

SOME PLANNING REQUIREMENTS PRIOR TO FOREST INDUSTRY DEVELOPMENT OF CARBONATE LANDSCAPES

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Resum

Per a qualsevol projecte d'aprofitament dels recursos naturals és fonamental un correcte inventari dels possibles perills per al medi ambient. L'aprofitament dels paratges calcaris es complica per la complexitat morfològica i de drenatge que resulta del substrat geològic. De l'establiment d'un inventari correcte i de mesures per la protecció ambiental en surt una posició crítica envers el millorar l'ús d'aquestes zones per la producció de fusta a llarg termini. Crítica igualment ho és envers la protecció i el manteniment de molts d'altres recursos naturals i d'altres oportunitats oferides pels paratges calcaris. Aquest treball proposa un conjunt de procediments adequats al desenvolupament de paratges calcaris semblants als de Tasmània, particularment al desenvolupament de zones, abans remotes, on és probable que s'hi estenguin les activitats forestals en els anys vinents. Aquests procediments destaquen la protecció dels recursos del sòl i de l'aigua, cercant la protecció dels valors econòmics, ambientals, científics i d'esbargiment.

Abstract

An adequate resource and environmental hazard inventory is fundamental to any natural resource development project. Development of carbonate landscapes for forestry purposes is complicated by the landforms and drainage complexities that commonly arise due to the solubility of the geological substrate. The development of appropriate inventories and measures for environmental protection are both critical to optimising the long term use of such areas for wood production. They are also critical to protecting and maintaining the many other natural resources and other opportunities offered by carbonate landscapes. This paper proposes a set of procedures appropriate to the development of carbonate landscapes similar to those in Tasmania, and in particular to the development of previously remote areas where forestry development is likely to extend in the next few years. These procedures emphasise the protection of soil and water resources in seeking to safeguard economic, environmental, scientific and recreational values.

Preamble

Karst environments are characterised by landforms such as sinkholes and caverns which primarily result from the solution of a soluble rock such as limestone or dolomite by natural waters. In such a landscape difficulties may be posed for developers due to an absence of surface water storage; in the maintenance of ground-water supply and ground-water quality; as a result of ground surface instability; and because of the other resource utilisation opportunities with which their own activities must

co-exist. The soil mantle commonly varies due to such factors as topography, environmental change over the geologically recent past and the possible deposition upon the karst surface of sediments derived from another location. Some residual limestone soils are sensitive to erosion and may take centuries or more to recover if eroded. The maintenance of the natural movement of water, air and food supply into caves is basic to maintaining many of the various values which karst offers for economic, scientific, educational and recreational users. An adequate inventory of each karst landscape together with an understanding of the processes involved in a karst landscape is also an important

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factor in optimising the long term use of any karst area for purposes of wood production.

This paper proposes a policy and a set of specific procedures appropriate to the development of karst lands similar to those in Tasmania for forestry purposes. Sound planning is essential to forestry operations in any area (Forestry Commission 1981). The proposals outlined in this paper are geared to the role of an hypothetical government agency responsible for ensuring the proper conduct of such developments. In the Tasmanian context, fire is an important tool in forest management hence some attention is given to this in addition to the other aspects of forest management with which overseas readers may be more familiar. The development of a road and track network in virgin native forests planned for logging is also an important part of Tasmanian logging.

1. A draft Karst policy for the «X Y Z Forestry Department»

(a) Policy goals and objectives

- I. to aid in the identification and protection of the natural resources which are offered by the karst landscapes which are under the control of the forest authority and in particular karst water, soils, caves and life forms;
- II. to ensure that any presence of karst in areas likely to be subject to forestry operations will be recognised;
- III. to ensure that assessment of each karst and the probable impact of forestry operations becomes a routine prelude to logging;
- IV. to provide a mechanism for the identification, ranking and management of caves and other karst landforms in areas of government land and such areas of private land as may fall within the influence of the authority;
- V. to minimise the physical danger to which forestry workers may be exposed when working upon karst landscapes;
- VI. to minimise economic losses (e.g. by road failure) caused by inadequate management;
- VII. to responsibly contribute to wider endeavours to improve the management of karst generally.

(b) Terminology

For the purposes of this document the following definitions are assumed:

Karst: a landscape generally formed on limestone or dolomite rock; the result of a high degree of rock solubility in natural waters;

characterised by various distinctive landforms.

Mantled Karst: a karst landscape in which the soluble bedrock is mantled by an accumulation of materials which have been transported from elsewhere by the agency of running water, frost, glaciers, wind, gravity, or other influences; these deposits form the parent material from which local soils have been derived.

Bare Karst: a karst landscape in which the soluble bedrock is not mantled by any transported material and in which the only available mineral base for soil development is the insoluble residue remaining after solution of the bedrock.

Karst Water: all water in a karst landscape including seepage and stream water.

Karst Catchment: an area which may neither be underlain by karst rocks nor exhibit any karst landforms but which forms the catchment of streams which flow to a karst area.

Karst Reserve: a reserve to protect a karst watercourse, or other karst feature, or to otherwise aid in karst forest management.

(c) Legal basis for this policy

This will vary from country to country but is likely to involve statutes related not only to forestry operations in particular, but also to Waters, Pollution, Highways and Roads, Archaeology, Scenery Preservation, Wildlife Conservation, Public Safety, Health, Fisheries, Recreation and other matters. These should be identified and their implications specified in the development of a karst management policy.

2. General strategies

(a) To establish formal mechanisms for the routine assessment of karst in areas to be subject at some time to forestry operations, and to oversee data gathering, devise management, operational and restoration procedures and monitor the results of karst management programmes. Within the authority one approach might be to establish some form of consultative group, which would meet regularly, and which might consist of:

- I. senior authority officer concerned with operations,
 - II. senior authority officer concerned with management,
 - III. senior authority officer concerned with environment protection,
 - IV. a karst scientist,
 - V. District Foresters as appropriate
 - VI. a representative of recreational caving groups.
- (b) To facilitate the compilation of karst inventories by:
- I. authority staff,
 - II. consultants,
 - III. formally engaged volunteers (as appropriate)
- (c) To establish and monitor a sequence for the investigation of karst areas - e.g.
- I. karst area identification,
 - II. baseline monitoring as appropriate,
 - III. deliberate search for karst landforms within each area,
 - IV. detailed recording of each inventoried site,
 - V. co-ordination, conduct of or support for any other necessary research,
 - VI. assessment of management requirements,
 - VII. implementation of management programs.
- (d) To provide maps of karst area locations to regional and district officers to alert them to possible karst implications in their area; and to maintain a central register to be called upon for detailed information when specific logging plans are prepared.
- (e) To co-ordinate general resource management within karst forests including produce such as earth materials.
- (f) To facilitate communication between the authority and other karst users.
- (g) To take such steps as are necessary to safeguard karst resources on authority land, including where appropriate the designation of specific sites as karst reserves or the limitation of access to sensitive sites through gating or other means.
- (h) To review and issue delegated management authorities to other bodies where appropriate. This would involve the prior review of proposals for use of karst features on authority land, including the development of educational facilities, the acquisition of caves for tourist development and the use of caves by adventure tourism companies. In rare cases it might also be necessary to consider agreements with recognised bodies such as the relevant Speleological organisation for short term control of particular caves gated by the authority although ideally management should remain with government.

- (i) To prepare and implement karst forest management plans.
- (j) To manage other use of karst features including recreational use of caves in accordance with the forest management plan.
- (k) To maintain cave and surface landform records within the context of (d) above. Locational information should be locked and generally unavailable to the general public and uninvolved government employees except insofar as may appear appropriate to the consultative group in specific cases after consultation with other involved parties such as the Speleological organisation.
- (l) The authority will not advertise cave locations or otherwise encourage access to caves except in accordance with the specific initiative of the consultative committee following assessment of their values for particular purposes and the compatibility of those different uses.
- (m) The authority will demand that persons visiting authority controlled sites, particularly caves, adhere to the spirit of the Speleological organisation Code of Ethics with respect to their impact upon the area.
- (n) To specify appropriate responsibilities at forest managerial and operator/contractor levels.
- (o) To facilitate the transfer of specific sites to the administration of alternative management authorities in any cases where the conservation significance of a particular site is high and the intensity of management required exceeds that which can reasonably be provided by the authority.
- (p) To monitor and review the effectiveness of the foregoing procedures.
- (q) To support research into karst environments.

3. Implementation

(a) Compilation of a data base

To enable better management of its karst forests the authority needs to gather two types of information. The first type of information consists of inventories of karst landforms and resources. These should be prepared for any areas which are likely to be subject to intensive forestry operations. Detailed operational planning and management can then be guided by these inventories. The second need is for information on the natural processes within the karst areas, upon the basis of which attempts may be made to gauge the magnitude of the impact of forestry operations. Karst areas generally facilitate the gathering of more complete quantitative data on overall erosion rates than do

most other types of landscape hence more useful information with direct relevance to management can be compiled.

I. Karst inventories

(a) The following inventory sequence will be followed:

1. The karst area location maps provided to regional offices will be consulted by them as a matter of course and as early as possible in forest planning, and where this or some other factor gives reasonable grounds to believe that forestry operations may impinge upon karst lands or karst catchments the consultative group will be informed of this possibility.
2. Where the likely extension of forestry operations in or close to karst areas is confirmed, inventory procedures will be initiated involving firstly the location of karst landforms and secondly an assessment of site significance.
3. The inventory procedure will be initiated within the authority and co-ordinated by a designated authority officer.
4. Each site will be classified by the inventory coordinator after consultation with appropriate parties and subject to verification by the consultative group.
5. The consultative group will be responsible for the preparation, implementation and monitoring of surface management plans, and any detailed cave management plans.
6. Consideration will be given to the feasibility and desirability of integrating this data base with that of the relevant speleological organisation.

(b) The following inventory procedures will be adopted:

1. Surface landform details and specific cave details will be recorded on standard proformas.
2. These specific site inventories will not be considered complete until all spaces are notated.
3. There will be a need for regular review and updating of the proformas.
4. A permanent reference file will be established and retained only at Head Office and will include such things as:
 - inventory form
 - history
 - access details
 - cave maps
 - photographic record
 - entry records
 - management records
 - any other relevant data.
5. Cave entrances will be physically tagged with a corresponding file number in all cases where the continuation or otherwise of the cave cannot

readily be ascertained from the surface. This numbering system will be integrated with that of the relevant speleological organisation.

6. Inventory data will be synthesised to provide the following data for management planning:
 - I) the distribution of karst land forms, including the location, extent and directional trend of cave development;
 - II) the pattern of apparent karst drainage, preferably with confirmation by water tracing experiments;
 - III) the nature, thickness, stability and transmissivity of the surficial mantle;
 - IV) the significance of the sites with respect to the values listed on the inventory form;
 - V) the proposed classification of each site.
 7. Detailed operational planning will not be implemented until stage (6) above has been attained.
 8. Monitoring will be maintained with respect to the discovery of any new sites, new developments regarding the significance of known sites, and the effectiveness of management strategies implemented.
- (c) The authority will encourage liaison and communication between itself and other karst users by:
1. Ensuring that both karst scientists and also recreational cavers are included in the consultative group, together with such other interests as may be appropriate in particular circumstances (e.g. water supply authorities; farmers).
 2. Encouraging direct communication between other karst users (e.g. karst scientists and forestry companies) with the aim of minimising unnecessary adverse impacts and adversary relationships.
 3. Appointing local and head office contact persons who will be responsible for initiating action on karst management issues and to liaise with various karst users.

II. Baseline data and monitoring procedures

1. The authority recognises the need for baseline data on undisturbed karst areas against which the impact of logging can be judged.
2. To this end the authority recognises that there exists a need to investigate the effects of forestry operations upon karst environments and in particular upon the stability of karst soils, upon the quantity, distribution and character of cave waters and upon cave organisms.
3. The authority will make every reasonable attempt to fully characterise a number of carefully selected and apparently representative drainage basins, caves and other sites; the need to record such information on a stable and long term basis is acknowledged.

4. The authority will also consider the establishment of experimental catchments to be harvested and monitored following an initial period of data collection under undisturbed conditions.

(b) Protection of soil and water values

Residual limestone soils on bare karst are commonly thin, slow to form and easily eroded.

While trees are a renewable resource, the soil in which they must grow is not, at least over a human time scale. Thin limestone soils cannot sustain pressure. On the other hand, some of the soils which form on some transported materials carried by natural agencies onto karst landscapes («mantled karst») are sufficiently thick to sustain some erosion, and even effect a moderately rapid recovery. But even here though there is need for caution. In both situations the soil mantle performs a vital role in regulating the flow of water which infiltrates underground and also determines its chemistry (important for instance in maintaining underground water supplies and in maintaining the attractive character of cave decoration and enabling the continued existence of cave fauna). The soil grains eroded from hillslopes might conceivably even block underground drainage routes in some circumstances, diverting streams and drying up springs or perhaps causing further erosion elsewhere by diverted water. The authority recognises that:

- I. The maintenance of natural water flows and storages and the protection of soils is a fundamental requirement.
- II. The possibility of soil erosion being caused by progressive site degeneration due to fires, insect and disease infestation and poor vegetation cover due to low soil nutrient status means that particular care needs to be exercised in forest management and monitoring in karst areas.
- III. Disturbance by machinery is likely to be the most common cause of erosion and warrants particular attention.
- IV. Limestone derived soils («bare karst» soils) are highly susceptible to erosion and if lost will not redevelop over a human time scale; transported mantle soils («mantled karst») may pose a lesser risk in some cases, but because of the karst context no covering mantle should be managed as if posing less than a moderate erosion risk even if soils formed on its dominant rock constituent are normally considered of low erosion risk.
- V. Every effort will be made to ensure that steep exposed slopes and long exposed slopes are minimised; to adequately drain site works to prevent erosion and cave siltation; and to

take every care to avoid landslides and other forms of slope failure which may damage karst soils and silt karst streams or block the exchange of air between caves and the outside environment.

- VI. Works which will disturb the ground surface will be timed to coincide with periods when the risk of heavy rains is least; burning plans also need to minimise the risk of post-fire erosion.
- VII. Because clearfelling may produce higher erosion potential than selective extraction, the latter may be preferable in sensitive karst areas.
- VIII. The degree of site disturbance will be a function of the type of logging system used. Unplanned operations will not be permitted in karst forests or in sensitive karst catchment areas.

(c) Karst Reserves

I. The functions of karst reserves are to:

1. Maintain infiltration flows to underground conduits.
2. Maintain streamsink flows to underground conduits.
3. Filter out unnatural sediment and logging debris.
4. Ensure streambanks are not destabilised.
5. Give protection to shallow or otherwise delicate caves and underground watercourses.
6. Maintain stream shade and natural water temperatures to protect aquatic fauna.
7. Minimise ionic imbalance in karst waters which might adversely affect fauna and speleothems.
8. Ensure an adequate food supply is available for those cave species which feed outside and bring energy back to cave food chains.
9. Afford protection to significant surface karst plant and animal communities.
10. Prevent the clogging of air exchange between caves and the external environment or the opening up of new pathways for air movement.
11. Provide a mechanism for zoning hazardous areas «off limits» to forestry workers.
12. Protect the recreational, scientific or other potential of particular surface karst features.

II. Karst reserves should be established in the following cases:

1. All surface stream channels should be managed as «Defined Streams» irrespective of the length of the surface portion of their cour-

se, and irrespective of whether the channel conducts a permanent intermittent or ephemeral flow; any watercourse lying in a karst catchment area where logging over an area in excess of 20 ha is to occur within 2 km of the karst should also be defined.

2. Within reason, where natural standing water bodies occur.
3. Where sinkholes or other karst landforms have been assessed as significant to the local drainage.
4. Where thin cave roofs or unstable terrain susceptible to collapse makes logging operations potentially dangerous to a significant cave or to forestry workers.
5. Where the transmission of shock waves may cause damage to a significant cave.
6. In such other cases as may arise.

III. Appropriate sizes for karst reserves in particular circumstances involves all that land:

1. Within 60 metres of an active surface watercourse or within 40 metres of an inactive watercourse.
2. Within 40 m of any natural standing water body of significance.
3. Within 40 m of any sinkhole assessed to be significant.
4. Within 100 m of any significant cave.
5. Of such size over the roof of any significant cave as is necessary to protect the cave structure or any cave contents susceptible to vibration or other damage (eg. dehydration).
6. Of such size as is necessary or desirable to safeguard forestry workers in unstable or otherwise hazardous country.
7. These proposals represent standard minimum sizes adequate to ameliorate adverse environmental impacts when development is to occur. It is recognised that in some cases it will be appropriate to reserve larger areas (e.g. protection of complete drainage basins where the retention of baseline sites for scientific study or preservation of very important cave systems is required).

IV. Restrictions on karst reserves

1. No tree should be felled within any karst reserve, nor into any karst reserve.
2. Fire should not be permitted in any karst reserve (within reason).
3. No logging machinery or roads should enter karst reserves other than at designed and constructed stream crossings if these are totally unavoidable.
4. All care should be taken to minimise ground

disturbance in the construction of stream crossings.

5. All care should be taken to ensure that human wastes, petroleum products, litter, herbicides and other pollutants (particularly eroded silt) do not enter karst reserves.

(d) Timber Harvesting

- I. No roading or logging operation will commence until completion of the karst inventory and assessment procedures.
- II. Roading operations will take into account the need for particular care to be taken in karst areas; road planners will be familiarised with the contents of this draft policy and necessary considerations for infrastructure development (Kiernan, this vol.).
- III. Snig track planning should be fully integrated with road planning so as to minimise soil disturbance.
- IV. Forest operators and contractors and (authority) field officers who are active in karst areas will be familiarised with the general contents and intent of this policy, and particularly operational guidelines to inform them of ways in which they may minimise their adverse impact upon the karst and also minimise the risk to their personal safety which may stem from working in such an environment.
- V. In view of the risk inexperienced persons put themselves to in entering unknown caves, forest workers will be discouraged from entering caves; they will be encouraged to report their existence.
- VI. No camps or living quarters will be established in karst forest areas, except where an existing settlement is present in which case all care should be taken to minimise any detrimental environmental impact even if the impact of other development is already severe. Any new development in such circumstances should aim to reduce the adverse impact of earlier development wherever possible.
- VII. All waste materials should be removed from karst areas. No dumping of refuse or ballast in sinkholes or other topographic lowpoints will occur.

(e) Forest Maintenance

- I. As the soil must provide the medium for growth of forest crops all care will be taken to ensure that it is adequately protected from excessive compaction and redistribution by machine or erosion.
- II. While most of Tasmania's commercial native forests are ecological pioneers which require

a mineral seed bed and freedom from competing vegetation to establish, the quantity and chemistry of seepage and other waters may be changed as a consequence of regeneration burning. This may have adverse effects upon caves. Karst soils may suffer erosion and nutrient volatilisation. Slash burning should therefore not be carried out within bare karst areas steeper than about 15°, in close proximity to karst reserves or significant sinkholes, or on thinly mantled karst. This may entail the prior preparation of firebreaks.

- III. Because the evolution of each karst environment is strongly influenced and controlled by the surface vegetation, and because insufficient data is as yet available on the relationship between tree species and ground water distribution and chemistry to demonstrate that cave decoration or biota will not be adversely affected, no major changes of forest type will be undertaken over significant caves, or in significant cave catchments. Pine plantations appear to have seriously dried out caves in some cases. There may be a case for delaying changes on bare karst or thinly mantled karst other than those which are of assistance to the gathering of process data.
- IV. Because of the likelihood of increased evapotranspiration losses ultimately diminishing the supply of water to karst caves, regrowth denser than the natural cover will not be encouraged over known decorated caves.
- V. Where slope stability is in question, advanced seedlings of fast growing species should be established after cutting.
- VI. Fire management plans should aim to prevent fires extending onto bare karst or any karst reserve, the implications of karst should be considered in planning access routes, back-burning and other procedures.
- VII. Care is required in the management of animal pests because of the specialised conditions under which cave organisms have evolved and the sensitivity of cave ecosystems to disturbance.
 1. Where toxic substances are used to minimise browsing by vertebrate animals or to inhibit insect attack or where herbicides are used, all cave entrances and karst streams should be avoided.
 2. Great care is required to minimise the loss of those elements of the cave food web which feed outside as this may have grave implications for cave species with a low number of individuals.
- VIII. The thin soils and rapid infiltration of moisture in karst areas may impose water stress, as a consequence the tolerance of tree and

shrub species to a certain degree of attack by root rot fungi (e.g. by *Phytophthora cinnamomi*) may be lower in karst areas. This may be significant both to some residual stands (e.g. on karst reserves) subject to microclimatic change due to adjacent clearfelling, and also to successful regeneration; particular care is warranted with respect to sanitary procedures. Although some evidence suggests that high calcium levels may be antagonistic to *Phytophthora* there may be little calcium in the soils of mantled karst.

- IX. Management of pest problems should receive high priority in areas of unstable slopes or severe soil erosion.

(f) Management and Protection of Caves

- I. Because cave decoration, certain cave deposits and cave biota are easily damaged by human traffic and because human visitors commonly inflict the greatest damage in this regard, the authority will develop and implement specific management strategies for individual caves: all management decisions will be the responsibility of the consultative group.

A specific cave management policy will need to be developed.

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