TIMBER HARVESTING ON KARST LANDS: SOME OPERATIONAL CONSIDERATIONS AND PROCEDURAL REQUIREMENTS

by Kevin KIERNAN (*)

Resum

En emprendre el desenvolupament de zones càrstiques, els tècnics en gestió forestal es troben amb la preocupació pel medi ambient i amb uns especials problemes pràctics. Durant la fase operacional cal fer uns acurats ajusts. S'ha de parar especial esment al drenatge i al disseny, localització i manteniment dels camins. És necessari prendre precaucions especials durant l'extracció de troncs i en la localització i ús de les instal·lacions de càrrega de troncs. Aquí avançam unes propostes estudiades per reduir l'impacte ambiental associat amb el procés de tala als boscos de les zones càrstiques de Tasmània. Aquestes propostes poden tenir una aplicació més ampla o adaptar-se a medis càrstics onsevulla s'emprengui l'activitat fustaire.

Abstract

The forest Manager is confronted by special environmental concerns and practical problems in seeking to develop karst areas. Carefull adjustments need to be made at the operational stage. Particular attention must be given to drainage and road design, road location and road maintenance. Special precautions need to be taken during log extraction and in the location and utilisation of log loading facilities. Specific proposals are advanced that have been designed to minimise the adverse environmental effects associated with the process of timber harvesting in Tasmanian karst forests. These may have wider potential application or may be adaptable to karst environments elsewhere where logging activity is undertaken.

Karst landscapes result from the dissolving of soluble bedrock by acidic natural waters, and are characterised by predominantly underground drainage systems; underground caverns; surface depressions (sinkholes); dry creek beds; large springs; sinking streams and other landforms. Because such landscapes commonly offer a variety of economic, scientific and recreational resources, and because these are often highly sensitive to disturbance or damage, forestry operations must be conducted with extreme care. At all times very high priority should be accorded to:

— protection of the soil and its ability to store and transmit water;
— protection of water quality and the natural drainage pattern - if streams become silted it could lead to caves being blocked or underground water supplies being damaged perhaps many kilometres distant;
— protection of the natural processes or airflow between caves and the outside world;
— protection of a zone of natural vegetation around cave entrances - cave dwelling organisms may be dependent upon this for their food supply.

Roading

(a) The principal environmental concerns in karst forest roading lie in the risk of soil erosion; blockage of underground drainage channels by sediment; drainage diversion; cave air flow diversion; increas-

(*) Department of Geography, University of Tasmania (formerly Division of Engineering and Operations, Forestry Commission, Tasmania).

ing public access to sensitive caves; overstressing thin cave roofs; diminution of water quality; and structural damage or damage to cave decoration by shock wave production during construction or by vibrations during road use (Kiernan 1984).

(b) The practical problems posed for the roading authority by karst include the presence of deep rifts in the bedrock or complexly fluted and undercut surface outcrops; ground surface instability including occasionally the possibility of collapse or washout; road subsidence due to sinkhole development (sometimes actually induced by the drainage changes caused by the road itself); and difficulties with highly irregular bedwork topography leading to unpredictable foundation depth (and strength) beneath overburden. Where sudden collapse has occurred, it tends less often to be due to bedrock failure than to the failure of overburden after fines have been flushed out of it and into hidden solution cavities in the limestone (Aley et al 1972, Kiernan 1984).

(c) The possible hydrological and water quality impacts of roads (Parizek 1971) include:

1. the beheading of aquifers in soil and shallow bedrock;
2. the development of groundwater drains where cuts extend below the local water table;
3. changes in ground and surface water divides;
4. the reduction of infiltration rates beneath the road and associated drains;
5. the reduction of streambed infiltration where sedimentation has occurred;
6. the silting of channels causing flashier runoff or flooding;
7. changes in runoff and recharge characteristics generally;
8. erosion and reduction in recharge areas and on flood plains;
9. the obstruction of groundwater flow by abutments and retaining walls;
10. changes in water chemistry where new bedrock components are exposed (e.g. more acid drainage if pyritic rocks such as pyritic shales in limestone are exposed);
11. pollution by petroleum, silt or other materials.

(d) The risk of mass slope failure is increased where road cuts are excessively steep or designed profiles exceeded; where roads cut below the local water table; where roads truncate the toe of previously stabilised transported mantles; where there is an increase in the pore water pressure of previously stable areas due to diminished transpirational uptake resulting from removal of adjacent vegetation; where roads incise steep slopes below convex breaks of slope; or where works are poorly drained (Kiernan 1974).

Road Design

With the above considerations in mind, road designers should take account of the need to:

1. await the completion of karst inventory and assessment procedures along the road route and in its general vicinity prior to the commencement of design work;
2. plan to construct roads only in fine weather and ensure that earthworks are stabilised as much as possible, particularly prior to any cessation of work for 48 hours or more or when rain is expected;
3. wherever possible, keep road width to a minimum to reduce the area of permeable mantle converted to an impermeable surface which will promote runoff rather than infiltration;
4. consider leaving roads across unmantled limestone country unsealed to slow runoff, unless siltation is a hazard;
5. balance cuts and fills to the maximum possible extent to avoid dumps of unused fill which may be washed into karst channels;
6. not construct roads across unstable sites such as active sinkhole margins or slip zones; to ensure assessment of mantle stability beforehand; to consider adopting an alternative route or leaving the particular location unharvested where necessary;
7. utilise full bench construction in critical situations;
8. bring in any extra fill needed from outside the karst area concerned or from sites where the karst is very heavily mantled by transported surface deposits;
9. ensure that roads do not enter any karst reserves apart from necessary crossings of streamside reserves where bridges are present;
10. anticipate survey and design for karst roads;
11. keep batter angles low where erosion susceptibility is high and siltation of underground karst channels is a risk; and to minimise the extent and angle of exposed soil and the duration of exposure.

Drainage Design

In order to safeguard soil and water values the following steps are recommended:

1. ensure that silt traps are provided downstream of bridgeworks or in other situations where there is a risk of karst stream siltation; and ensure there is adequate access to enable the traps to be periodically cleaned and the sediment placed in a position where there is no risk of it regaining access to the stream;
2. ensure adequate drainage and stabilisation during all stages of construction;
3. consider catch drains above cuttings to mini-

mise their erosion by surface runoff; line any steep portion, disperse water into soil or grade to culvert; the drains should be designed so as to minimise the localised entry of water into the soil profile and consequent risk of slope failure;
4. ensure table drains are of adequate capacity;
5. drain outlets to side drains, culverts, watercourses or soaks at a spacing in accordance with the criteria for high erosion risk class soils on bare karst, and according to the nature of the mantle in karst catchments;
6. provide for sediment traps to be installed on all surface watercourses (permanent or ephemeral); where streams enter nearby caves the trap should be sufficient to minimise the influx of material down to silt grade;
7. disperse runoff at bridges into vegetation rather than directly into the stream; construct bridges only when the risk of high flows is limited; properly bridge permanent, intermittent and ephemeral channels; contain the road surfacing material to the bridge; and emplace silt traps downstream during construction;
8. minimise any modifications to the catchment size or runoff characteristics of sinkholes when planning road drainage;
9. site sediment traps some distance downstream from the disturbance to maximise the length of natural channel available to absorb some of the sediment.

Road location

The following safeguards may be particularly important in karst areas:

1. to await the completion of karst inventory and assessment procedures before attempting to finalise road location;
2. to fit roads to the topography in an effort to minimise the infilling of sinkholes and generally minimise earthworks by adhering to topographic form;
3. to avoid unstable slopes, erodible soils, sinkholes, active or inactive drainage routes, draughting holes or cracks in the ground;
4. not to locate roads over the top of caves and to minimise road construction over probable underground drainage corridors along which caves probably occur;
5. to ensure that sidecast material cannot reach watercourses or sinkholes;
6. to avoid steep slopes where runoff is more difficult to control;
7. to respect all karst reserves and to maintain or establish buffering vegetation to filter runoff;
8. to minimise stream crossings and interference with natural drainage;
9. to minimise the clearing of vegetation beside roads consistent with allowing the road surface to dry satisfactorily;
10. not to leave excess ballast in a position where it may be eroded either during or subsequent to construction;
11. not to permit ballast or any form of debris to enter any cave entrance; karst reserve; significant sinkhole; active or inactive watercourse; draughting hole;
12. to stockpile soil for later revegetation wherever necessary and to revegetate construction tracks as soon as they are no longer needed;
13. to plan the location of snig tracks in conjunction with road planning, bearing in mind those considerations which are suggested in the karst logging guidelines.

Road Maintenance

(a) It is absolutely fundamental that all silt traps be regularly inspected and cleaned; access for cleaning and a safe site for debris dumping should be established beforehand.
(b) All drains should be regularly inspected and kept clear, particularly after logging ceases.
(c) Roads to be put to bed should be outsloped, drains cleared, water barred, blocked to traffic, also ripped and re-seeded if necessary; monitored.
(d) Consideration should be given to eliminating a road no longer in use if a sensitive cave exists close by and an effort to minimise excessive visitation appears warranted.
(e) Signposts referring to karst features should be installed only after detailed consideration of the implications by the karst specialists.
(f) Maintenance should be kept up on roads to be retained; some roads may need to be gated to limit misuse or excessive access to sensitive sites such as baseline karst process monitoring installations.

Logging operations

1. No forest operations should commence until the distribution and nature of the various karst resources of the area has been mapped and assessed.
2. All planning with respect to road and snig track locations and drainage should be in accordance with the provisions of the Karst Management Policy.
3. No logging operations should commence until the planning of any necessary karst reserves or other special safeguards has been finalised.

The following general guidelines should be followed:

1. No logging should occur on steep limestone slopes.
2. Logging of limestone slopes of more moderate angle should only occur during the driest months, in very small and dispersed units; logging should be curtailed with any unseasonal onset of wet weather when water runs in the table drains.
3. All karst reserves should be respected. These exist not only to protect environmental values but also to safeguard forest workers in areas prone to ground subsidence or collapse.
4. These should be no felling of trees towards any karst reserve, cave entrance or watercourse; sinkholes should also be avoided especially where they are known to contain a cave or stream.
5. No form of rubbish, debris or toxic material should be permitted to enter any sinkhole, watercourse or cave entrance; no insecticides should be allowed to settle in any natural vegetation zones outside cave entrances.
6. Where silt traps are installed they should be regularly inspected and cleaned when necessary; the silt removed from the trap should not be placed so as to be at risk of being washed back into the stream.
7. If further caves or streamsinks are discovered during logging the site should be avoided until assessment procedures have been completed.

The following specific precautions are suggested to minimise the risk of erosion and siltation during logging operations:

Log Extraction

1. Because soils are most susceptible to damage when they are wet, and because underground karst water channels are most easily silted when runoff is prevalent, forest managers should err on the side of caution in transferring logging from sensitive karst sites during winter.
2. The often sensitive soils, risk posed to drainage patterns by excessive silt in streams and the often rocky nature of karst means that particular care needs to be exercised in the selection of extraction equipment -
   a) where karst assessment procedures have identified the existence of a thick deposit of naturally transported earth and rock overlying the limestone, logging operations may proceed normally but giving full regard to the need to minimise soil erosion and stream siltation;
   b) where only thin residual limestone soils are present neither wheeled nor flexible tracked skidders should be used on limestone slopes of even moderate angle; only highline systems hauling upslope or skyline systems should be permitted on slopes steeper than about 10° and no logging at all on such slopes steeper than about 20°.
3. Snig tracks warrant particular attention because they frequently destabilise the soil, concentrate and alter the surface drainage pattern, and represent sites of soil compaction which alters the balance between water running off the soil and the water which soaks into it.
4. Planning of snig tracks should aim to reduce the length, density and gradient of snig tracks and should occur concurrently with road planning.
5. Cross drains should have been planned in advance to disperse rather than concentrate runoff, reduce water velocity and minimise sediment transport. Some of these cross drains should be activated whenever track use is interrumpted for 48 hours or more or if heavy rain seems likely.
6. Because maximum ground compaction occurs after only a few passes, snig tracks should be limited in number to reduce the affected area but carefully sited with respect to karst landforms and karst reserves.
7. Snig tracks should be outsloped and if necessary stabilised by fast growing grasses or legumes after use; sediment traps should be installed where required.
8. No snig track should enter any karst reserve or significant karst depression.
9. No watercourse should be used for snigging; no watercourse should be diverted to flush mud from a snig track, or any other form of mud-flushing undertaken.
10. Snigging should be conducted in an upslope direction to minimise downslope concentration of runoff in gouged channels.
11. Inadvertent water diversions should be dispersed and the basic cause rectified.
12. Drain spacing for karst areas with thin residual soils should be in accordance with high erosion risk sites; even where soils are thick they should be managed as posing not less than a moderate erosion risk.
13. In some cases it may be desirable to reduce log size in an effort to minimise the greater erosion potential posed by handling large logs.
14. To reduce ground vibration, logs should be suspended above the ground while being moved over shallow caves.
15. All assessments of erosion risk should be made by the karst inventory assessors and based

upon the true field-verified character of the soil and parent materials, not extrapolations from bedrock geological maps.

16. Cross cutting and debarking should occur at the stump to minimise the extent of necessary landings, but bark and other debris should be prevented from entering karst reserves and sinkholes etc.
17. Where logs are used as sediment barriers it will be necessary to clean the sediment out occasionally. If this is not done water may simply overtop the log and erode back underneath it through the development of a plunge pool. By this means the trapped sediment may eventually be realised as a result of drainage passing under the log.

Landings and Loading

1. No landings should be sited close to any karst reserve or significant karst depression.
2. Landing size should be minimised and alteration of the existing topography minimised.
3. Wherever feasible the surface soil should be stockpiled and kept free of logging debris for later restoration work.
4. Winter landings should be corded and all landings should be located on well drained sites.
5. Landings in karst areas should be drained into the surrounding vegetation or silt traps whenever wet weather threatens; this should occur whenever operations on thin limestone soils are suspended for 1 week or more increasing to one month or more on thickly mantled karst catchments.
6. Within reason the original ground contour should be restored as soon as possible after logging ceases; if necessary landings should be ripped and hand replanted. Operators should bear this in mind and not unnecessarily disturb stock piled soil.
7. Tracked front end loaders exert a significant cutting action upon the soil and should only be used where karst is thickly mantled by soil and of moderate angle. They should not be used during wet conditions. Where the soil is thin or the slope steeper (greater than about 10°) loading should only be by crane.

In addition to the safeguards that are presented here and are aimed specifically at the protection of karst environments, normal sound logging practices (eg. Forestry Commission 1981) should be adopted.

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