposed use for active tourism.

#### (b) Cave Level

By zoning, or classifying, individual caves on the basis of their resources and their relative importance, the appropriate level of protection can always be provided, irrespective of surface zoning's. To use the example cited above, the scientifically important cave in the

Development (Open) area may still be given the highest order of protection, and entry may be either prohibited or limited by permit.

Classification at the Cave Level must always be preceded by collection of all available data on each cave. Failure to collect those data may seriously compromise the value of important karst resources.

Six classifications at Cave Level have been proposed.

They are:

1. Closed Cave
2. Scientific Reference Cave
3. Limited Access Cave
4. Speleological Access Cave
5. Adventure Cave
6. Public Access Cave.

Classification of caves is the subject of widespread and continuing discussion among speleologists and cave 'management authorities, and these classifications will be used by the service until such time as a Nation-wide or commonly accepted system is adopted. They are fully defined in "A Basis for Cave Management" (Worboys 1977), and are further discussed below.

#### (c) **Within-Cave Level**

In most cases, management planning will not need to extend beyond the Cave Level of classification. However, it has been argued that in some cases there is a need to specify management requirements in greater detail. Just as the Cave Level of classification reflected and catered for variations between caves in any given karst area, so the within-cave Level reflects and caters for variations between chambers or passages in any given cave. By using this approach, particularly vulnerable sections of an otherwise resilient cave may be closed to visitors, and sections within large tourist caves may be set aside as controls for monitoring visitor impact.

Seven zones are proposed at this level. They are:

1. Closed
2. Scientific Reference
3. Limited Access
4. Natural Passage
5. Partially-developed Passage - no electric lighting
6. Developed Passage - electric lighting
7. Intensive Use Area

The latter three are of course only relevant to Public Access Caves. These zones are fully defined in "A Basis for Cave Management" (Worboys 1977).

#### 6. **Identification of Conflicts**

Once the objectives of management have been defined, management principles drawn up, and the karst resource zoned, the 'manager must take stock of all areas where existing

management practices or visitor use are in conflict with the objectives, principles and zoning. It is the resolution of these conflicts which must then take priority in management practices.

## **7. Identification of Management Practices**

The principle objectives of management for karst areas are to preserve natural features and natural ecosystems, and to ensure that natural dynamic processes are not unduly modified. Secondary to these, management aims are to provide opportunities for visitors to engage in scientific study and research, appropriate recreational use, and educational pursuits.

Accordingly, management practices will be based on the following:-

- \* action to resolve areas of conflict, and consequent rehabilitation works;
- \* implementation of a comprehensive zoning system of both surface and subterranean environments;
- \* the strict regulation of visitor access to caves;
- \* the encouragement of visitor awareness of the natural values of karst resources by interpretation, education and ranger-public contact, to reduce visitor-induced damage;
- \* initiation and maintenance of a process of data collection, monitoring and research as the solid basis for management of the resource.

Specific management practices are documented in section 6 below, to cover many of the planning areas the management will have to face.

## **8. Scheme of Operations**

Once the management practices have been identified, they will need to be programmed so that work can proceed in an ordered, planned and budgeted fashion. The scheme of operations is simply a scheduling of the work projects that have been recognised, but it is an essential step in the planning process.

## **9. Review of Planning**

The planning process must incorporate public participation vested interest group and Government agency involvement as an aid to more balanced decision-making. The manager will decide where, when and in what form this consultation will occur, however flexibility is the key factor here. Once the specific Management plan has been adopted, it will need to be reviewed on a regular basis in the future to maintain its relevance to the objectives of management. This is the dynamic process of management planning.

## **MANAGEMENT PRACTICES TO BE CONSIDERED**

Some of the common management practices that the manager encounters on a regular basis are discussed below. All other practices not discussed below must be considered in relation to the objectives of management.

## 1. **Conservation of Natural Systems**

### (a) **Management Resources Document**

This Document is a summary of information available on the karst area, which is regularly updated and amended to provide an essential reference document for the manager. It includes a bibliography of all relevant information which relates to the area, a summary of past management and visitor use (reviewed annually) and copies of any brochures or other service publications on the area. The Document is a key element in overcoming the shortcomings caused by staff transfers and changing management needs.

### (b) **Environmental Impact Studies**

All proposed works, developments or modifications within the karst catchment must be the subject of Environmental Impact Assessment. Each proposal may then be considered in relation to the pre-determined objectives and principles.

### (c) **Rehabilitation**

One of the first tasks of management will be the resolution of conflicts and rehabilitation of affected areas. Typical examples of this practice include:-

- \* rehabilitation of sites formerly used for waste disposal, extractive activities, buildings and other human disturbances;
- \* restoration of former roads and tracks, and areas damaged by vehicular access;
- \* the control of erosion from roads, tracks, batters, car parks and walking trails;
- \* the use of the most stringent soil conservation and anti-pollution measures available for all works and developments in the karst catchment.

The primary aim of rehabilitation is to retain or restore as much of the character of the local vegetation and landscape as is possible. All revegetation should be random at each site, using local, naturally-occurring species of trees and shrubs.

### (d) **Exotic Plant Control**

Wherever possible, exotic species must be eliminated from the karst area. This will require:

- \* assessment of the nature, extent and impact of exotic plants on the karst area;
- \* studies into methods of biological control of weeds on the karst area.

### (e) **Feral Animal Control**

A vigorous programme to eradicate pigs, goats, rabbits, foxes, cats and other feral animals from the karst area will be required. This may include a study of the impact on the karst area of feral animals that disturb ground cover.

#### (f) **Waste Disposal**

Sewage wastes must be removed from the karst catchment wherever possible. This will require:-

- \* location of toilet facilities outside the karst catchment wherever possible;
- \* use of pump-out septic system, or a piped effluent system to remove all wastes from toilet facilities that cannot be relocated outside the catchment;
- \* preparation of a comprehensive environmental impact assessment of any source of sewage or any system of sewage disposal proposed within the karst catchment;
- \* knowledge of the exact boundaries of the karst catchment, and of the geological formation, to assist in planning for visitor facilities.

#### (g) **Pollution Control**

Sources of stream pollution are not acceptable, within the karst catchment. This will require the manager to:-

- \* remove existing sources of pollutant spillage;
- \* locate any proposed potential source outside the karst catchment;
- \* implement the most stringent pollution control measures available for any source that cannot be relocated elsewhere.

#### (h) **Rubbish Disposal**

Dumping of rubbish and wastes within the catchment introduces a large potential pollution source through groundwater seepage, run off or dumping in dolines - This will require the manager to:-

- \* dispose of all rubbish outside the karst catchment;
- \* clean and rehabilitate former sites of rubbish disposal in the catchment;
- \* encourage visitors to remove all rubbish from the area;
- \* critically appraise any proposal to introduce a source or rubbish (such as a kiosk) to the karst area.

#### (I) **Fire Management**

Wherever possible fires must be managed carefully within the karst catchment. This will involve preparation of a Fire Management Plan to investigate:

- \* cessation of control-burn hazard reduction in all but those areas adjacent to investments, developments, and main roads;
- \* introduction of a "bulldozer-free" policy for all fires, by which active mechanical fire control would be limited to areas adjacent to developments and investments. control of fires elsewhere in the catchment will be by use of hand-tools or aerial suppression;
- \* research-oriented projects to define means of retaining a natural fire regime.

## 2. **Research and Inventory**

Effective management requires a continuing programme of research into, and inventory of, the natural resources of the karst area.

This should include:-

- \* detailed mapping of both surface and subterranean areas (with documentation of known cave resources taking priority over further exploration);
- \* research into hydrology;
- \* detailed studies of the cave biota;
- \* studies of cave meteorology (with particular emphasis on caves modified for public use);
- \* evaluation of the impact of visitation and development (surface and sub-surface);
- \* continued collection and analysis of data on volume and nature of visitor use;
- \* collection of data for cave classification;
- \* collection of data for interpretive and educational material and services, and for updating of the Management Resources Document.

Managers should not hesitate to insist that persons applying to carry out research in the karst area should conform to established priorities. This approach should ensure that approved research programmes will be of positive benefit to management at the expense of those that are more self-indulgent in nature.

### **3. Management of Visitor use**

#### **(a) Monitoring**

Management needs to establish an on-going system to monitor visitor numbers and activities throughout the karst area. This is vital to the planning of visitor control measures and facilities, and to assessment of visitor impact.

#### **(b) Access to Surface Areas**

Visitor access over the surface of the karst area will be largely determined by conventional zoning (such as Wilderness, Strict Natural) and by classification of the surface (such as Closed or Restricted Access Cavernous Area) .

##### **(i) Vehicular Access**

As a general rule, vehicular access over the karst area must not be permitted. This will require the manager to:

- \* review the need for all existing roads and tracks within the karst catchment;
- \* close and restore all non-essential routes, and securely gate those required as service trails;
- \* zone any routes within the catchment that must remain open to the public, as Access corridors, and ensure that vehicles cannot deviate from those routes;
- \* locate access routes outside the karst and its catchment wherever possible, allowing only pedestrian access in the karst area.

##### **(ii) Walking Tracks**

It is clearly inappropriate for the manager to site walking tracks in areas classified as closed or Restricted-Access, or in some semi-Restricted Access areas. The walking track facility is best suited to an Open cavernous area, where restriction of access is not critical to protection of the resource. Regardless of the surface classification, visitors should be encouraged to keep to walking tracks where they are provided.

### (c) **Access to Sub-Surface Areas**

Visitor access to caves can only be planned and managed effectively after the caves have been classified. But regardless of individual classifications, effective control of visitor use of caves requires the implementation of a Permit System. While this may be criticised as bureaucracy, the bureaucracy of the system is directly related to the importance of the resource.

#### (i) **Permits for Speleological Visits**

The permit system relies entirely on the karst area manager's understanding of the implications of cave access. It also relies on a close liaison between the manager and speleological groups.

A practical and effective system that relates directly to the objectives of management and the particular resource being managed will need to be prepared.

#### (ii) **Caves Classification**

Each classification at The Cave Level implies a different management requirement. These are as follows: -

##### 1. **Closed caves**

In the case of dangerous caves, no entry is permitted at all. In the case of those awaiting classification, entry is permitted only to experienced speleologists who have Service approval to carry out a classification study. A gate is required when possible.

##### 2. **Scientific Reference caves**

These are outstanding scientific samples. and to remain pristine they require very strict control. A gate is a prerequisite for this classification. visits would be very rare, and limited to experienced speleologists who are carrying out approved research in the cave under a current Scientific consent form. Feedback on this research is essential.

##### 3. **Limited Access Caves**

These caves require special management protection because of their quality or degree of difficulty. visits would be infrequent, party sizes small, activities very specifically defined, and only experienced and known speleologists would be approved. Feedback from the user groups is essential. A gate is required where possible.

##### 4. **Speleological Access Caves**

These are usually caves that do not require the high level of protection implied by the Closed, scientific Reference or Limited Access classifications. This is often due to the inferior or easily-explored nature of the cave. but may also be due to an inability to physically protect the cave by gating or other closure. This classification implies suitability for inexperienced and novice cavers, with experienced leaders. Access and numbers would follow each cave's physical characteristics. some limited facilities may be provided in these caves, such as paths defined by removable plastic lines, to protect fragile areas, but generally the policy should be one of minimum interference, to enhance the visitor's experience. For the more important caves of this classification,

visitors may have to be supplied with a track description to delineate sensitive areas and caving practices.

## 5. Adventure Caves

These caves are suitable for inexperienced (but properly equipped) parties. These may be non- speleological (e.g. scouts, youth groups etc.,) and the classification reflects a low scientific value, low degree of difficulty and low potential danger. A gate should, however, be erected where possible.

## 6. Public Access Caves

This classification implies a fairly concentrated use by non-speleological visitors, usually with no special equipment or clothing, and usually accompanied by a Ranger unless the cave is otherwise designed (such as the self-guiding caves at Yarrangobilly and Wombeyan). This type of cave brings with it a host of special management requirements. These may include:-

- \* decisions on the nature of inspections, e.g. will the cave be guided or self-guided? will inspections be limited to fully developed and illuminated passages or will they include some "wild" cave tours (as in Exit cave, Tasmania)? Will provision be made for the handicapped to participate in cave inspections?
- \* delineation of within-cave classifications to set aside (for example) Reference sections as "controls" to assess visitor impact, or to act as refuge for fauna, or closed sections to prevent visitor injury or cave damage.
- \* design and installation of a wiring/lighting system that will not disfigure, pollute or otherwise mar the cave, and which will not lead to growth of algae.
- \* constructions of platforms, paths and steps (or ramps for wheelchairs) in appropriate materials and designs that will not interfere with cave hydrology or morphology, or compromise visitor safety.
- \* identification of cave "carrying capacity" i.e. the level of visitation beyond which the cave and its ecosystem suffer an unacceptable level of damage, or beyond which visitor satisfaction significantly declines. (This will also influence the provision of visitor facilities on the surface) .
- \* where a developed cave is "inherited" from previous managers, restoration of any damaged areas, removal of algae, re-design of unacceptable track layouts, wiring/lighting systems, "chicken- wire", etc.
- \* provision of power for those show caves with electric lights. The need to choose between a diesel generator (with noise, fumes and pollution within the karst area) , or hydro (with modifications to stream flow and hydrology) or connection to Electricity Commission grid (with disturbance to pole-lines and easements, or excavations for underground lines) or solar generation (?).
- \* provision of visitor facilities on the surface such as picnic and parking areas, toilets, ticket office, kiosk. visitor centre, etc.
- \* comprehensive Environmental Impact Assessment of all the above proposals.

At all times, when making decisions regarding public access caves, the manager must bear in mind that the primary objectives of management pertain to preservation of natural resources. Our karst areas are seen to be more of a scientific educational resource than a revenue-earning resource. Accordingly management decisions should at all times err towards conservation values rather than economic or recreational values.

(d) **Visitor Protection**

To minimise risks to visitor safety the manager should:-

- \* ensure that wherever practical undeveloped caves are gated, or at very least sign-posted to discourage entry by inexperienced and unauthorised visitors.
- \* scrutinise visiting speleological groups to ensure they have at least the minimum equipment specified for the caves they are authorised to visit.
- \* classify particularly dangerous surface areas, caves or passages as Closed, and label them accordingly.
- \* route walking trails and Access Corridors away from dangerous areas.
- \* design routes through public Access Caves to avoid slippery floors, excessively gloomy track lighting, injury from roof decoration, and to separate visitors from all electric installations.
- \* advise visitors on sensible apparel for cave inspections (especially for "wild" cave tours) and for bush-walking in the karst area.
- \* develop active liaison with nearby speleological groups in regard to assistance with emergency rescues from caves.

(e) **Day Use and Overnight Accommodation**

As a general rule, camping and other forms of overnight accommodation, should not be permitted in karst areas, due to the attendant problems of waste disposal, rubbish, fire destruction of ground cover and vegetation, and difficulties of visitor supervision at night.

The need for overnight accommodation and day use areas should be assessed on the basis of data on visitor use patterns. Wherever possible, such areas should be located outside the karst catchment. If they cannot- be located outside the catchment, stringent pollution control, soil conservation, fire control and karst protection measures must be instituted.

(f) **Materials Design and Research**

When structures such as cave gates, or facilities such as car parks, are planned for the karst area, they must be the subject of environmental impact assessment, and research into appropriate materials and appropriate designs, so that all constructions will be compatible with the karst environment and the objectives of management. of particular concern in such cases are:-

- \* staining and introduction of trace pollutants into caves from gates, meshes, handrails, wiring, lighting, interpretive devices, etc.

\* impeded infiltration due to impervious paved surfaces on the karst area, e.g. car parks, paths.

\* algal growth on paths and speleothems in developed passages due to poorly placed or poorly designed lighting.

### (g) **Interpretation**

With careful planning, interpretation stands to help resolve the conflict between protection of irreplaceable resources and continued public use of those resources, by enhancing visitor experience and perception of the karst resource.

Interpretation of the karst area should aim to give visitors an integrated perception of the ecological and physical resources of the karst area, as well as the aesthetic attractions of caves. Certain fundamental environmental concepts need to be dealt with, including:

- \* the biological, geological and chemical processes that have shaped the landscape and (in most cases) are still active;
- \* the complex inter-relationship between surface and sub-surface environments;
- \* the vulnerability of the cave ecosystem;
- \* the importance of specialised life forms in caves;
- \* the value of conservation of natural ecosystems and features of man's understanding of his environment.

The manager must take care to avoid a total preoccupation with caves, which are, after all, only one component of the karst landscape. surface manifestations of the geomorphology, geology and biology of the karst area should also be interpreted for the visitor. Similarly sociological and historical aspects of the area must be considered.

A comprehensive Interpretation and Education Plan should be prepared for the karst area to include details of:-

- \* proposed interpretive displays;
- \* proposed high-quality interpretive brochures and booklets;
- \* an interpretive programme (perhaps using seasonal staff during peak periods of visitation);
- \* interpretive methods to be used in developed caves (to include consideration of guided versus self-guided, mechanical devices versus static displays, appropriate designs and specifications for lights, gates, wiring and other devices) .

### (h) **Publicity**

In order to adequately protect the karst resource, the manager must have some control over the nature and extent of publicity that the karst area receives. Publicity of the presence of caves and their contents may appear in a number of forms including: -

### (i) **Public Media**

In most cases there is no need to advertise caves in service areas through radio, television and/or newspaper media bearing in mind that the primary objectives of management place conservation before the pursuit of economic returns .

These media may, however, be used to publicise management decisions made for well-known karst areas. For example, decisions to remove camping, close access routes, cease to operate a

show cave, and so on, may incur some public wrath. In such cases, the media should be used to emphasise positive aspects of those decisions, such as a new camping area (outside the karst catchment), new walking trails, and so on.

#### (ii) **Tourist Promotions**

Local tourist promotion organisations may publicise karst areas in service estate as yet another addition to the "List of Local Attractions", with both verbal description and depiction on a map and signposting along roads. Thus a karst area may receive widespread publicity without any input or control from management. The manager should liaise with local tourist promotion organisations to ensure that any publicity of the karst area is of a nature consistent with the objectives of management and at a level consistent with the service's ability to control visitor use.

#### (iii) **Maps**

Cartographers have the task of depicting both natural and cultural features of the landscape and may not hesitate to depict and label caves or karst features where they exist. When these maps are available to the public, the sight of a closed depression marked "Sinkhole" adjacent to the highway may prove irresistible to the visitor, who would otherwise have been oblivious to its presence. The previously unknown sinkhole suddenly has a high non-speleological visitation, with all the attendant problems of tracks, litter, debris and fire. The manager must seek to prevent this kind of unwitting publicity by liaison with the mapping agency before local maps are published.

#### (iv) **Speleological Publications**

It is not altogether uncommon for speleological publications to proclaim discovery of a new passage, a new cave, a new cave system, a new bone deposit, etc., in karst areas within Service estate. Undue publicity and exhortation may create a demand among less responsible readers to experience at first hand, the new discovery. If management has not had the time, the forewarning, or the materials to provide adequate protection for the newly-found resources, they may well be destroyed or irretrievably damaged.

The onus rests with both speleological visitors and the manager. Responsible visitors should immediately report any new find of significance to the local manager, and should not publicise it in any way until its adequate protection is ensured. The group will then not only have the kudos for the discovery, but will also have the satisfaction of having made its protection possible. It is up to the manager to have close liaison with all visiting speleological groups, and to insist that no data be published without adequate vetting and relevant approval as a basis for protecting the resource. The manager must also act quickly to secure newly-found resources, by zoning and gating where necessary. Until they are fully documented, appraised and classified, any new passage, cave or system should remain "Closed, awaiting classification".

## **CONCLUSION**

A systematic planning process has been outlined that provides karst area managers with a sound and rational basis for the management of karst resources. The planning approach that has been identified includes ten basic steps:

1. Study of karst resources
2. Karst resource inventory
3. Assessment of relative function
4. Definition of objectives
5. Delineation of Constraints
6. Zoning
7. Identification of Conflicts
8. Identification of Management Practices
9. Scheme of Operations
10. Review of Planning

## **REFERENCE**

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