# Geoconservation in forest management—principles and procedures

C. Sharples
Forestry Tasmania

**Abstract**

*Geoconservation aims to maintain the diversity of geological, geomorphological and soil features, systems and processes. As with biodiversity, the more vulnerable aspects of geodiversity will not be preserved on multiple-use land tenures unless they are specifically managed for. The successful management of geodiversity requires the existence of databases indicating the types, conditions and vulnerability of the features and assemblages present, and a procedure for identifying features of geoconservation significance and arriving at appropriate management prescriptions for those which are vulnerable to disturbance. These requirements are at an early stage of development compared to biodiversity management, but in Tasmania are the subject of ongoing projects within both Forestry Tasmania and the Tasmanian Parks and Wildlife Service.*

**Introduction**

Conservation concerns have historically been focussed mainly on biodiversity, with the physical parts of the earth—rocks, landforms and soils—being seen largely as a platform upon which biological systems are situated. Of course, the inter-relationships between bedrock, landform, soil type and biological habitat have long been recognised, and there is also a widespread understanding that hazards such as soil erosion, landslips and karst subsidence impinge directly upon the viability of forest (and other) ecosystems, and on their use by humans. However, the non-biological parts of the earth also have values of their own. Thus, just as the conservation of biodiversity is important, so too is it important to preserve the diversity of the earth's physical features and processes. If the diversity of the earth's natural systems is not maintained, then not only will ongoing natural processes dependant on that diversity be affected, but the earth will become incrementally more uniform, an incrementally impoverished environment. From a human perspective, a diversity of environments—both natural and cultural—are important cornerstones of the human search for meaning and identity (Relph 1976).

The maintenance or conservation of the diversity of the earth's physical features and processes (*geodiversity*) is the basic goal of *geoconservation*. This goal is comparable to the basic aim of bioconservation, insofar as both are concerned with protecting the diversity of natural phenomena and processes. Because of the similarity in goals, there are also analogies in the methods and databases required for the achievement of conservation aims. In particular, there is a requirement for classifications and comprehensive 'species lists' of earth phenomena, and for data on their present conservation status. However, the relatively recent recognition of the importance of geoconservation, and the small number of workers active in the field, means that collection of the necessary data, and development and implementation of appropriate geoconservation strategies, lags considerably behind bioconservation in many respects.

The Tasmanian *Forest Practices Code* (Forestry Commission 1993) recognises the importance of protecting geoconservation values in State forest. However, the compilation of preliminary inventories of significant geological, landform and soil features in Tasmania, analogous to biological species



Published by Forestry Tasmania, Hobart

lists, has only commenced in earnest during the last few years. (Such inventories, many unpublished, include Eastoe 1979; Kiernan 1984, 1989, 1995; Dixon 1991, 1994; Bradbury 1993; and Sharples 1994 a,b).

A larger range of inventories exists on mainland Australia, notably including those prepared by the Geological Society of Australia. However, although appropriate for a scientific society, these explicitly value sites only for their scientific and educational interest (GSA 1992), rather than for the broader range of values (see below) for which geodiversity can be considered important, regardless of whether or not we actually study it.

The purpose of this paper is to outline philosophical principles, definitions of terminology, and basic procedures for implementing geoconservation management which have been developed through informal collaboration between Forestry Tasmania and the Tasmanian Parks and Wildlife Service (Department of Environment and Land Management, Tasmania). Although partly developed to facilitate the conservation of geodiversity within State forests in Tasmania, the principles and methods proposed apply to geoconservation generally.

## Geoconservation—goals and definitions

Geodiversity is defined here as *the range (or diversity) of geological (bedrock), geomorphological (landform) and soil features, assemblages, systems and processes.* So defined, geodiversity includes both current processes and features currently being formed, as well as older 'fossil' features which preserve evidence of past processes. On this basis, geoconservation can be defined as that endeavour which has as its basic goal *the conservation of geodiversity for its intrinsic, ecological and (geo)heritage values.*

These values are understood as follows:

The concept that a thing has *intrinsic value* means that its existence is of value in itself, rather than only because of a purpose for which it might be used by humans or by other living things. The idea that non-human and even non-living things have intrinsic worth implies that moral consideration should be extended to non-human things by those capable of acting as moral agents (i.e. by humans). The development of intrinsic value theory, or 'ethical extensionism', as a philosophical basis for conservation has been described in some depth by Nash (1990) and Fox (1990).

The *ecological value* of a thing or process is its importance in maintaining natural ecosystems and ecological processes of which it is a part, where ecosystems are understood as comprising both biotic and abiotic components which interact and are interdependent. Biological systems are inextricably linked to physical systems, most immediately through the media of soils and geomorphological processes.

*Geoheritage* comprises those aspects of natural geodiversity which are of *significant* value to humans for purposes which do not decrease their intrinsic or ecological values; such purposes may include scientific research, education, aesthetics and inspiration, recreation, cultural development and contribution to the 'sense of place' experienced by human communities.

The concept of significance is discussed elsewhere in this paper. Although the term 'heritage' strictly implies *value to humans*, in lieu of a better term the word 'geoheritage' is sometimes used more broadly to encompass aspects of geodiversity which are significant for their intrinsic and ecological values, as well as any strictly heritage values they may have.

Numerous other terms are currently being used to describe the conservation of geodiversity, including such terms as 'earth science conservation' and 'earth heritage conservation'. Terms such as these do not encompass the full range of values involved; for instance 'earth science conservation' suggests that only scientific values are important, whilst 'earth heritage conservation', a term defined at a recent international conference (Stevens 1994), does not obviously encompass intrinsic or ecological values, and at the same time is capable of being interpreted very broadly to mean all things on earth, not just the non-biological components implied by 'geo-conservation'. Similarly, the use of terms such as 'geological monuments' or 'significant geological features' (GSA 1992) should be carefully restricted, since these terms do not properly encompass geomorphological or soil phenomena. The writer prefers to use the neologisms *geoconservation* (for the discipline concerned) and *geodiversity* (for the things being conserved), since these are the only terms which he considers can be construed to encompass all the relevant values and features.

It should also be stressed that *geoconservation*, as outlined in this paper, is philosophically distinct from the management of *geomorphic hazards* such as landslips and soil erosion, although the two areas necessarily overlap. The distinction is that, whereas the management of hazards seeks to minimise the effect that degradation of earth systems may have on human aspirations for the use of particular areas (Kiernan 1990, p. 8), geoconservation is concerned with protecting the values and significance of earth systems themselves, regardless of utilitarian consequences.

## Purposes and priorities of geoconservation

Geoconservation can be considered important from a variety of value perspectives which have been defined above. This section briefly expands on certain aspects of the definitions.

- *Intrinsic values*

  Fox (1992) and Spash and Simpson (1993) have argued that recognition of intrinsic values leads to better outcomes for conservation, since the onus of justification shifts onto those whose actions would interfere with the integrity of natural values. In a sense, all things could be said to have some degree of intrinsic value, and therefore to be worthy of moral consideration from a conservation perspective. However, this does not imply a blanket ban on human exploitation of the earth, any more than giving moral consideration to other humans precludes exploiting their services. Rather, it means that while humanity may have a right to exploit natural resources to fulfil its own legitimate needs and purposes, it should not be done in such a way that geodiversity is unnecessarily reduced by the elimination of entire classes of things, and that representative systems of natural processes are no longer able to unfold and evolve in their own ways at a variety of spatial and temporal scales. The concept of geodiversity is essentially a tool which we can use to make practical decisions about what things to conserve for their intrinsic value, and what things to exploit or alter despite their intrinsic value. Such decisions can be made by considering the importance or significance that particular things have in maintaining geodiversity. For instance, an example of a common type of feature might be considered individually less significant than a rare feature, and therefore more suitable for exploitation if necessary.

- *Maintenance of ongoing ecological processes*

  Geoconservation should not aim to preserve an unchanging 'museum-piece' natural environment. Rather, one fundamental aim of geoconservation is the protection, by maintaining ongoing and dynamically changing geological, geomorphological and soil processes, of the broader web of ecological processes of which these are a part. A corollary is that if natural processes ultimately erode and remove significant features then this is an acceptable outcome of the dynamic evolution of natural earth systems; the point is to not allow such losses to occur artificially and un-necessarily.

- *Anthropocentric (geoheritage) values*

  The protection of those utilitarian conservation values of geodiversity which are of heritage significance to human

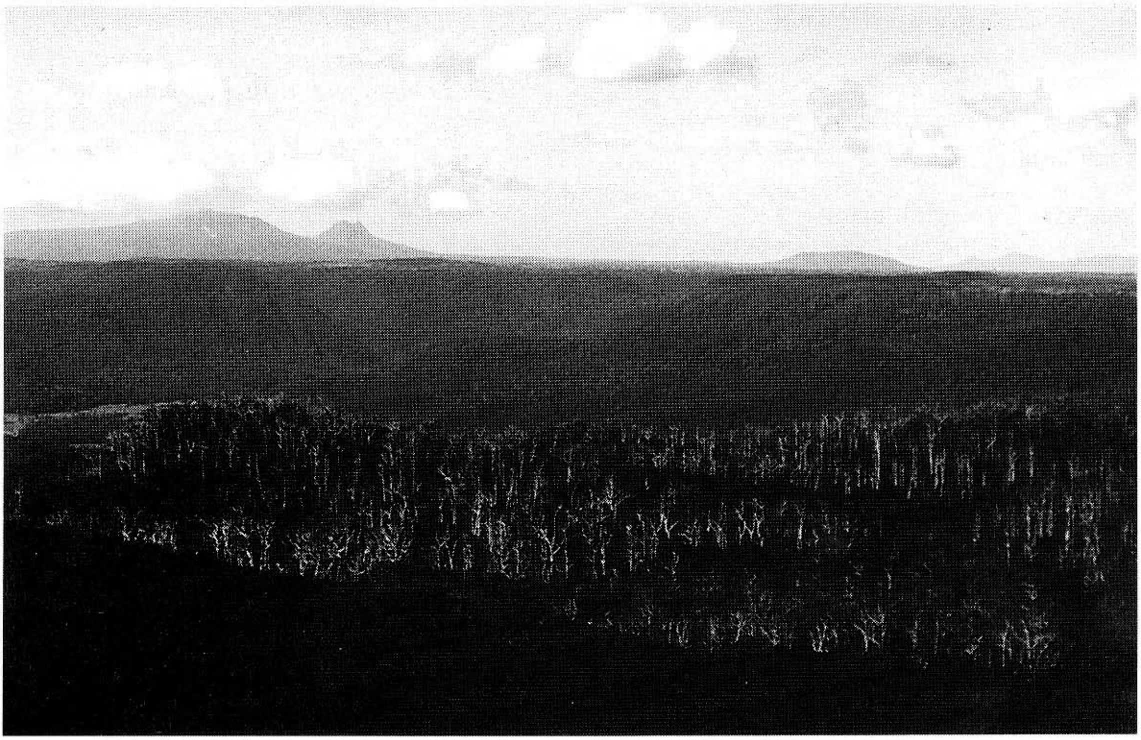

*Photo 1. The planar surface of the north-eastern Tasmanian highlands plateau is a landscape surface which was originally eroded to its present planar form in pre-Permian times (c. 300 million years BP), was then buried by younger rocks, and has now been exhumed by geologically recent erosion. From a geoconservation perspective, it is significant as an extensive and well-expressed exhumed 'fossil' landscape surface. However, its significance resides in its large-scale form only, since no vulnerable small-scale pre-Permian features have been identified on the exhumed surface, and it is consequently robust to the effects of forestry operations.*

culture and science contrasts with the utilitarian resource values derived from the removal, processing or manipulation of rocks or soils by means such as mining or agriculture. Examples of geoheritage include features significant for scientific research and education, the use of unaltered natural systems as baselines against which to monitor environmental changes elsewhere, landforms which contribute to the 'sense of place' of a community or which have played a significant role in the lifestyles of past cultures, and features which are valued for recreational, aesthetic and tourism purposes.

*Vulnerability*

The conservation values of many aspects of geodiversity are robust in the face of normal human activities, which is to say that such activities impinging on these features will not degrade the particular characteristics for which they are considered to have conservation value. Such features generally require little specific protective management (Photo 1). Many, however, do have values which are vulnerable[1] to common humanly generated disturbances, and it is this fact which requires geoconservation to be incorporated into land management planning (Photos 2 and 3).

In principle, however, the natural values of any feature could ultimately be degraded by some type or degree of interference. Thus, a judgement as to the vulnerability of particular features must be made by explicit reference to the types and degrees of human activities to which they might be subject in the absence of any special management prescriptions.

*Distinction between the management implications of geological sites, and of landforms and soils*

It follows that there is a need to pay more attention to the conservation of vulnerable features than of robust ones. Although this is a generalisation subject to qualification, it is broadly true that the geoconservation values of landforms and soils are commonly more vulnerable to artificial disturbance than are the values of bedrock geological features.

The difference in management implications arises because, whereas a landform necessarily is defined by a morphological expression on the earth's surface, and a soil by its profile relative to surface and bedrock, geological features are bedrock phenomena whose original form is generally not expressed in the present landscape, and whose values lie essentially in their contents, independently of relationships to the present surface. Hence, whereas landforms are by definition damaged by activities that modify the surface contours of the Earth, and soils by activities that degrade profiles, the scientific value (at least), and perhaps the aesthetic or other values, of a geological site may in some cases be enhanced through excavation of a good exposure.

Moreover, landforms and soils are the dynamically evolving interface between bedrock and the surficial environment. Thus, damage to landforms and soils, which are integral to ongoing physical and biological processes, can interfere with ecological systems. In contrast, bedrock geological features are for the most part only indirectly involved in ecological processes, to the extent that they influence the development and characters of the landforms and soils which are the active interface. However, this distinction is weaker in the case of some things such as groundwater processes.

*Features and assemblages*

It is important to sustainably manage *assemblages*, or groups of inter-related *features*, and not just individual geological, geomorphological and soil phenomena. Individual features are the product of interacting processes in the assemblage to which they belong, and they all continue to affect and be affected by other features in the assemblage (Davey 1984; Kiernan 1990).

If only an individual feature is managed for conservation, that feature may still become degraded in time by disturbances which are allowed to take place in other parts of the broader environment or assemblage to which it belongs. An oft-quoted example is that it is not possible to protect a cave without also managing the water catchment which drains into the cave; disturbances in the catchment area can cause siltation, chemical and hydrological changes and other resulting degradation to occur within the cave. The decision to close a quarry within the catchment of the Exit Cave system near Lune River constitutes a recognition of the importance of these systemic relationships and impacts (Kiernan 1993).

Similarly, from a research and educational point of view, where a feature is an integral and interacting component of a broader system, its scientific significance can only be properly appreciated if the systemic relationships by which the features in an assemblage interact are taken into account. Without such contextual information to illuminate the origins and controls on a feature, it would be of little scientific value.

---

[1] *Vulnerability* refers to the degree of ease with which the particular characteristics for which a feature is considered to have conservation value may be degraded or destroyed. Although the terms 'vulnerability' and 'sensitivity' are often used synonymously in geoconservation, Kiernan (1995, p. 298) suggests a useful distinction, namely that *vulnerability* should refer to the potential for degradation of conservation values (whether or not hazards, as defined earlier, are thereby created), whereas *sensitivity* should refer to a combination of both vulnerability and the scale of any hazards that may result from degradation (such as soil erosion, subsidence and mass movement).

*Site function*

In order to assess the management requirements of a particular feature, and in particular the degree of disturbance (if any) which it can sustain without degradation of its values, it is necessary to have a clear idea of the function of the site (Kiernan 1991a). The function of a site can be understood to be its role in contributing to the goals of geoconservation, which is determined by the particular values which make it significant to geoconservation. For instance, in many cases, features may be seen as important primarily for their intrinsic value as a significant aspect of geodiversity or for their role in maintaining ongoing natural processes, so that the site function is to provide an undisturbed example of a phenomenon which is best served by minimising or preventing artificial disturbance. In another case, the main function of a site may be considered to lie in its value from a research and educational (geoheritage) perspective, in which case some disturbance may be acceptable or even desirable (see Photo 3).

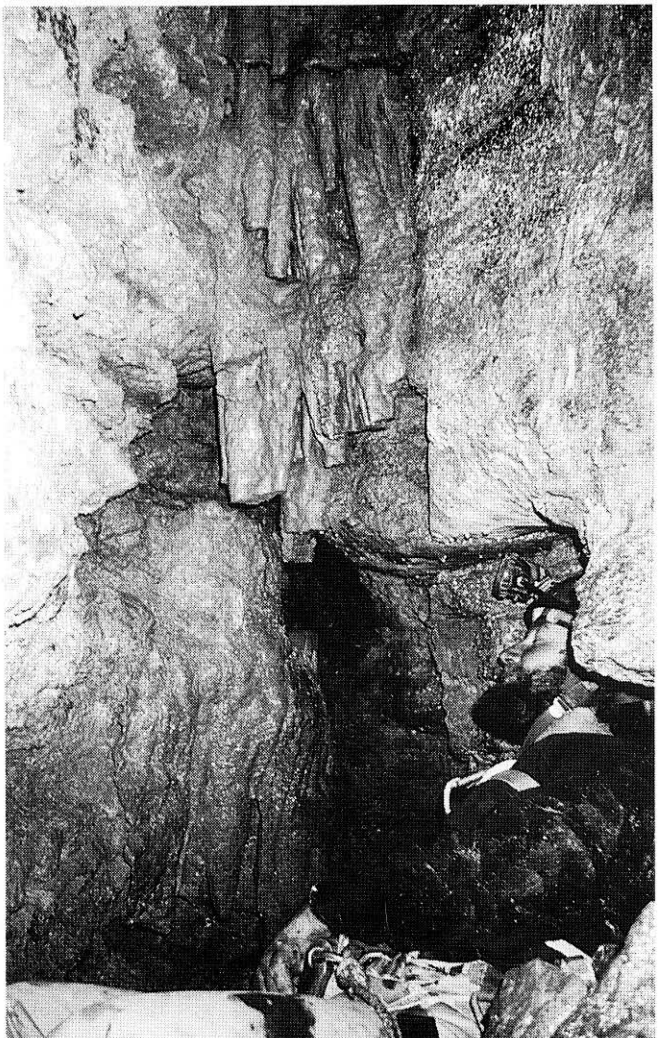

*Photo 2. Well-developed karst systems may respond sensitively to changes in physical and chemical conditions, and so tend to be vulnerable to a variety of disturbances. These stalactites in the bottom of Bottomless Pit, a pothole in Permian limestone at Mount Elephant near St Marys, have probably been broken by recreational visitors. The Mount Elephant karst is the only substantial terrestrial karst known in eastern Tasmania or in Permian limestones anywhere in Tasmania, and is significant for these reasons. Its significance combined with its vulnerability require that land uses which may impinge upon it be managed with particular care.*

As noted above, the values of landforms are in part defined by their surface contours. Although excavation of landforms may sometimes yield useful scientific information by revealing their structure and constituents, their intrinsic value as natural features is inevitably degraded by this means. Excavation of landforms can be thought of as analogous to dissection of animals for meat or study: it may be justifiable to do it to a small proportion of the total population of a species, but if it happens to most or all members, then that species will be destroyed or seriously endangered. Since there are commonly far fewer individuals in a class of landform than in many biological species, and since many landforms—particularly 'fossil' ones formed by no-longer active processes —may be less capable of regeneration, the protection of geodiversity requires that proportionately fewer landforms in any given 'species' (landform class) be 'dissected' (excavated) for study or exploitation. Where such disturbance does occur, it is important that other replicated examples of the same phenomenon can be identified and protected from disturbance.

Therefore, in many cases it is appropriate to consider geomorphic studies requiring excavations to have a lower priority than maintaining landforms in a natural condition. In this case, intact landform morphologies are available for study but, in studying landform contents, we may be restricted to whatever natural exposures are available. In those cases where this approach does not yield as much scientific information as might be preferred, it is a case of making the value judgement that there are situations in which other ethical 'goods' should take precedence over scientific knowledge.

**The concept of 'significance' in geoconservation**

Determination of the range and extent of earth features which should be explicitly managed for conservation purposes revolves around the idea of identifying which features are *significant* (Dixon 1991). In essence, judging a feature to be significant means judging that its conservation is meaningful or important to the realisation of one or more of the overall geoconservation goals, namely the conservation of geodiversity for its intrinsic values, the maintenance of ecological processes, and protection of geoheritage values.

This said, the problem of actually deciding what is or is not significant can be a difficult

*Photo 3. This 17-metre long fossil log of mid-Mesozoic age (possibly Jurassic, c. 170 million years BP) in State forest at Lune River is the largest fossil discovered in Tasmania to date. Its discovery highlights a classic dilemma in geoconservation: its existence only became known as a result of excavations associated with forestry activities, consequently its scientific significance was arguably enhanced by artificial exposure. However, the log is intensely fractured and suffered vandalism and theft whilst exposed. It proved necessary to re-bury the log in order to protect it from further damage pending a decision on its long-term management.*

one since, in practice, judgements of significance are dependent on one's subjective perspective, which determines the specific criteria or attributes in terms of which one judges or measures significance. In western culture, it is typical, in judging significance, to give emphasis to attributes such as size and prominence, diversity and contrast, juxtaposition and spectacle (Davey 1989). Although not without value, these are relatively crude criteria, and it is necessary to guard against placing undue emphasis on them. From many perspectives (including the scientific and ecological), more subtle attributes may be of greater importance.

Various workers are currently devoting effort to making significance assessments less subjective, by means of the development of detailed lists of attributes or criteria of significance and by the development of typology's of classes of phenomena against which particular examples can be compared to determine whether they fall above or below a threshold of significance (O'Brien 1990). None of these approaches, however, escapes the need for a subjective judgement of which attributes or criteria actually constitute or most appropriately measure significance in the first place. Attempts to develop a more objective formulation of significance—if such is possible—will require further examination of the concept at a philosophical rather than a purely procedural level.

Due to the subjectivity of significance assessments, the judgements of as many experts as possible should be obtained. Davey (1984), for instance, conducted a wide-ranging survey of karst experts in drawing up an assessment of the significance of Australia's karst landforms, and Eastoe (1979) and Dixon (1991) performed similar exercises.

*Representative/outstanding significance approaches*

It has become customary in geoconservation to classify significant features (explicitly or otherwise) as being of *outstanding* and/or *representative* significance (Joyce and King 1980; Davey 1984; Dixon 1991). An outstanding feature is one which exemplifies an earth process through a feature or assemblage which is rare, unique, an outstandingly well-expressed example of its type, or otherwise of special scientific, cultural or aesthetic importance. A representative feature may be either rare or common but is considered significant as a well-developed or well-exposed example of its type.

Geoconservation purposes cannot adequately be fulfilled if attention is focussed only on individual features which are considered to be *outstanding*. Although outstanding features are those which it is generally easiest to gain public and institutional support for protecting, there are several inherent problems in focussing only on this approach (Davey 1984). In the first place, current scientific fashions and cultural pre-occupations may make a feature seem outstandingly significant which in the future may be considered less important, and *vice versa*; thus 'outstandingness' is a subjective and culture-dependant attribute which is likely to be only ephemeral.

Secondly, if we are to fulfil purposes such as the preservation of a suite of features sufficient to illuminate fully the development of a given region, then we need to manage for the conservation of (at least) features and assemblages *representative* of all aspects of the geodiversity of the region; outstanding features alone will only encompass a very partial picture. Indeed, a thorough approach to geoconservation must involve identifying representative examples of *common* or *ordinary* features. Philosophically, this is necessary since common features are arguably the dominant components of the environment. From a procedural point of view, it is required to provide a comprehensive and less subjective database on geodiversity. From a management perspective, it is also important since failure to identify and conserve representative examples of common features could ultimately cause them to become rare (Kiernan 1990; Hay 1994).

Finally, the conservation of a system of representative aspects of geodiversity comes closer to ensuring the continued natural functioning of ecological processes than does a more arbitrary selection of outstanding features, and supports biodiversity by protecting a full range of habitat substrates.

*Classification*

The compilation of inventories of representative features requires a comprehensive classification which would allow differentiation and ordering of all earth phenomena in accordance with a small range of over-arching criteria such as origins or histories. A widely accepted classification of this sort does not yet exist in the earth sciences, in contrast to the Linnean–Darwinian taxonomic system of biology, which aims to place all organisms within a logical system in accordance with the over-arching criterion of their evolutionary relationships. Many existing 'classifications' of earth phenomena are better described simply as 'listings', since they are not related to listings of other types of earth phenomena by means of any over-arching scheme within which all aspects of the earth sciences could be placed.

From a geoconservation perspective, a classification system which groups features having common characteristics will better facilitate grouping them according to their management implications and requirements (M.R. Banks, *pers. comm.*). It will facilitate an assessment of the relative frequency and conservation status of particular phenomena, and will enable comprehensive inventories to be prepared (Davey 1984; Soutberg 1990; Sharples 1993; Forestry Commission 1994; Kiernan 1995). By comparing a comprehensive classification with the range of features currently managed for conservation (or whose maintenance is adequately ensured by their robustness), it will be possible to identify gaps in the geoconservation estate for any given region. This approach has previously been applied to the conservation of karst features on State forest at Mole Creek by Kiernan (1984, 1989).

Current geoconservation inventory work, both within Forestry Tasmania and elsewhere, includes the development of preliminary listings and classifications with a view to applying them to evaluation of the status of geoconservation (Kiernan 1991a, 1995; Sharples 1993, 1994a,b; Eberhard 1994; E.B. Joyce, K.G. Grimes and C.D. Ollier, unpublished draft manuscript).

*Levels of significance*

Significant features can be classified as being of outstanding or representative significance at a level ranging from local to international. The adoption of this system provides for both the recognition of outstanding features which are amongst the best developed of their type at a global, national or state level, and also for the recognition of features which, while not exceptional, are nonetheless important in maintaining geodiversity at the level of local or regional systems.

An alternative is simply to assign 'high', 'medium' or 'low' levels of significance to particular features, using clear definitions of these terms. The relative merit of this approach requires further assessment.

**A procedure for identification and management of significant features and systems**

A basic procedural approach to geoconservation has been developed within Forestry Tasmania with a view to applying the various considerations discussed above. In essence, the goal of this procedure is to identify which features and assemblages in a given study area are of *outstanding* or *representative* geoconservation significance, and which are *vulnerable* to disturbance. This then allows the management requirements of significant vulnerable features to be determined, implemented and monitored.

The procedure revolves around the preparation of inventories of significant features, systems and processes. The inventory process can occur at any of three levels, namely first order, second order or detailed inventories.

***First Order Inventories*** are 'first pass' inventories whose preparation is largely based on available published information and which tend to have a bias towards outstanding features, to those which have been most studied in the past, and to those with which the person compiling the inventory is most familiar. These inventories are prepared without a thorough systematic comparative analysis of the sort described below as a *second order* analysis. Most geoconservation inventories produced in Tasmania to date fall into this category, and it is hoped that most public lands in the State will have been covered to this level of detail by 1996.

***Second Order Inventories*** may begin with a first order inventory database and upgrade it in a systematic fashion by developing a classification or typology of the geodiversity in the region in question so as to determine which classes of phenomena have adequate representative examples identified in the first order inventories and which do not. The availability or preparation of systematic geological, geomorphic and soil maps and other research data are essential to a thorough inventory process of this sort. The most appropriate representative examples to fill gaps identified in the inventories are systematically located, if present. This process can also result in deletion of some features from first order inventories where it is determined that these are not the most appropriate representative examples. *An Atlas of Tasmanian Karst* (Kiernan 1995) is the only second order inventory database which has been prepared in Tasmania to date; however, the preparation of second order inventories for other classes of earth phenomena is the logical next step in the development of geoconservation strategies in Tasmania once the initial process of collating first order inventories is well advanced.

The preparation of a second order inventory involves a series of logical steps as outlined below. Limitations on data, time and information-processing capacity mean that this ideal process will not always be able to be adhered to rigorously. Where ideal conditions cannot be met, the quality of the resulting inventory will depend on the breadth of knowledge of the persons involved, and the degree of consultation with other relevant experts.

1. *Classification*

   Using the range of phenomena identified in first order inventories as a starting guide, the earth features and assemblages of the region being considered are classified in order to identify the full range present and identify gaps in the first order inventories. The process of classification cannot be completed prior to development of a comprehensive inventory, and so must continue concurrently with step 3 below.

2. *Context of significance*

   In order to guide the search for the best examples of each phenomenon classified, it is necessary to first identify in each case the region in which that type of feature occurs. This is the context area for the phenomenon in question. Where a class of feature occurs very widely, it may be appropriate to define a smaller context area on other criteria for the purpose of identifying representative features at a regional or local level.

3. *Inventory*

   For each phenomenon identified in the classification process, all known examples within the relevant context area are identified and mapped, beginning with data already compiled in first order inventories, and the quality and condition of each is documented. This search should be conducted without reference to land tenure boundaries since the most appropriate examples for geoconservation management may not necessarily occur on the tenure under immediate consideration.

4. *Comparative assessment*

For each class of phenomenon under consideration, all the comparable examples identified in step 3 are considered. The best representative examples are selected on the basis of assessing the relative quality of the attributes and condition of each available example, and the importance of their inter-relationships with other significant features. The selected examples are then considered to be 'significant' to geoconservation.

5. *Replication*

In tandem with step 4, an assessment is made of how many representative occurrences of each particular type of significant feature or assemblage should be specifically identified for protective management, and in what areal distribution. It is generally appropriate that more than a single example of a class of earth feature be identified as significant and, if necessary, protected. Replication is necessary not only because of the role many features play in ecological systems wherever they occur, and in maintaining diversity at local levels but also, at least in the case of vulnerable features, because of the risk that any particular representative example could be degraded by events beyond the control of land managers. Criteria for determining the appropriate degree of replication include rarity, vulnerability to disturbance, and ecological importance.

6. *Assessment of vulnerability and determination of management requirements*

Considering each identified 'significant' occurrence in turn, an assessment is made of the degree to which its values are likely to be vulnerable to forestry or other anticipated activities which might degrade it in the absence of special prescriptions to the contrary. An assessment of vulnerability will result in a management classification stating that the feature is robust or vulnerable.

Features which are robust with respect to anticipated activities require no specific management prescriptions. However, where the geoconservation values of a feature are assessed to be vulnerable to likely activities, appropriate management will involve modifying those activities to eliminate the particular impacts which are of concern. In the case of complex assemblages, further research at a *detailed inventory* level may be necessary to determine appropriate management responses.

Given that all features are vulnerable to some type or scale of disturbance, the vulnerability of particular features must be re-assessed if there arise proposals to conduct different and previously unanticipated types of activities in their proximity, or if other conditions change significantly.

***Detailed Inventories*** are required as a basis for the actual management of specific complex phenomena which have been identified as significant by either a first or second order inventory process, and which are also both vulnerable to disturbance and likely to be impinged upon by human activities. A detailed inventory consists of that information about a particular feature or assemblage which is necessary to design specific management regimes to avoid human activities degrading the identified conservation values of the phenomenon. A number of detailed-level inventories have been prepared in Tasmania, most notably studies of important karst systems such as those at Mole Creek (Kiernan 1984, 1989), Exit Cave (Houshold and Spate 1990; Kiernan 1991b; Houshold 1992) and Junee River (Eberhard 1994).

**Geoconservation status indicators**

The need to develop indicators of the status of geoconservation in Tasmanian State forests has been foreshadowed in the first *State of the*

*Forests Report* (Forestry Commission 1994), and will also be required in the context of State of the Environment reporting. The purpose of such indicators is to assess the success of past and present management strategies and regimes in facilitating geoconservation, and to identify problems and areas in which conservation goals are not being achieved so as to highlight issues requiring further attention. Geoconservation status indicators will therefore need to comprise measures of the degree to which natural geodiversity has been and is being conserved in various areas under various management regimes. Application of the procedures described in this paper has the potential to provide a suitable database from which to derive quantitative indicators. Since the protection of geodiversity requires protection of both *features* and *processes*, it will be necessary to develop both *site integrity indicators* and *process integrity indicators*.

The development of suitable indicators and the assessment of their usefulness is therefore foreshadowed as an important focus for future geoconservation work within Forestry Tasmania and the Tasmanian Parks and Wildlife Service. As a bare minimum, a completed first order geoconservation inventory for the whole of Tasmania will be necessary to provide sufficient data for the development of useful indicators.

## Conclusion

Geoconservation, under various names, has in Australia often tended to be focussed largely on identifying and conserving bedrock exposures and some landforms primarily for their value to scientific research and education (see GSA 1992). This paper aims to establish a broader basis for geoconservation which will allow it to make a broader contribution to nature conservation generally, both by identifying the diversity of bedrock, landform and soil systems as all being equally worthy of conservation, and by recognising that these systems not only have aspects which are of value to humanity for utilitarian, scientific and heritage reasons, but that their existence also has intrinsic value irrespective of human interests, and is fundamentally important for the integral role they play in natural ecological processes.

By recognising the wider range of phenomena, interests and values at stake, this approach to geoconservation can provide more comprehensive data and give better guidance to land managers in their endeavours to account for the interests of the full range of stakeholders in the management of State forest and other lands.


## Acknowledgements

This paper is a condensed and updated version of an unpublished report (Sharples 1993) produced during the preparation of inventories of significant landforms and geological sites in Tasmanian State forests. That report was internally funded by Forestry Tasmania through the District Conservation Fund. The development of the principles and terminology defined in this paper is partly based on previous work as cited in the text, and was substantially assisted and influenced by ideas and critiques from Kevin Kiernan and Rolan Eberhard (Forestry Tasmania), Mike Pemberton, Grant Dixon, Ian Houshold and Jason Bradbury (Parks and Wildlife Service) and Max Banks (University of Tasmania). Notwithstanding this input, the author takes responsibility for the interpretations presented in this paper and for any errors which remain.


## References


Bradbury, J. (1993). *A Preliminary Geoheritage Inventory of the Eastern Tasmania Terrane.* Report to Parks and Wildlife Service, Tasmania.

Davey, A.G. (ed.) (1984). Evaluation criteria for the cave and karst heritage of Australia—Report of the ASF National Heritage Assessment Study. *Helictite* 15(2): 1–40.

Davey, A.G. (1989). An overview of the national and international significance of the Australian Alps. In: *The Scientific Significance of the Australian Alps* (ed. R. Good), pp. 337–343. The Proceedings of the First Fenner Conference on the Environment, Canberra, September 1988. The Australian Alps National Parks Liaison Committee in association with the Australian Academy of Science.

Dixon, G. (1991). *Earth Resources of the Tasmanian Wilderness World Heritage Area—A Preliminary Inventory of Geological, Geomorphological and Soil Features.* Occasional Paper No. 25. Department of Parks, Wildlife and Heritage, Hobart.

Dixon, G. (1994). *A Preliminary Geoheritage Inventory of King Island Tasmania.* Report for Parks and Wildlife Service, Tasmania.

Eastoe, C. J. (1979). *Geological Monuments in Tasmania.* The Geological Society of Australia Inc., Tasmania Division. (reprinted 1986)

Eberhard, R. (1994). *Inventory and Management of the Junee River Karst System, Tasmania.* Report to Forestry Tasmania.

Forestry Commission (1993). *Forest Practices Code.* Forestry Commission, Tasmania.

Forestry Commission (1994). *State of the Forests Report.* Forestry Commission, Tasmania.

Fox, W. (1990). *Toward a Transpersonal Ecology—Developing New Foundations for Environmentalism.* Shambala Publications, Inc., Boston.

Fox, W. (1992). New philosophical directions in environmental decision-making. In: *Ecopolitical Theory—Essays from Australia* (eds P. Hay and R. Eckersley), pp. 1–20. Occasional Paper 24. Centre for Environmental Studies, University of Tasmania.

GSA (1992). Policy on Geological Heritage in Australia. *The Australian Geologist,* Newsletter of the Geological Society of Australia Inc., No. 85: 18–19.

Hay, P. (1994). Introduction. In: *Our Common Ground—A Celebration of Art, Place and Environment* (eds J. de Gryse and A. Sant), pp. 11–15. Centre for Environmental Studies Occasional Paper 25. The Australian Institute of Landscape Architects (Tasmania) and The Centre for Environmental Studies, University of Tasmania.

Houshold, I. (1992). *Geomorphology, Water Quality and Cave Sediments in the Eastern Passage of Exit Cave and its Tributaries.* Report to the Department of Parks, Wildlife and Heritage, Tasmania.

Houshold, I. and Spate, A. (1990). *The Ida Bay Karst Study—Geomorphology and Hydrology of the Ida Bay Karst Area.* Report to the World Heritage Planning Team, Department of Parks, Wildlife and Heritage, Tasmania.

Joyce, E.B. and King, R.K. (1980). *Geological Features of the National Estate in Victoria— An Inventory Compiled for the Australian Heritage Commission.* Geological Society of Australia Inc., Victorian Division.

Joyce, E.B., Grimes, K.G. and Ollier, C.D. (draft manuscript). Classifying Geological Heritage. A methodology study for the Australian Heritage Commission. (unpublished)

Kiernan, K. (1984). *Land Use in Karst Areas. Forestry Operations and the Mole Creek Caves.* Report to the Forestry Commission, Tasmania, and the National Parks and Wildlife Service, Tasmania.

Kiernan, K. (1989). *Karst, Caves and Management at Mole Creek, Tasmania.* Occasional Paper 22. Department of Parks, Wildlife and Heritage, Hobart.

Kiernan, K. (1990). *Geomorphology Manual.* Forest Practices Unit, Forestry Commission, Tasmania.

Kiernan, K. (1991a). Landform Conservation and Protection. *CONCOM Fifth Regional Seminar on National Parks and Wildlife Management, Tasmania, October 1991. Resource Document.* Tasmanian Department of Parks, Wildlife and Heritage, Hobart, pp. 112–129.

Kiernan, K. (1991b). *The Exit Cave Quarry, Ida Bay Karst System, Tasmanian World Heritage Area—A Hydrogeological Perspective.* Report to the Department of Parks, Wildlife and Heritage, Tasmania.

Kiernan, K. (1993). The Exit Cave quarry: tracing waterflows and resource policy evolution. *Helictite* 31(2): 27–42.

Kiernan, K. (1995). *An Atlas of Tasmanian Karst.* Research Report No. 10. Tasmanian Forest Research Council.

Nash, R. F. (1990). *The Rights of Nature—A History of Environmental Ethics.* Primavera Press, Leichhardt, New South Wales.

O'Brien, M. (1990). *Future Directions in Assessing National Estate Significance.* Discussion Paper, Australian Heritage Commission, Canberra.

Relph, E. (1976). *Place and Placelessness.* Pion Limited, London.

Sharples, C. (1993). *A Methodology for the Identification of Significant Landforms and Geological Sites for Geoconservation Purposes.* Report to the Forestry Commission, Tasmania.

Sharples, C. (1994a). *Landforms and Geological Sites of Geoconservation Significance in the Huon Forest District.* Report to the Forestry Commission, Tasmania. 2 vols.

Sharples, C. (1994b). *A Reconnaissance of Landforms and Geological Sites of Geoconservation Significance in the North-East Tasmanian Forest Districts.* Report to Forestry Tasmania. 2 vols.
Soutberg, T.L. (1990). *Towards a Descriptive Geomorphic Classification System For Nature Conservation Purposes.* Occasional Paper 23. Department of Parks, Wildlife and Heritage, Hobart.
Spash, C.L. and Simpson, I.A. (1993). Protecting sites of special scientific interest: intrinsic and utilitarian values. *Journal of Environmental Management* 39: 213–227.
Stevens, C. (1994). Defining geological conservation. In: *Geological and Landscape Conservation* (eds D. O'Halloran, C. Green, M. Harley, M. Stanley and J. Knill), pp. 499–501. Geological Society, London.

Tasforests