CONCEPTS AND PRINCIPLES OF GEOCONSERVATION

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(1.0) INTRODUCTION

GEOCONSERVATION

The "forgotten half" of Nature Conservation.

Much of the focus in nature conservation is on living things - biodiversity. Geoconservation deals with the conservation of non-living parts of the natural environment - geological features, landforms and soils.

These non-living parts of the natural environment have significant values, and many aspects of this geodiversity are just as sensitive to disturbance as biodiversity. Moreover, biodiversity is dependant upon geodiversity, so that successful nature conservation requires the integration of bioconservation with geoconservation.

This document is intended to provide an introduction to the issues of geoconservation, aimed at both the general interested public and at land management professionals.

It is hoped that the information in this document will :

- inform interested members of the public about current geoconservation work in Tasmania, and why it is important;
- encourage conservationists and land managers elsewhere to develop similar approaches to integrating geoconservation into nature conservation;
- provide useful tools for conservation professionals, in the form of details of principles and procedures for implementing geoconservation management; and also:
- generate ideas and discussions which will contribute to the further development of geoconservation concepts and management approaches.

Acknowledgements
This document has been compiled by Chris Sharples, a Tasmanian geologist who has been closely involved in the development of concepts and practical approaches to the issue of geoconservation since 1992. Many of the ideas presented here were synthesised and systematised in the context of practical land management work conducted for the Tasmanian Forest Practices Unit, the Tasmanian Parks & Wildlife Service, Forestry Tasmania, various sections of the Tasmanian Department of Primary Industries, Water and Environment (DPIWE),and in the course of private consulting work. Development of ideas was also spurred by involvement in the development of the Australian Natural Heritage Charter by the Australian Heritage Commission. The development of the concepts and principles presented here was greatly assisted by discussions with Kevin Kiernan, Ian Houshold, Rolan Eberhard, Grant Dixon, Mike Pemberton, Max Banks and others.

(2.0) WHAT IS GEOCONSERVATION?

(2.1) THE SCOPE OF GEOCONSERVATION

Geoconservation aims to preserve the natural diversity - or 'geodiversity' - of significant geological (bedrock), geomorphological (landform) and soil features and processes, and to maintain natural rates and magnitudes of change in those features and processes.

Geoconservation recognises that the non-living components of the natural environment are just as important, for nature conservation, as the living components, and just as much in need of proper management. Indeed, geoconservation is an essential basis for bioconservation, as geodiversity provides the variety of environments and environmental pressures which directly influence biodiversity. The degradation of landforms, soils and waters will adversely impact on the biological species and communities living in or on them.

However, geoconservation does not focus solely on the importance of non-living things in conserving biological systems, but is also based on the premise that geodiversity has important conservation values of its own, independent of any role in sustaining living things.

It is often argued that there is no need for geoconservation because earth features are generally robust. This is commonly not the case, however. Important geological exposures such as delicate fossil or rare mineral sites are easily destroyed by inappropriate excavations or uncontrolled collecting. Ongoing land forming processes, for example in cave (karst) and river (fluvial) systems, can easily be degraded by inappropriate disturbances in their water catchment areas. Old vegetated sand dunes can be 'blown out' following disturbance of their thin stabilising soil cover by vegetation clearing, vehicle use or fires. Peat soils can be entirely destroyed by a single bushfire. These examples are just the tip of the iceberg. Indeed, geoconservation often deals with relict or 'fossil' features which are not still forming, so that any degradation is permanent and unsustainable. There is a very good reason for active geoconservation management of such features, arguably greater than bioconservation where things can potentially be 're-grown'.

If the natural values of bedrock, landform and soil systems are to be retained as part of the broader nature conservation estate, it is essential that land management procedures pay specific attention to the sensitivities which many aspects of geodiversity display.

Thus, conserving the values and sustainability of natural environments requires full integration of geoconservation into broader nature conservation programs. However, historically most geoconservation work in Australia has been focussed on a "geological heritage" approach, in which geodiversity (under various names such as 'geological monuments', 'geological heritage' or 'significant geological features') was seen as being important mainly for its value to scientific research and education. Because this approach does not address issues of intrinsic values and ecological sustainability, the 'geological heritage' approach to geoconservation has largely been ignored or treated as a minor issue in nature conservation programs because of its perceived lack of relevance to central issues in land management.

This document describes a newer and broader approach which aims to properly integrate geoconservation into its rightful role as an essential part of nature conservation. On the Australian scene, a significant part of this theoretical and practical development has occurred within Tasmanian land management agencies from the mid-1980's onwards. Because of its youth, the theoretical concepts and management approaches of geoconservation are still in a process of development.

For this reason, the principles and approaches which have been adopted by geoconservation workers in Tasmania are presented here to:

- provide ideas and principles which other workers may find a useful starting point for developing their own approaches to geoconservation

- to encourage discussion and debate on geoconservation principles and approaches, hopefully leading to further development and improvement of the approaches currently being used.

All references cited throughout this document can be found in the Bibliography (section 3.0).

(2.2) HISTORY OF GEOCONSERVATION IN TASMANIA

Although some early conservation actions, such as the reservation of outstanding caves and areas of scenic landforms, could be broadly regarded as the beginnings of geoconservation work in Tasmania, the first work clearly directed at the conservation of geodiversity in Tasmania was centred around the 'Geological Heritage' or 'Geological Monuments' approach of the Geological Society of Australia. This early work, based mostly on recognition of the scientific and research values of certain bedrock features as heritage which informs us about the Earth's past development, resulted in the preparation of two inventories of significant bedrock sites and some landform features (Jennings *et al.* 1974, Eastoe 1979).

However, whilst the 'Geological Heritage' approach is of undoubted importance, its focus on the value of significant features for scientific research and education has not been widely seen to have much immediate relevance to the broader issues of land management and ecological sustainability. This has generally resulted in geoconservation remaining something of an oddity, divorced from mainstream nature conservation, and so it has generally had low priority within land management agencies such as Parks and Forestry services.

There has long been a recognition that the management of landform and soil processes is important from the practical, utilitarian perspective of avoiding hazards such as landslips and subsidence which may impinge on the human use of certain areas. More recently, however, there has been the development of an approach centred on recognition of the fact that bedrock, landforms and soils have intrinsic values additional to their importance for scientific research, and that they need to be managed properly not only to avoid hazards, but to protect other values as well. This approach accepts the fact that bedrock, landforms and soils form the essential and integral basis of the broader ecological systems on which most nature conservation concern has been focussed. From this perspective, the integral role of geoconservation in nature conservation generally can be readily appreciated.

The presence of a large area of wilderness in Tasmania has meant that nature conservation issues generally have dominated the Tasmanian political agenda since the late 1960's, with the controversial flooding of the unique Lake Pedder landform assemblage by a hydro-electric development being widely regarded as the issue that effectively launched environmental politics in Australia generally. The political importance of conservation in Tasmania continued through the Franklin River dam issue and the forestry debates of the 1980's and 1990's. The high profile of nature conservation issues in Tasmania over this period has provided the political and intellectual environment for a broadly - based and management - relevant approach to geoconservation to be developed in recent years.

During the mid-1980's, a number of political events created a climate in which concerned geoscientists were able to directly press the case for geoconservation to be recognised as an important land management issue in Tasmania. Geomorphic values were raised as a major issue in the 1987 Helsham inquiry into Tasmanian forest conservation values (Helsham *et al.* 1988), and karst and glacial geomorphic values were prominent in the subsequent listing of extensions to the Tasmanian Wilderness World Heritage Area in 1989. Around this time (in 1986), the Tasmanian Forestry Commission (now Forestry Tasmania) began to take landform conservation seriously and a specialist geomorphologist was employed by the newly-created Forest Practices Unit. In 1988 bank erosion on the World Heritage - listed Gordon River caused the Tasmanian Parks and Wildlife Service to employ an Earth Scientist, and later concerns regarding damage to Exit Cave (in southern Tasmania) by quarrying similarly resulted in employment of a karst specialist.

Once ensconced in government land management agencies, these officers, together with other project staff, have initiated programs within their agencies to further raise the profile of geoconservation. In particular, the 1996 - 1997 Regional Forest Agreement process for Tasmania has provided an opportunity to consolidate work to date and has resulted in further theoretical development of approaches to geoconservation (e.g., Houshold *et al.* 1997; see also Jerie *et al.* 2001). The Regional

Forest Agreement process also provided an opportunity to consolidate existing geoconservation inventories into a single database, now known as the Tasmanian Geoconservation Base (Dixon & Duhig 1996). In 1999, an expert reference group known as the Tasmanian Geoconservation Database Reference Group (TGDRG) was convened to provide ongoing expert advice on the identification of sites of geoconservation significance in Tasmania.

A more detailed discussion of the early development of geoconservation in Tasmania, and a comparison with approaches elsewhere, can be found in Dixon (1995b).

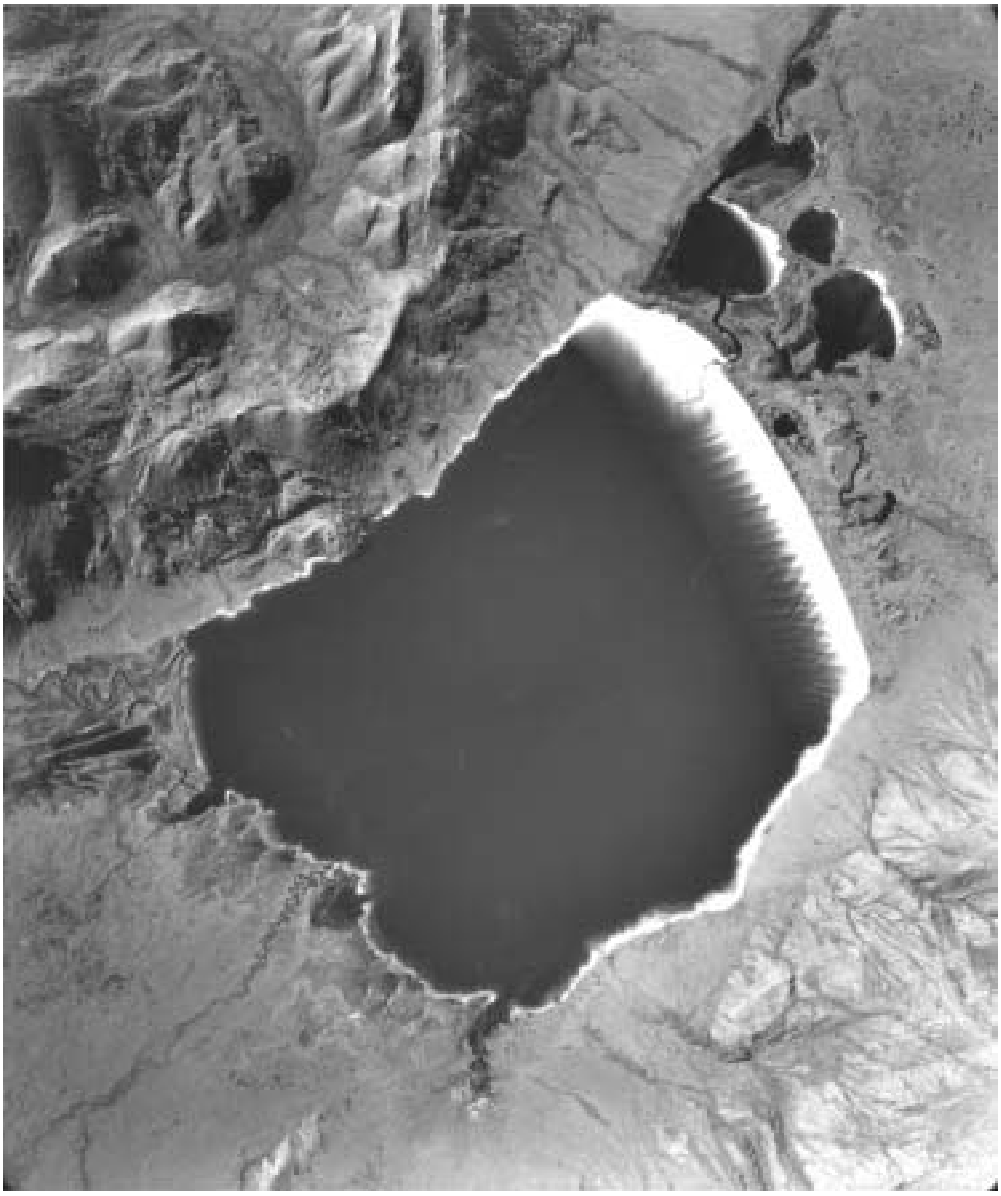

Figure: The original Lake Pedder, a lake formed during the Pleistocene when glacio-fluvial sediments impeded the Serpentine River, seen in a 1972 vertical airphoto immediately prior to being inundated beneath a much larger hydro-electric lake which was (cynically) also named "Lake Pedder". The original lake had both globally unique geoconservation values, and was a wilderness lake of outstanding aesthetic beauty. It's inundation produced an unprecedented outcry in Australia, and is widely acknowledged to have been the event which kick-started environmental politics in Australia. At the same time, the loss of this outstanding element of Tasmania's geodiversity also started a process leading to the development of concepts of geoconservation in Tasmania (see Kiernan 2001). Photo © Department of Primary Industries, Water & Environment, Tasmania.

(2.3) CONCEPTS AND PRINCIPLES OF GEOCONSERVATION

This section discusses concepts and principles of geoconservation in a moderate degree of depth. This is deliberate: geoconservation is still a relatively new field, which is developing rapidly. By describing geoconservation ideas in some detail, it is hoped to provide an outline of approaches to geoconservation which can serve as a useful source of ideas and approaches to be considered, applied and also critiqued by land managers elsewhere. Critical comments on the concepts and principles described here are welcomed.

(2.3.1) DEFINING GEOCONSERVATION

Geoconservation

'Geoconservation' can be defined (Sharples 1995a) as:

the conservation of geodiversity for its intrinsic, ecological and (geo)heritage values,

where 'geodiversity' means:

the range (or diversity) of geological (bedrock), geomorphological (landform) and soil features, assemblages, systems and processes

Compatible alternative, slightly longer and more explicit, definitions of these terms have been given by Eberhard (1997, p. v). *See* the Glossary of Geoconservation Terminology (section 2.4) for a discussion of some issues relating to the use of the term 'geodiversity'.

Geoconservation is an approach to the conservation management of rocks, landforms and soils which recognises that geodiversity has nature conservation values. Considering nature conservation to necessarily comprise both geoconservation and bioconservation provides a more wholistic approach than is often the case in purely biocentric approaches to nature conservation.

This approach is philosophically distinct from other earth science - based approaches to land management such as soil conservation, environmental geology and geomorphic hazards management, which are essentially focussed on utilitarian or anthropocentric values: that is, these latter approaches seek to prevent degradation of landforms, waters and soils (eg, by artificially accelerated landslips, soil erosion, turbidity, groundwater contamination or karst subsidence) so as to minimise the effects that such degradation may have on human use of the land. The essential distinction is that geoconservation seeks to prevent or minimise degradation in order to protect the *natural* and *intrinsic* values of bedrock, landforms and soils, rather than only to maintain their usefulness (or *utilitarian* value) to humans.

As an example of the distinction, consider a relict (inactive) landform of significant nature conservation value, such as a moraine ridge providing evidence of the maximum extent of glacial ice in Tasmania. Under the proper controls, it might be possible to entirely quarry away such a feature without creating any substantial erosion, turbidity or slumping hazards that might degrade the usefulness of the site to humans; nevertheless, a feature of high conservation significance would have been destroyed. The former hazards are a specifically 'environmental geology' issue, whilst the latter issue is a 'geoconservation' concern.

Despite this distinction, the practical interests of geoconservation and environmental geology or soil conservation overlap in many ways, since hazards such as accelerated soil erosion or artificially-triggered landslips may impact on both the natural integrity of geomorphic and soil processes, and also upon their utilitarian usefulness to humans. Thus, in practical terms geoconservation often involves the same management actions and concerns as environmental geology or soil conservation, but the broader focus of geoconservation also deals with a range of additional issues and concerns that are not normally dealt with as environmental geology issues, namely the conservation of features such as significant geological sites and cave systems for their value *as* natural features or systems.

Geological Heritage

The term 'Geoconservation', as used here, encompasses but is broader than the approaches which are known by such terms as 'Geological Heritage Conservation', Earth Heritage Conservation', 'Earth Science Conservation' or 'Geological Monuments Protection'. The latter approaches tend to focus on the protection of significant geological and landform features because of their scientific, educational, research, aesthetic and inspirational values to humans (e.g., Legge & King 1992). Geoconservation encompasses these concerns, but is based on the view that geodiversity is also important because geological, landform and soil processes are the essential basis upon which all ecological processes depend. Thus, a primary focus of geoconservation is the protection of natural geodiversity in order to not only protect features of direct scientific or inspirational value to humans, but *also* in order to maintain the natural ecological (including biological) processes which are the focus of most nature conservation concerns.

Examples

The Tasmanian Geoconservation Database (Dixon & Duhig 1996) lists Tasmanian features and systems which have been identified to date as having geoconservation significance. The following brief list, excerpted from the Tasmanian Geoconservation Database, is provided here to illustrate the variety of features and systems which may be of geoconservation concern, and briefly identifies some of the management issues which may be involved.

Picton River Fossil Site

Rich assemblage of silicified Ordovician fossils standing proud of limestone matrix, spectacularly exposed on sloping surfaces by natural weathering of limestone outcrop. The excellent exposure is dependant upon natural weathering, and the exposed fossils are delicate and easily crushed. The protection of site values depends on preventing artificial excavation of the site and avoiding excessive sampling, trampling and crushing of the exposed fossils. To prevent damage by uncontrolled collecting or trampling, the site location is currently being kept unpublicised.

Poatina Triassic Section

Important stratigraphic section through the Triassic sedimentary sequence, exposed in road cuttings. Appropriate management involves maintaining road cutting exposures by avoiding covering of cutting exposures with fill or vegetation, and re-exposing weathered surfaces where possible.

Northeast Highlands Exhumed Pre-Permian Landscape Surface

Largest portion of the pre-Permian landscape surface (unconformity) exhumed in Tasmania, and forming part of the modern landscape surface. Values reside in large scale form only, which is robust and requires no specific management prescriptions.

Wielangta Slump Landform Complex

Excellent examples of slope mass movement landforms formed at the end of the Last Glaciation (including slump ponds with Holocene pollen records). One of the best examples of such landform complexes in Tasmania, and important for scientific information about Last Glacial environments and processes in Tasmania. Susceptible to renewed slumping and instability if slope soils, vegetation and drainage are disturbed (thus, management involves both geoconservation (values) and environmental geology (hazards) issues).

Junee - Florentine Karst

One of the most extensive active karst systems in Tasmania, including the deepest and some of the longest caves in Australia, with numerous attributes including importance in maintaining natural karst and fluvial processes, and the ecology of the Junee - Florentine area. Partly in State Reserve, partly State forest. The complex nature of the karst system has been studied in several major geoconservation management studies, and a regime of special management prescriptions and protection zones have been implemented by Forestry Tasmania to protect karst features and processes.

Henty Dunes Aeolian Landform Assemblage
One of the largest complexes in Tasmania of both active and fossil (vegetated) dunes of Pleistocene to Holocene age. Plantation forestry is currently conducted on the vegetated dunes. Development of special logging prescriptions is urgently needed to protect the thin dune soils and prevent unnatural wind erosion of the fossil Pleistocene dune forms.

Western Tasmania Blanket Bog Peat Soils
Most extensive blanket bog peat soils in the southern hemisphere, and possibly the most extensive areas of undisturbed blanket bog in the world. Highly susceptible to destruction by inappropriate burning, resulting in extensive erosion of underlying substrate. Large portions lie within State Reserves, but are not immune to management burns which therefore need to be properly timed and controlled to protect the soils.

(2.3.2) THE NEED FOR GEOCONSERVATION

Geoconservation is important because:

- •Geodiversity has a range of values which are important and worthy of protection; and:

- •Geodiversity includes many features and processes of significant value which are sensitive to disturbance and which, in areas subject to human activities, may easily be degraded if they are not specifically managed for. Furthermore, many elements of geodiversity are relict or 'fossil' features which are irreplaceable if degraded.

These two points are discussed further below, followed by further elaboration on the issue of sensitivity:

The Value of Geodiversity
Geodiversity may be considered to be of conservation value from a variety of perspectives, and numerous workers have provided long lists of reasons for considering certain bedrock, landform or soil features and processes to be of value. However, most values which have been identified in the literature (see bibliography section 3.0) can be subsumed under one or more of three (partly overlapping) basic groups of values (Sharples 1995a, Kiernan 1997b), namely:

- *Intrinsic (or 'existence') value*
- *Ecological (or 'natural process') value*
- *Human* - *centred (anthropocentric or (geo)heritage) values*

Each of these three value groups is discussed below.

Intrinsic (or 'existence') Value
To say that a thing has intrinsic value is a commonly misunderstood statement; it does not necessarily mean that it has to be a sentient, conscious being worthy of being hugged! Rather, the concept of *Intrinsic Value* (or 'Existence Value') simply means that the existence of a thing may be of value *in itself,* rather than only because of some purpose that humans (or even other living things) might put it to. It constitutes a rejection of the anthropocentric view that nothing is of value unless it is of *direct* value or usefulness to humans, and implies that things do not necessarily need human approval to justify their continued existence (Kiernan 1997b).

Although the idea of intrinsic value is a well recognised concept in nature conservation thinking (eg, see Nash 1990, Fox 1990, Spash & Simpson 1993), many workers in Geological Heritage have difficulty coming to terms with it, preferring instead to justify geoconservation purely on the grounds that certain things should be conserved because they are of direct scientific or aesthetic value to humans (eg, Legge & King 1992).

However, to say that a geological feature or landform has intrinsic conservation value is in the final analysis simply to say that it should be conserved because it is a good example of its type, regardless of whether humans actually scientifically study or even look at it. Recognition of the intrinsic value of geodiversity constitutes a widening of the focus of our ethical concerns beyond humans and even beyond living things, so that we can give moral consideration to non-human things to the extent of saying that: "a well developed representative example of a class of landform *should* be protected *simply* because it is a good example - no other justification (such as value for scientific research) is needed". (Note that in this example the use of the term 'should' is indicative that a moral claim is being made.)

Recognition of intrinsic value as an ethical value with moral consequences does not imply a blanket ban on human exploitation of the earth, any more than giving ethical consideration to other humans precludes exploiting their services. Rather, it means that while humanity may have a right to exploit natural resources to fulfil our own legitimate needs and purposes, it should not be done in such a way that the diversity of natural geological, geomorphic and soil features and processes (geodiversity) is unnecessarily reduced by the unnatural elimination of entire classes of things, or in such a way that representative systems of natural processes are no longer able to unfold and evolve in their own ways (Sharples 1995a). See further discussion of intrinsic values in 'Judging Significance' (section 2.3.4).

Objections to Intrinsic Value Theory
Some have argued that it is not possible to conceive of non-human things having intrinsic value because entities cannot be said to be worthy of moral consideration in their own right if they are not themselves capable of (consciously) demanding moral consideration and of extending it to others (Fox 1990, p. 184). However this 'contractual' view of ethics and morality is in itself no more than a subjective judgement about what should constitute the basis of ethical relationships, and no logical fallacy is invoked by rejecting it; moreover, the statement is belied by the fact that we would normally extend moral consideration to humans who are neither conscious nor capable of extending moral consideration to others (eg, brain damaged people in comas).

Again, it is sometimes maintained that the idea of attributing intrinsic value to non-human things is incoherent, because such a value is one held or promulgated by humans anyway - in other words, it is still an anthropocentric value judgement because it is a value judgement made by humans. However, as Fox (1990, p. 20) notes, this argument fails to distinguish between a trivial, tautological, sense of anthropocentrism (i.e., that all human statements are statements by humans), and a strong, informative sense that humans may make substantive statements about non-human things.

The fallacy is the same as that in claiming that it is incoherent for a male to support women's rights, or for a white person to support the rights of black people; it confuses the trivial fact of our *identity* as humans arguing against anthropocentrism with the strong fact that, in arguing for recognition of non-anthropocentric intrinsic values, we are arguing in a substantive and informative way against the treatment of non-human things in a way which assumes they merely exist solely for human use or enjoyment. For a human to argue that non-human things have value beyond their usefulness to humans is no more incoherent than for a white man to argue that black women have rights of their own irrespective of white men's claims.

The conflation of the trivial (tautological) and the strong (informative) senses of a statement is known in philosophy as the *fallacy of equivocation*, and Fox (1990, p. 21) refers to the version of this fallacy which suggests that a human cannot hold substantive non-anthropocentric values as *the anthropocentric fallacy*.

A number of other objections to the idea of intrinsic values are discussed and refuted in some detail by Fox (1990, p. 184 - 196). Further useful reading on the philosophical aspects of intrinsic value theory can be found in Fox (1990), Nash (1990).

Ecological or Natural Process Values
The *ecological value* of a thing or process is it's importance in maintaining natural systems and ecological processes of which it is a part. Noting that 'ecosystems' are understood as comprising both biotic and abiotic components which interact and are interdependent, the 'ecological value' of geodiversity can be understood as its importance in both maintaining geological, geomorphic and soil processes in themselves, and also in maintaining the biological processes which depend upon those physical systems.

Recognition of the importance of geodiversity in underpinning ecological processes is the key to integrating geoconservation within the broader field of nature conservation. The traditional biocentric bias of most nature conservation management should be modified by the recognition that it is not possible to conserve biological species and communities without also conserving the physical earth processes upon which these depend, and which have had a major influence on plant and animal evolution for the best part of 4,600 million years.

One example commonly given is the extreme dependence of cave-adapted organisms on the continuity of natural karst geomorphic processes and habitats. However, the same general principle holds true for all geomorphic and soil processes.

Human - centred (anthropocentric or heritage) Values

The direct values of geological, landform and soil systems to humans, as our 'geoheritage', are the reasons most frequently cited to justify geoconservation, and these are indeed important, albeit not the only, reasons to value geodiversity.

Geoheritage comprises those elements of natural geodiversity which are of *significant* value to humans for non-depleting purposes which do not decrease their intrinsic or ecological values. The import of this definition is that it implies a distinction between the utilitarian *resource* values derived from the removal, processing or manipulation of rocks, landforms and soils by means such as mining, engineering or agriculture, and the *conservation* values of rocks, landforms and soils as heritage in their natural state.

Geoheritage may be of value to humans as:

- providing scientific evidence of the past development of the Earth, and of the evolution of life on Earth;
- sites of importance for research and education;
- features which inspire us because of their aesthetic qualities or because of the insights they give us about the nature and origin of the Earth, and of life on Earth;
- features of recreational or tourism significance (e.g., mountains, cliffs, caves, beaches, etc);
- features which form the basis of landscapes that have contributed to the 'sense of place' of particular human communities;
- features which play a role in the cultural or spiritual values of human communities (e.g., sacred caves and mountains).

Although it is useful to conceptually separate the three broad value groups discussed above, they do overlap in many respects. For example, the ecological value of geodiversity is also of direct value to humans in maintaining the amenity of the environment in which we live.

The Sensitivity of Geodiversity

There is a widespread misconception, which still prevails amongst some land managers, that rocks and landforms are mostly robust, so that no special management of their values is necessary. Whilst this is true of some features, there are many aspects of geodiversity which are highly sensitive to disturbance. A sampling of examples includes:

- Important fossil or mineral sites of limited extent, whose scientific value may easily be destroyed by uncontrolled excavation or over-enthusiastic amateur or scientific collecting (e.g., see Banks 1976).

- Active karst and fluvial landform systems whose ongoing processes may be degraded by activities such as quarrying or excessive vegetation clearance in their catchment, resulting in changes to hydrological regimes, sediment budget, water chemistry and a range of other parameters which may in turn destroy landforms and extinguish biological communities living within the karst or fluvial landform systems (e.g., see Bradbury *et al.* 1995, Kiernan 1988, 1995b, Houshold 1997, Gillieson 1996).

- Inactive (relict or 'fossil') landforms, such as Pleistocene sand dunes and glacial moraines in Tasmania, are significant aspects of our geoheritage that tell us about past environmental conditions. Since they were formed by processes no longer acting, they cannot be regenerated if destroyed, and their defining forms can be destroyed if disturbed by excavations or artificially accelerated erosion (e.g., Kiernan 1996).

- Many soil types are sensitive to a range of accelerated erosion and other degradation hazards. Good examples from a geoconservation perspective are the sensitivity of limestone soils (e.g., Gillieson 1996), and the susceptibility of the globally rare blanket peat bog soils of western Tasmania to destruction by improper fire management (e.g., Pemberton 1988, Horwitz *et al.* 1997).

A small sampling of specific cases of degradation of features and systems of geoconservation value which have occurred in Tasmania includes (but is not limited to):

- Inundation of the Lake Pedder landform assemblage (by hydro-electric development) causing changes to natural processes and impeding access to the site.

- Removal of a terminal moraine marking a maximum glacial ice advance in the Mersey Valley (by quarrying for construction materials).

- Severe erosion of levee banks and other alluvial deposits on the World Heritage - listed lower Gordon River (by the wake from tourist cruise boats).

- Removal of a clear and striking exposure of Precambrian folding near Somerset (by excavation due to road realignment).

- Removal of all surface evidence of sub-basaltic silicified tree trunks from exposures at Macquarie Plains and Petrifaction Bay, Flinders Island (by souveniring and uncontrolled collection).

- Destruction and removal of speleothems from Croesus and Lynds Caves, Mole Creek area (by souvenir hunters, and for possible commercial sale).

- Excavation, then burial, of travertines containing Tertiary marsupial fossils, Geilston Bay (by quarrying and subsequent landfill).

- Destruction of karst features and degradation of karst processes at Exit Cave (by limestone quarrying in part of the cave system).

- Ongoing degradation of Newdegate Cave, Hastings (through tourism impacts).

- Degradation of thermal spring mounds and associated swamps, Smithton area (by agricultural and residential developments).

- Alteration of natural dune forming processes and dune forms across large parts of the coast, particularly in northeast Tasmania (by marram grass stabilisation).

- Ongoing erosion of dunes and Aboriginal middens in the Arthur/Pieman Rivers area (through off-road vehicle use and cattle grazing).

- Erosion on Tasmania's central plateau, resulting in the loss of an estimated 9,000,000 m^3 of alpine soils (through grazing and firing).

- Loss of at least 300,000,000 m^3 of organic soils (blanket bogs) in western Tasmania (because of wildfires and inappropriate management burns).

- Covering of exposures of geochronologically - important Cooee Dolerite at Burnie foreshore (by land reclamation and coastal protection works).

- Degradation of rare magnesite karst and associated warm spring, Arthur River area (by mineral exploration excavations and commercial tapping of spring).

Terminology
Some terms to describe aspects of the sensitivity of geodiversity to disturbance are defined and discussed in the Glossary (section 2.4).

Some General Distinctions between the Sensitivities of Bedrock, Landform and Soil Features
Although it can be dangerous to generalise, some broad distinctions between the characteristic sensitivities of the geoconservation values of bedrock features, landforms and soils can be identified (Kiernan 1991a, 1997b, Sharples 1995a, Dixon *et al.* 1997a). These are outlined below. Although there are numerous exceptions to these generalised distinctions, they have broad implications for the types of management appropriate to the conservation of bedrock features, landform systems and soils that are considered to have significant geoconservation value. These broad distinctions are:

Geological (bedrock) Sites
Where bedrock features (e.g., fossil sites, stratigraphic type sections or exposures of important structural relationships) are considered to have geoconservation values, those values reside essentially in the *contents* of the rocks - their internal structures and constituents which provide evidence of past processes - independently of relationships to the present land surface. Bedrock geological features are for the most part only indirectly involved in ongoing surface and ecological processes, to the extent that they condition the development and character of the landforms and soils which are the active interface between the earth and the surficial environment (albeit this distinction is weaker in the case of groundwater processes, for example).

Thus, in some cases the geoheritage (scientific and educational) values of bedrock sites may be enhanced by artificial disturbances such as excavations which better display their contents. Note however that *excessive* excavation can destroy site values. A further exception occurs where naturally weathered surfaces display the bedrock contents better than a freshly broken surface (such as the spectacular exposure of silicified fossils on weathered limestone surfaces).

Geomorphic (landform) Features and Systems
In contrast to purely bedrock features, landforms are defined by their surface contours, and in the case of active landform systems, are dependant upon ongoing natural processes for the maintenance of their integrity. Furthermore, all landforms - whether active or relict - are integral to ongoing surface processes, which are also the basis of ecological systems.

Therefore, in contrast to features valued purely for their bedrock characteristics, the disturbance of significant landform contours (e.g., by excavation) will by definition degrade their geoconservation values, and may also interfere with ongoing geomorphic and ecological processes. Interference with the natural rates and magnitudes of change in ongoing geomorphic processes may degrade landform system values.

Soil Sites and Systems
Soils are defined by the nature of their profiles relative to surface and bedrock, and are also integral to ongoing natural surface processes.

The geoconservation values of soils are therefore degraded by activities which disturb their profiles and their ongoing soil-forming processes. Such disturbances may include soil erosion, compaction, puddling, mixing and large scale excavations, whilst changes to vegetation cover and hydrological regime may also degrade soil-forming processes. For instance, removal of native vegetation has the potential to decrease native invertebrate habitation by 50%, with major impacts on soil processes. Such degradation may in turn impact on groundwater and other ecological processes.

Degrees of Sensitivity
Particular elements of geodiversity cannot be simply classified as either 'robust' or 'sensitive' to disturbance; rather, any element of geodiversity will be sensitive to some types of disturbance and robust in the face of others. Hence, in assessing the sensitivity of particular features or processes, it is necessary to identify the disturbing activities in terms of which the assessment is being made.

To provide a means of classifying the sensitivity of geodiversity with this in mind, Tasmanian geoconservation workers are trialling a 10 - point scale of sensitivities for geodiversity, which is provided below. This scheme is intended to be simple, not tied to land tenure, and capable of providing a clear idea of what sorts of activities might degrade features of a given sensitivity level. In essence, the scale runs from most sensitive (1) to most robust (9 or 10) features. In a broad way, a more protective management response is required for sensitive features numerically low on the scale, whilst features of sensitivity 9 or 10 will normally require little or no active conservation management.

***Scale of Sensitivities in Geoconservation*:** Indicative sensitivity scale for geoconservation values, based on the intensities and patterns of disturbance entailed in particular land use practices (from: Dixon & Duhig 1996, Dixon *et al.* 1997a, Kiernan 1997b; based on a scheme developed by Kevin Kiernan):

1 *Values sensitive to inadvertent damage simply by diffuse, free ranging human pedestrian passage, even with care.*
Examples: fragile surfaces that may be crushed underfoot, such as calcified plant remains; gypsum 'hairs' in some karst caves that may be broken by human breath.

2 *Values sensitive to effects of more focussed human pedestrian access even without deliberate disturbance.*
Examples: risk of entrenchment by pedestrian tracks; coastal dune disturbance; drainage changes associated with tracks leading to erosion by runoff; defacement of speleothems simply by touching their surface.

3 *Values sensitive to damage by scientific or hobby collecting or sampling, or by deliberate vandalism or theft.*
Examples: some fossil and mineral sites; speleothems.

4 *Values sensitive to damage by remote processes*
Examples: degradation of geomorphic or soil processes by hydrological or water quality changes associated with the clearing or disturbance of catchments; fracture/vibration due to blasting in adjacent areas (e.g. to stalactites in caves); karst sites susceptible to damage if subsurface seepage water routes change due to creation of new fractures.

5. *Values sensitive to damage by higher intensity shallow linear impacts, depending upon their precise position.*
Examples: features whose values would be degraded by vehicular tracks, minor road construction, or excavation of ditches or trenches.

6 *Values sensitive to higher intensity but shallow generalised disturbance on site.* (This might involve either the removal or addition of material.)
Examples: values which may be degraded by: clear felling of forests and replanting, but without stump removal or major earthworks; light snig tracks and associated drainage changes; land degradation such as soil erosion due to bad management practices; natural revegetation, covering and/or weathering of artificial exposures or by human-promoted site rehabilitation (resulting in degradation of significant bedrock exposures in quarries or road cuttings).

7 *Values sensitive to deliberate linear or generalised shallow excavation.*
Examples: values which may be degraded by minor building projects; simple road construction; shallow borrow pits; plantation establishment involving the removal of stumps.

8 *Values sensitive to major removal of geo-material, or large scale excavation or construction.*
Examples: values which may be degraded by quarries; sites of large dam construction.

9 *Values sensitive only to very large scale contour change.*
Examples: values which may be degraded by very large quarries or open cut pits.

10 *Special Cases*
Examples: values which would only be destroyed by erosion caused by sea-level rise from humanly - induced greenhouse warming, or by catastrophic events such as meteorite impacts; large water impoundments where the value is rendered inaccessible through inundation beneath an artificial reservoir, and its natural processes are rendered inoperative, although the physical characteristics of the site may remain intact. Large regions whose geoconservation values reside essentially in their large scale form (e.g., very large structural landforms) will commonly have a sensitivity of 10.

(2.3.3) THE AIMS OF GEOCONSERVATION

Introduction - Aims

Two basic aims of geoconservation management can be identified:

- *Maintenance of Geodiversity*
  Geoconservation aims to retain significant representative examples of the (geo)diversity of bedrock, landform and soil features. This aim encompasses the traditional 'geological heritage' approach of conserving features for their research and education value (see Defining Geoconservation: section 2.3.1), but goes further by recognising a wider range of values underpinning geodiversity. Thus, this aim is important for maintaining the richness of our geoheritage, because geodiversity underpins the integrity of broader ecological processes, and also in recognition of the intrinsic value of geodiversity.

  In practice, this aim of geoconservation tends to be approached through the development of inventories of specific important elements of geodiversity which should be managed to protect their natural values (see Identification of Significant Sites and Processes: section 2.3.5).

- *Maintenance of natural rates and magnitudes of change*
  Geoconservation aims to keep ongoing geological, geomorphological and soil processes operating - and changing and evolving - within natural limits both because of the intrinsic value of the geo-processes themselves, and also to maintain a natural balance in broader ecological processes which depend upon geo-processes. Hazards such as accelerated karst subsidence, accelerated erosion and landslips due to human disturbances are examples of unnatural rates and magnitudes of change in geomorphic and soil systems.

  This aim essentially means *maintaining natural processes* and *maintaining the capacity of natural systems to change and evolve in their own ways.* However, this aim has been formulated as "maintaining natural rates and magnitudes of change" in order to emphasise that the aim is not to preserve a static natural 'museum', but rather to maintain the capacity of natural systems to change and evolve in natural (rather than artificially accelerated) ways.

  This aim of geoconservation tends to be approached not only through the development of inventories of significant sites and systems, but also through the general application of management principles designed to support the continuing functioning of natural processes wherever and to whatever extent it is feasible and practicable to do so in any given situation. However, there is considerable overlap with the inventory approach, in that it goes without saying that active systems listed in a geoconservation inventory should be managed to maintain the natural rates and magnitudes of change in those systems.

A commonly voiced presumption (one might say, a hoary old chestnut...) amongst some geologists is that, because the geological record shows that dramatic changes in the Earth's environment have sometimes occurred in the past, similar changes are implicitly more or less acceptable today. Some people have, with straight faces, used this sort of argument to justify the destruction of significant landforms on the grounds that natural erosion will sooner or later do the same thing anyway. However, if we took this line of argument seriously, then nothing would be worthy of protection since nothing will last forever anyway! More seriously, this argument takes no account of the differing environmental conditions and processes applying at the time of geologically - rapid changes, nor of the natural time scales and rates of change involved in processes such as erosion. The emphasis in geoconservation on maintaining *natural rates and magnitudes of change* is important because it highlights the fact that, whilst the earth is a dynamically changing environment, it is neither natural nor necessarily desirable for such changes to be artificially accelerated by human activities.

We can distinguish two broad groups of phenomena whose diversity and natural rates and magnitudes of change geoconservation aims to maintain, namely relict or 'fossil' features formed by past processes that are no longer active today, and contemporary or 'active' features which are being formed by processes that are ongoing today. These two groups of phenomena have implications for the management of geoconservation which differ in certain respects, and these are discussed below:

Ongoing Process Systems

Contemporary landform and soil systems are those which are actively developing under the influence of ongoing environmental conditions. In Tasmania, such systems include fluvial and karst landform systems, as well as most soils, coastal phenomena and minor periglacial phenomena. In part, these contemporary systems involve the gradual modification of older relict features by natural modern day processes. Contemporary landform and soil systems are important to geoconservation not only because of the intrinsic and heritage value of the diversity of phenomena they display, but also because the active processes involved are an important basis for the earth's ecological systems; thus a major aim of geoconservation is to maintain the natural rates and magnitudes of change in contemporary landform and soil systems because of their ecological values as well as their 'geoheritage' value.

Because the development of contemporary features is ongoing, some degree of damage to significant features may be self-repairing if artificial disturbances are removed and the natural processes re-instated. Thus, for example, a river system choked by sediment resulting from alluvial mining operations in the catchment may eventually be able to scour out the excess sediments and its channels may return to their natural bed forms if the source of accelerated sedimentation is removed.

However, the self-repairing capacity of ongoing natural landform and soil systems is limited by factors of *time* and *scale*. Many instances of artificial degradation in a natural landform or soil system will only be naturally repaired over time scales far longer than human lifetimes. Furthermore, many instances of degradation will be of such a scale that the original state will never be regenerated; rather, the system will settle into a new state in equilibrium with its artificially altered surrounding environment. Thus, increased rates of surface runoff and flooding in an urbanised or agricultural catchment area may result in the erosion of river channels into permanently enlarged forms.

In both cases - long delayed regeneration of natural features, and permanent alteration to natural systems - any significant natural values will have effectively been lost due to the artificial acceleration of natural rates and magnitudes of change in the contemporary process systems. This will in turn impact on other aspects of natural ecological systems which are dependant on the natural landform and soil systems, potentially resulting in the loss of associated significant biological and other ecological values.

Some degree of long term or permanent change to ongoing natural process systems may be acceptable in areas which human society wishes to occupy or exploit for natural resources in order to further the legitimate aims of human society. However, where the natural geoconservation values of an area or a contemporary landform or soil process system are considered to be of sufficiently high significance as to warrant their protection, then the appropriate management response must be to minimise or eliminate artificial acceleration of the natural rates and magnitudes of change in those systems. In active process systems, this requires an integrated systems approach which considers not only specific landforms or soils themselves (a 'site-based' approach), but that also considers the totality of the processes controlling the ongoing development of those features. Thus for example, in the management of significant ongoing karst or fluvial landform systems, it is essential to protect natural geomorphic processes throughout the catchment basin, not just in the local area of the specific caves or river channels that may be thought of as significant sites.

Relict ('fossil') Features
Relict features include the majority of bedrock geological phenomena that are considered to be of geoconservation significance, landforms produced by past environmental conditions (such as glacial moraines in Tasmania), and buried soil horizons (palaeosols). The significance of these features to geoconservation is primarily based upon their intrinsic and geoheritage value as records of the past development of the earth and its surface environments - they are the heritage that has been inherited from the past, and without which we would have no idea of how the earth, and life itself, came to be what it is today.

Because relict features are no longer forming today, any artificial damage to them is irreversible, and the destruction of such features will result in their permanent loss. Their protection therefore requires controls on such activities as artificial excavation.

On the other hand, the protection of such features does not require maintenance of the broader processes which formed them, since those processes have ceased anyway. Thus, in contrast to active process systems, the protection of relict features can often be achieved with a largely site-based approach that mostly considers the protection of the specific feature itself with less need to consider the ongoing processes in surrounding regions. This is the approach usually taken to the protection of, for example, important fossil exposures: provided the exposure site itself is protected from excessive artificial excavation or covering, and from accelerated erosion or mass movement, then the geoheritage values of the site will be preserved even though ongoing land-forming processes in the surrounding region may be altered by human activities. However, it is important to be aware that this is a generalisation, and that there will be cases in which artificial disturbances in the broader surrounding environment will result in process changes, such as increased fluvial erosion and sedimentation, that may impact on the values of the significant site itself (as for example, a significant fossil site in a river bank which is at risk of eroding away due to unnaturally increased flooding resulting from human disturbances in the catchment).

Site Function
Consideration of the differing management requirements of active and relict features of geoconservation significance highlights the need to have a clear conception of the 'site function' of a phenomenon of geoconservation significance. Site function depends upon the particular values for which a phenomenon is considered to be of geoconservation significance.

Thus, a relict feature whose value lies primarily in its importance as part of our scientific heritage may perhaps be appropriately managed as an isolated feature requiring only protection of a limited site area. In some cases, such as bedrock geological exposures of fossils, minerals or structural and sedimentary features, limited excavation of the site may be beneficial for scientific research and education purposes. However, in the case of a relict *landform*, excavation for scientific purposes is problematical, since such excavation will disturb the surface contours which define the feature (see also 'Some General Distinctions between the Sensitivities of Bedrock, Landform and Soil Features': section 2.3.2). In many cases it will be appropriate to consider geomorphic research requiring excavations of significant relict landforms to have lower priority than maintaining landforms in their natural condition in recognition of their intrinsic value as undisturbed geoheritage. In this case, intact landform morphologies are available for scientific study, but access to landform contents 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 desired, it is a case of making the value judgement that there are situations in which other ethical 'goods' should take precedence over availability for scientific research.

On the other hand, where a feature is valued as an integral part of an active, ongoing geomorphic or soil process system, its site function will require both minimal disturbance of the specific feature or assemblage of features, and also protection of the broader processes in the surrounding environment which are controlling the ongoing development of the feature, and its integral role in ongoing ecological processes.

Features and Assemblages

The above discussions have emphasised the fact that it is generally inadequate to manage specific individual features (e.g., an individual cave or stretch of river bank) within active landform or soil systems in isolation from other components of the systems of which they are part - active landform and soil systems need to be considered and managed as integrated assemblages or systems, rather than as isolated features, because they are all linked by the effects of ongoing processes.

However, although it is noted above that individual relict (inactive) features can on the other hand sometimes be protected in isolation from their surrounding, this too is not always the case. In many cases, particular relict features form part of broader assemblages of relict features having a common origin. Such features have less meaning considered in isolation, and their full scientific significance only becomes apparent in the context of the larger assemblage of related features. Thus, whilst a glacial cirque produced by past glacial processes may be of some interest in isolation, its full significance only becomes apparent when it is considered in the context of an assemblage of related features, such as the over-deepened rock-basins, rochés moutonnées, eskers, moraines and outwash deposits, which the same glacier produced. Without the evidence provided by the assemblage of related features, the information which any one isolated feature can give us about past processes is limited. Thus, whilst each relict feature may be capable of being protected on an individual site basis, it is still important to aim for the protection of a fully representative assemblage of related features, rather than just one or two individual components of the total related assemblage.

Replication

'Replication' here refers to the *identification* of multiple examples of particular features, assemblages or systems as having geoconservation significance and being worthy of protection as necessary (Sharples 1993, 1995a), rather than to the actual number of examples of each feature (etc) that exist.

It is generally appropriate that more than just a single example of any particular type of feature or system be identified as significant and, if necessary, protected for geoconservation purposes. From the perspective of maintaining geodiversity this is important because:

- a particular example of a feature may become degraded for unforeseen reasons, thus replication provides some security against the complete loss of a particular aspect of geodiversity;

- replicated examples of a class of feature occurring over a broad region are necessary to maintain geodiversity at local scales; and

- variability within a class of related features can only be represented by a replicated suite of such features.

From the perspective of maintaining natural rates and magnitudes of change in geomorphic, soil and ecological systems, replication is important because:

- maintenance of ongoing natural process systems requires that the component parts of such systems be replicated across a region - protection of only one example of each component part of a natural system will not allow the whole system to remain viable.

Criteria for determining the appropriate degree of replication for particular features, assemblages and systems include:

Rarity:
The fewer examples of a phenomenon that exist, the more important it is to protect a higher proportion of extant examples in order to guard against the possibility of all examples being degraded or destroyed for unforeseen reasons. For example, where a particular fossil assemblage is known from only two or three locations, it is arguable that all the sites should be identified as significant and protected. On the other hand, a common fossil assemblage may only need to have its very best occurrences identified as significant and protected, although in such cases ongoing reviews of conservation status should be conducted to ensure sites of a 'common' type do not become rare in future.

Sensitivity:
Easily degraded types of features need a higher degree of replication because of the higher risk of individual examples being degraded. It is partly for this reason that most well-decorated limestone caves - a sensitive landform type - are considered worthy of protection. Easily degraded soil types and vegetated dunes, for example, are similarly worthy of a high degree of conservation replication.

Ecological importance:
The more important the role of a feature is in maintaining ecological processes (i.e., the higher its ecological significance), the more important it is that replicated examples be protected to ensure the protection of those ecological processes. Thus, in most fluvial systems the protection of all active channels is important, as is the protection of all potentially unstable slopes. On the other hand, the specific identification of stable slopes as ecologically significant landforms requiring protection may be less important.

Scientific importance:
In the case of a simple and uniformly repeated phenomenon (e.g., a common type of fossil assemblage), protection of a relatively small number of examples may suffice to ensure the phenomenon remains available for research and education. However, a complex, variable or poorly understood phenomenon may require a greater degree of replication to ensure protection of sufficient sites to allow the understanding of the feature. For example, in a glacial landform assemblage which is poorly understood, it is arguable that all known glacial features are important in piecing together the overall glacial development of the area. With further study, it may become possible to define certain features within the assemblage as being common components and less in need of replication, but in the interim precautionary considerations demand a greater degree of replication.

(2.3.4) THE CONCEPT OF SIGNIFICANCE

The concept of '*significance*' is fundamental to geoconservation. Determination of the range and extent of features and systems which should be explicitly managed to protect their geoconservation values revolves around identifying which features are *significant* (Dixon 1991): that is, we direct our primary management efforts towards the conservation of those things we consider to be significant. In essence, judging a thing to be of geoconservation significance means judging that its conservation is meaningful or important to the realisation of one or more of the overall *aims of geoconservation*, namely the maintenance of geodiversity and the maintenance of natural rates and magnitudes of change in earth systems.

The Need for a Concept of Significance

The need for a concept of significance (and indeed, for geoconservation in general) arises from the fact that human society uses, alters, exploits and depletes rocks, minerals, landforms and soils in the course of fulfilling its needs and purposes. This results in the depletion of some elements of geodiversity and a greater or lesser degree of alteration to natural rates and magnitudes of change in some natural systems. Assuming agreement that it is legitimate for human society to pursue its own ends through some degree of exploitation of natural resources, it is therefore not possible to preserve all individual occurrences of every element of geodiversity, nor is it possible to avoid altering natural rates and magnitudes of change in some examples of natural systems.

However, as noted previously (in 'The Need for Geoconservation' section 2.3.2), an underlying principle of geoconservation is the recognition that, while humanity may have a right to exploit natural resources to fulfil our own legitimate needs and purposes, this should not be done in such a way that the diversity of natural geological, geomorphic and soil features and processes (geodiversity) is unnecessarily reduced by the elimination of entire classes of things, nor in such a way that at least representative examples of natural systems are no longer able to unfold and evolve in their own ways (i.e., at natural rates and magnitudes of change).

We therefore need a means of assigning conservation priorities, so that we identify which concrete examples of the various elements of geodiversity are of the highest priority for conserving in their natural state in order to best fulfil the aims of geoconservation, and which can be justifiably altered and exploited by human society to serve the legitimate needs and purposes of humanity. A means we can use to assign such priorities is to assign levels of significance, such that the assignment of "high significance" identifies those things that are of highest priority for preserving their natural values, whilst the assignment of "low significance" denotes things whose disturbance or exploitation will not substantially reduce the overall conservation value of natural systems.

Judging Significance

We can identify two stages in judging the conservation significance of things: we must first decide on criteria by which to assess significance, and then use those criteria to assign levels of conservation significance (from high to low) to particular phenomena in order to determine conservation management priorities. This section addresses the first of these stages - identifying criteria of significance - whilst the second stage is addressed in the later section 'Assigning Levels of Significance'.

Criteria of Significance

The normal approach to judging the conservation significance of a thing is to evaluate its qualities and characteristics against a list of criteria. As one example, Rosengren & Peterson (1989) assessed significance in terms of two groups of criteria:

1. The importance of a feature in displaying past and present geological, geomorphological or soil processes and allowing analysis of the evolution of a region; and

2. The contribution a feature makes to defining the physical characteristics of a region.

Virtually every geoconservation and 'Geological Heritage' study to date has commenced by drawing up - in greater or lesser specific detail - such a list of criteria in terms of which significance will be judged, and has then proceeded to identify as significant a suite of things which best fit those criteria (e.g., Eastoe 1979, Davey 1984, Rosengren 1984a, Cochrane & Joyce 1986, Kiernan 1989a, Dixon 1991, Sharples 1993, Dixon & Duhig 1996, etc).

A relatively recent development aimed at making this approach more systematic and defensible has been to classify groups of phenomena which are of conservation interest, to draw up a type profile of each class of phenomena within those classified groups, and to then compare individual examples of the phenomena in each class against the type profile for that class, so as to determine which examples fall above or below a 'threshold of significance' (O'Brien 1990). In this approach, to fall above the threshold of significance essentially means that the example under consideration fits the characteristic type profile for its class to an above - average degree of excellence - that is, it is a particularly well-developed or well-expressed representative example of its class. In this approach, the defining characteristics of a type profile are the criteria against which the (representative) significance of things will be judged. The recent development of detailed landform classifications in Tasmania by Kiernan (1995b, 1996, 1997c) is partly aimed at facilitating a similar approach to landform significance assessment, and Rosengren (1992, 1994) has used a similar approach in assessing the significance of volcanic features in Victoria (Australia).

These criteria or type-profile based approaches to judging geoconservation significance are the most obvious and logical means available of judging significance, and will most likely remain so (see: 'Practical Implementation of Geoconservation: Identification of Significant Sites and Processes' section 2.3.5).

The Basis for Choosing Criteria of Significance

However these approaches, taken in isolation, beg the philosophical question of why the *particular* chosen criteria (or type profile characteristics) determine significance, and not some other criteria. This leaves open the question of whether the criteria used are purely arbitrary, or have some justifiable rationale underpinning them. For example, it is common in judging significance to place emphasis on criteria such as size, prominence, contrast, juxtaposition and spectacle (Davey 1989). Although not without value, these may be relatively crude criteria from many perspectives, and it is important to guard against placing undue emphasis on them. From some perspectives such as the scientific and ecological, more subtle attributes may in fact be of more importance.

To define a basis for choosing criteria in terms of which to judge geoconservation value, it is first necessary to acknowledge that there is no *absolute* basis on which to determine what the 'correct' criteria are. The decision to adopt particular criteria to assess significance is in the end a *value* judgement (Davey 1989, 1997, Dixon 1991) which, Platonic superstitions about the objective reality of 'forms of the good' notwithstanding, can in the final analysis only be subjective. This does not mean, however, that the choice of criteria need be arbitrary or illogical. Contrary to the assumption that is sometimes imputed by Platonists, the lack of an ultimate, objective basis for value judgements does not imply that 'anything goes' (for the simple reason that we naturally desire order and predictability, which is impossible if 'anything goes'). Instead, it is rational to choose criteria which best reflect a consensus of opinion as to what it is about natural phenomena - in this case, geodiversity - that is important and worth protecting. That is to say, the underlying basis for choosing criteria to judge geoconservation significance must be a judgement, or decision, as to what it is about the natural world that we - as scientists, land managers, conservationists or the community as a whole - hold to be of value and worth conserving.

It is important to be aware of the implications of the idea that a choice of criteria for judging significance will be based on a consensus of opinion about values. This approach is inherently fraught with danger, since the consensus of opinion as to the best values to adopt may change over time, and indeed the history of ethical thought is replete with examples of this. The problem, however, is that since we are making a *value* judgement, there is no ultimate or absolute authority to which we can appeal to determine the 'correct' values and criteria to adopt, and so consensus would appear to be the best, or perhaps only, means available. One might argue, in fact, that the ultimately subjective nature of value judgements means that we have only two choices anyway, namely to make a purely personal judgement, or to accept a consensus judgement. Both approaches have their place in the development of values and ethics, with personal rebellion against a consensus opinion often being a catalyst for what later comes to be regarded as progress in values and ethics.

In general however, and in the context of valuing geodiversity, choosing criteria for significance on the basis of a broad consensus of opinion would appear to be the best method available to us, since it will at least reflect a large body of thought and opinion on what it is about geodiversity which can be perceived to be of value.

It is useful to think of this as an ethical issue, since we are trying to determine how we *should* act in relation to natural phenomena, and to do this we need to decide what we consider to be the *values* of natural things so that we can act to protect those values. It goes without saying that the preceding discussion has only skimmed the surface of a large and complex philosophical issue revolving around ethics and values.

However, as Davey (1997, p. 15) notes, there is an expectation amongst land managers (and many members of the public) that professional assessments of the conservation significance of a thing should be objective, empirical and repeatable - in other words, scientific. This is in principle not possible for the *entire* process of significance assessment, since a significance assessment is at bottom a value judgement, not an empirical measurement of some objective quantity. It is important to fully recognise this fact, and be aware that whilst we may (and should) use objective criteria to measure how well a phenomenon contributes to a certain type of value, the relevance of that underlying value to conservation is itself subjectively determined (this 'two-stage process' is described further below). Davey (1997, p. 15) suggests that the usefulness of a significance assessment should not be judged against a yardstick of objectivity so much as one of explicitness. That is, we need to spell out the values in terms of which we are judging significance since this provides the only transparent means for peer review or public review to properly assess the judgements we have made. As Davey (1997, p. 18) comments: "explicitness and the capacity for peer review which it promotes provide the only practical way of responding to social expectations of objectivity in the face of the manifestly judgemental characteristic of significance".

As with many aspects of ethical thought, the consensus of ethical opinion relating to nature conservation has changed and developed over time (see Nash 1990). The simplest view on conservation is the anthropocentric or utilitarian one: that the important conservation values of nature are those which are directly useful to humans. From this perspective, it is typically the value of geodiversity for research and education purposes, and perhaps its aesthetic and recreational values, which are held to be the appropriate basis for assessing its conservation significance (eg, Legge & King 1992). In contrast, a view prevailing in nature conservation circles generally, and in many land management agencies in particular, is that the main value of natural phenomena is the role they play in maintaining natural (including ecological) processes, upon which human and all other life depends. Finally, there is a growing consensus amongst at least some conservationists that natural phenomena also have intrinsic value quite apart from any 'instrumental' or 'utilitarian' conservation values they may have to humans; this is simply to say that an excellent example of something may be considered important simply *because* it is an excellent example, regardless of any more direct use it's conservation may have for us (these value groups have been discussed under 'The Value of Geodiversity' section 2.3.2).

In this document, it is considered that all the above value groups form part of a growing broad consensus of opinion as to what is important and valuable about geodiversity, albeit that particular individual workers may not consider all these value groups to be important.

Choosing Criteria of Significance

The implication of the above discussion is that - whether we recognise it or not - we judge the conservation significance of particular phenomena by a two-stage process, which involves firstly a value judgement, and secondly an objective assessment against specific criteria relating to those values judged to be important:

1. First, we implicitly or explicitly make a *judgement* as to what it is about natural phenomena generally - and geodiversity specifically - that is of *value*. There is no absolute basis for making such a judgement, however neither need it be arbitrary. In choosing the values we consider most meaningful, we have regard to the broad consensus of opinion amongst geoconservation workers, although the ultimately subjective nature of such value judgements means that we may be justified in advocating newer or less popular conceptions of what is of value. In either case, we need to be explicit or transparent about these, and to be able to argue that they constitute a useful value set in terms of which to judge conservation significance (in much the same way that we would advocate any other ethical values we hold dear).

2. Then, having identified our set of values, we can *objectively* assess particular phenomena to determine how important (i.e., how significant) they are in contributing to those values. This is done by drawing up a list of criteria by which the contribution of things to a particular value can be measured, and then objectively – scientifically, in fact - assessing how well any given example of a phenomenon measures up against those criteria.

This two stage process is described in more detail below:

1. *Choice of Values*

The values in terms of which natural phenomena are widely considered to be significant have been mentioned above, and are described elsewhere in this document (see 'The Value of Geodiversity' section 2.3.2.) These broad value sets, which incorporate and synthesise most reasons which have been advanced in the literature for considering geodiversity to have value, are:

- Intrinsic Values
- Ecological or Natural Process Values
- Anthropocentric or (Geo)heritage Values

It is advocated here that all three of these value sets are important, since they each relate directly to one or both of the *aims of geoconservation* (namely the *maintenance of geodiversity* and the *maintenance of natural rates and magnitudes of change*). All three of these value sets should be used as a basis for drawing up objective criteria in terms of which to judge the conservation significance of specific phenomena.

2. *Choice of Objective Criteria for Assessment of Values*

The following paragraphs discuss the sorts of objective criteria which can be used to assess the significance of particular phenomena against each of the three basic value sets identified above:

<u>Intrinsic Values and Representativeness</u>

If we agree that nature in general has intrinsic value, then it makes little sense to single out some particular natural things as having intrinsic value, and say that other natural things do not have such value. In fact, the concept of intrinsic value undermines value systems which differentiate things on scales of relative significance and ultimately put people at the top. However, for this reason it is difficult to 'operationalise' - i.e., to quantify in an objective way and act upon in practical conservation management - the concept of intrinsic value, since it does not provide any direct, practical means of differentiating between things of higher and lower priority for conservation. 'Intrinsic value' is a concept which cannot be directly measured or quantified.

Nonetheless, the idea of intrinsic value is fundamental to the approach to geoconservation advocated in this document, because it makes explicit the idea that human interests should not be considered the sole arbiter of how we manage the natural environment. A recognition of intrinsic values makes us consider all the impacts of our actions on the environment, not just those particular impacts which directly affect human interests.

From this perspective, it is desirable to find some way of incorporating the idea of intrinsic value into conservation strategies and management actions. The approach taken in this discussion is to consider intrinsic value as an underlying value which can be 'operationalised' through *surrogate* means revolving around the concept of 'representativeness'. The logic of this 'surrogate' approach proceeds as follows:

If we consider that nature as a whole has intrinsic value, but also allow that humans have a legitimate right to exploit and consume some natural resources, then we must in practice determine which natural things we can ethically exploit *despite* their intrinsic value, and which we should conserve *because* of their intrinsic value. In this approach, we do give ethical consideration to all natural things, but in certain cases we make the ethical judgement that our own justifiable utilitarian interests over-ride the intrinsic value of certain natural things.

Now, if the justifiable requirements of human society mean that we cannot respect the intrinsic value of nature to the extent of maintaining each and every individual thing in its natural state, then it would seem that the next best alternative is to endeavour to at least maintain the natural *diversity* of things. That is, we need to endeavour to maintain at least *representative samples* of all the elements of geodiversity (and also biodiversity, of course). In other words, to respect the intrinsic value of nature implies that we should try to ensure that human alteration, exploitation and consumption of natural resources does not result in entire classes of natural phenomena ceasing to exist, or (in the case of active processes) becoming incapable of operating and changing at natural rates and magnitudes.

A procedure by which we can objectively assess the *representative* significance of specific elements of geodiversity, in order to identify a suite of representative phenomena whose conservation will best respect the intrinsic value of geodiversity, is described in 'Identification of Significant Sites and Processes: Systematic and Thematic Inventories' (section 2.3.5). In brief, this involves undertaking a systematic inventory process in which we first *classify* the range of phenomena which constitute geodiversity (so as to *identify* the diversity of phenomena), and then identify the best or *most representative* examples, in good condition, of each class of phenomenon in our classification.

In this approach, each class of phenomenon within our classification is defined in terms of its *type profile*, and it is the characteristics of the type profile that constitute the objective criteria against which we ultimately measure - by surrogate means - the intrinsic value of specific phenomena.

The approach of using 'representativeness' as a surrogate for intrinsic value cannot be perfect or absolute, as is implied by its surrogate nature. For instance, the use of classification systems to identify representative phenomena imposes somewhat arbitrary and artificial divisions on nature (see 'Identification of Significant Sites and Processes: Systematic and Thematic Inventories' section 2.3.5). Indeed, the notion that diversity itself is a value worth aiming to preserve is itself simply a value judgement. However, as noted above, all judgements of significance must ultimately be based on value judgements which cannot be absolute (see 'The Basis for Choosing Criteria of Significance' above), and the 'representative' /geodiversity approach goes a long way towards satisfying widely held views on why earth phenomena may be of conservation value.

Ecological or Natural Process Values

To assess the ecological value of an element of geodiversity, we need to determine the role which that element (which may be a physical feature or a physical process) plays in the broader environment and the ecological processes of which it is a part. Such a determination is a matter of scientific research and monitoring. This allows us to determine whether the disturbance, degradation or destruction of the phenomenon in question will result in an unacceptable degree of change or degradation to the broader natural environment and ecological processes of which it is a part.

The limits of acceptable change in an environment will vary depending upon the sensitivity of the particular environment (see 'The Sensitivity of Geodiversity' section 2.3.2), and also to some extent on the context. For example, very little artificial change would be acceptable in a fluvial landform system in an area that is valued as wilderness, whereas a much greater degree of change might be acceptable in a fluvial system in an urban area.

In any case, the criteria in terms of which we can measure the ecological value of a particular element of geodiversity consist of objective scientific data on the role which that element plays in maintaining the natural processes in its broader environment. Measured against such objective criteria, an element of geodiversity would be considered to have high ecological significance if its degradation or destruction would cause changes to the broader environment or ecosystem that are beyond the limits of acceptable change which can be defined for that environment or ecosystem.

This of course raises the question of how we objectively define the 'Limits of Acceptable Change'; however, for the purposes of the present discussion this question is a separate issue which need not be addressed here. Considerable work has been done on identifying Limits of Acceptable Change in karst geomorphic systems (e.g., *see* Gillieson 1996, p. 251), and similar principles will apply to other geomorphic, geological and soil features and systems.

The assessment of geomorphic systems as having high geoconservation significance in virtue of their ecological values has been a strong theme in a number of detailed Tasmanian geoconservation studies, such as those concerned with the Exit Cave karst (e.g., Kiernan 1991b, Houshold 1992, 1997), the Junee-Florentine karst (Eberhard 1994, 1996), and the lower Gordon River (Soutberg 1991, Bradbury *et al.* 1995).

Anthropocentric or (Geo)heritage Values

We can determine the degree to which particular features are of direct geoheritage (or 'anthropocentric') value to human society by determining the degree to which particular elements of geodiversity are *in fact* valued by humans. This approach by-passes the problem that people may value geoheritage for highly subjective reasons (eg, aesthetic reasons), and simply measures the degree to which people do in fact value certain things.

As noted elsewhere in this document (see 'The Value of Geodiversity: Geoheritage' section 2.3.2), geoheritage may be valued for a variety of specific anthropocentric reasons (or values). The following list tabulates some of these reasons, and indicates objective criteria by which we can measure the degree to which people consider particular phenomena significant in terms of each reason or value.

In practice these criteria are often measured in a fairly rough way using essentially anecdotal evidence. However, it is possible to measure each criterion in a relatively rigorous fashion: for example, the value of a feature to scientific research could be measured by the number of times it has been cited in scientific papers as opposed to other features of the same type, or the aesthetic value of a landform could be measured by the frequency with which it appears in paintings and published landscape photos. It must of course be acknowledged that such procedures have limitations; for example a little known feature in a remote area might legitimately be considered to have high aesthetic value despite the fact that very few people have actually seen or photographed it.

Geoheritage Value (anthropocentric reasons for valuing particular elements of geodiversity)	**Criteria** (by which value to humans can be measured)
Aesthetic value	Formal landscape quality assessment methods; Frequency with which phenomenon has been featured in paintings and photographs; Community opinion (assessed by polling?)
Scientific/research/educational value	Degree of excellence with which a feature is considered to display aspects of the nature and development of geological, landform or soil systems in its region; Use as type sites; Frequency of citation in scientific papers; Use as a teaching site; Whether feature is a site at which important measurements or discoveries have been made;
Recreational value	Frequency of recreational usage (eg, caves, cliffs, beaches, rivers); Degree to which relevant recreational groups value feature as a venue for their activities (determined by poll or literature survey);
Social/historical value	Degree to which a feature has played a role in the life or development of past or present human communities (as determined by historical and archaeological research);
'Sense of Place' value	Degree to which a human community regards a feature (eg, a landform) as integral to the 'identity' of their place (determined by historical research, prominence in local folklore, or by polling local communities);
Spiritual/religious value	Degree to which a feature figures as sacred or holy in a community's spiritual life (eg, Mt Kailas, Uluru, the Mecca meteorite, Selminum Tem cave - 'the underground road of the dead');

Numerous (most?) geoconservation and geological heritage studies have focussed on identifying features and systems as significant in terms of anthropocentric criteria such as those outlined above (e.g., Eastoe 1979, Davey 1984, Cochrane & Joyce 1986, etc).

Representative and Outstanding Significance
It has become customary in geoconservation to classify significant features as being of *outstanding* and/or *representative* significance (e.g., Joyce & King 1980, Davey 1984, Dixon 1991):

- an *outstanding* feature is one which exemplifies an aspect of geodiversity through a feature which is rare, unique, an exceptionally well-expressed example of its type, or otherwise of special importance; whilst:

- a *representative* feature may be either rare or common, but is considered significant as a well-developed or well-exposed example of its type.

Although some early approaches to geological heritage focused mainly on individual features that are considered outstanding, the *aims of geoconservation* cannot be adequately fulfilled if attention is focused solely on this approach. Although outstanding features are typically those which it is easiest to gain public and institutional support for protecting, there are several inherent problems in focussing solely on this approach (Davey 1984, Sharples 1995a):

- Firstly, current scientific interests and cultural fashions may make a certain feature seem outstandingly significant which in the future may be considered less important, and vice versa. 'Outstandingness' is commonly a subjective and culture-dependant judgement which is likely to be only ephemeral (albeit some things may be outstanding in more objective ways - for example, the biggest thing is objectively the biggest - but the 'most' spectacular, beautiful or interesting things are clearly only so in a purely subjective sense).

- Secondly, the basic geoconservation aim of maintaining geodiversity (for its intrinsic, scientific, and other values) implies that we need to manage for the conservation of (at least) phenomena *representative* of all aspects of the geodiversity of a region. Outstanding features alone will only encompass a very incomplete sampling of the features characteristic of a region.

- Thirdly, the geoconservation aim of maintaining natural rates and magnitudes of change - so as to maintain the ecological value of geodiversity - is better served by a system of features and processes representative of all aspects of the geodiversity of a region than by a more arbitrary selection of outstanding features. A system of representative bedrock, landform and soil types also supports biodiversity by protecting a full range of habitat substrates.

For these reasons, it is more useful to focus on identifying features of representative significance, although particular features may still be identified as 'outstanding' in order to highlight cases of special importance. Such an emphasis on representativeness 'dovetails' neatly with the approach described above to incorporating consideration of intrinsic values into geoconservation significance assessment, and is implicit in the idea of valuing geodiversity.

Because of the historical emphasis on outstanding features in early geoconservation inventories, many inventories are still heavily weighted towards outstanding features. However, with a growing emphasis on systematic inventory studies (*see* 'Systematic and Thematic Inventories' section 2.3.5), it is envisioned that the balance will gradually shift towards more representative databases.

Nonetheless, it is arguable that features of "outstanding" significance should continue to be inventoried as such, because they provide indicators of the potential endpoint of the development of features or systems (Houshold *et al.* 1997).

Assigning Levels of Significance

Having chosen the criteria by which we will judge the conservation significance of things (*see* 'Judging Significance' above), we can then use these criteria to assign levels of significance. However, there are at least two distinct ways in which we can assign levels of significance to various elements of geodiversity:

1. We can assign levels of conservation priority by identifying things most worthy of conservation as having 'high significance', and things of less priority for conservation as having 'low significance'. This is fundamental, since the very purpose of having a concept of 'significance' is to allow us to differentiate between things of greater or lesser importance to achieving conservation aims.

or:

2. We can identify the spatial context within which a thing may be considered to have high significance, by identifying things as being significant at levels ranging from global to local. It is important to note that this system of assigning significant levels is not simply an alternative way of expressing a 'high' to 'low' significance hierarchy. A thing which is of Local Significance is not properly speaking of 'low' significance compared to a thing which is of Global Significance; rather, it is a thing which has high significance in a local (but not a global) context.

The current method of assigning levels of significance which is widely used in geoconservation in Australia essentially addresses the second (spatial context) purpose above, but not the first (conservation priorities) purpose. As such, the current method is of limited practical use in determining management priorities. The current approach is outlined below, followed by a discussion of its limitations and a proposal for an improved system which would address both the ways of assigning levels of significance that have been identified above.

The Current Approach

In Australia, significant features are customarily classified as being of outstanding or representative significance at levels ranging from local significance to international (world or global) significance (eg, Rosengren 1984a, Dixon 1991, Sharples 1993, Joyce 1995, 1997). However as noted above, the use of an 'outstanding/ representative' distinction is of limited value, and this approach does not otherwise really identify differing conservation priorities, since all features identified as significant in this system are implicitly of high significance at the particular spatial level (global to local) to which they are assigned.

Under this approach, levels of significance are assigned as below, based on consideration of the criteria that have been chosen to judge significance by (from Rosengren 1984a, Sharples 1993):

WORLD ('global' or 'international') SIGNIFICANCE:
Phenomena which are rare in the world, and/or by the nature of their scale, state of preservation or display are comparable with examples known internationally. May be illustrative of processes occurring or having effects at an inter-continental or global scale.

NATIONAL SIGNIFICANCE:
Phenomena which are unusual or unique nationally, and/or by the nature of their scale, state of preservation or display are comparable with examples known nationally. May be illustrative of processes occurring or having effects at a continental or national scale.

STATE SIGNIFICANCE:
Phenomena which are important in the context of the geological, geomorphological or pedological development of the State, and/or which are amongst the best developed, expressed or preserved examples of their type in the State.

REGIONAL SIGNIFICANCE:
Phenomena which are important within the context of a region. Regions may be defined on political or administrative boundaries, or on the grounds of characteristic geological, landform and/or soil features (in the latter case, such regions are crude georegions; see the next sections (below) and 'The Georegional Approach' section 2.3.5). May include phenomena which are amongst the best developed, expressed or preserved examples of the features which characterise the region.

LOCAL SIGNIFICANCE:
Phenomena which, whilst not unique to a local area, are amongst the best developed, expressed or preserved examples of their type within a local area defined on geographic grounds, such as a valley, catchment basin, or the administrative boundary of a city or town.

UNKNOWN SIGNIFICANCE:
Unknown significance may be assigned where a phenomenon is insufficiently well known to allow comparison with other examples of its type, or where insufficient data exists on the distribution and quality of other examples of its type.

In summary, the essence of the above system of assigning levels of geoconservation significance is that a feature, area or value is considered to be significant at the (spatially defined) level where it is amongst the best representative (or outstanding) exemplars of its type. Thus a feature which is of only local significance is likely to be of a type which is relatively well represented at a state–wide level, but which is the best example in its local area. In contrast a feature of state significance will be one of the best examples of its type in the state (and so on).

It should be noted that these spatially-based levels of significance do not necessarily relate to the actual geographical distribution of a class of phenomena; for example a feature which only occurs in one local area could well be of world significance by virtue of its rarity, whilst a particular example of a class of features of global occurrence may have only local significance as the best example (of a relatively common feature) within its local area.

Critique of the Current Approach to Assigning Levels of Significance
Although a global - to - local hierarchy of significance levels might be interpreted as a hierarchy of greater to lesser significance levels, this is not properly the implication of the system; as noted above, the purpose is rather to indicate the spatial context (global to local) in which things can be considered to be of high significance. In fact, it is a major limitation of this approach that it gives a misleading impression of differentiating between things of higher and lower significance when in fact it is not doing so. Thus, there is a need for a system which actually does differentiate between things of higher and lower significance, since this is a fundamental reason for having a concept of 'significance' in the first place.

The usefulness of the above geographically-based approach to assigning levels of significance is further limited by the arbitrary nature of the levels used. "National", "State" and "Local" sub-divisions are generally delimited on political and cultural grounds which have little relevance to the natural distribution of geological, landform or soil systems. Whilst there are cases where national, state or local boundaries relate to natural boundaries - such as islands or catchment basins - such situations are probably the exception rather than the rule.

A Proposal for Development of an Improved Approach to Assigning Levels of Significance

A more meaningful approach to assigning levels of significance for particular phenomena would be one which both makes distinctions between things that are of greater and lesser priority for conservation, and which would also be tied in some way to the actual spatial distribution of those features rather than to political or cultural boundaries which are irrelevant to geodiversity. To provide such a system, it is necessary to be able to define things as being of high or low significance in a defined spatial context which is meaningful in scientific terms, and which can be of global to local extent.

Tasmanian geoconservation workers are developing such an approach to assessing significance levels, in which it is proposed to base significance levels on 'georegions' that are defined in ways relevant to geodiversity. A discussion of the Georegional Approach is provided elsewhere in this document (section 2.3.5; *see also* Dixon & Duhig 1996, Houshold *et al.* 1997, Duhig *et al.*1998, Jerie *et al.* 2001), while Houshold *et al.* (1997) and Duhig *et al.*(1998) describe the potential application of georegions to a better method of assessing significance.

In brief, a georegion is a mappable region in which particular geological, geomorphic or pedological processes have operated under particular conditions (or 'system controls') during a particular period of geological time. Each georegion is therefore characterised by particular distinctive types of geological, landform or soil systems. Thus, the use of georegions will allow the significance of particular features to be assessed within the specific context of the regions of which they are actually characteristic, rather than within the context of political sub-divisions whose boundaries may bear little relationship to the actual spatial distribution of the class of phenomena in question.

Assignment of significance levels to particular phenomena on a georegional basis would involve classifying particular phenomena as having 'High', 'Medium' or 'Low' significance within the georegion of which they are characteristic. Depending upon the level of detail at which a georegion is defined, the georegion in question might comprise one or a number of discrete areas of the same type, and these might be distributed anywhere from globally to only locally. Thus, a particular phenomenon could still be assessed to be of global or national significance, but within the more rigorous context of a georegion defined (on relatively broad scientific criteria) to have a particular global or (roughly) national distribution. On the other hand, georegions defined on more precise and thus narrower criteria would probably be less extensive, providing a means of identifying features that are significant in a (roughly) state or local context.

In all cases, the approach would be to assign 'high', 'medium' or 'low' significance to a particular feature within the context of its georegion, with the level of detail at which the georegion is defined being made explicit so as to indicate whether the significance levels have been assigned in a broader (eg, global) or narrower (eg, local) context. Thus, a notation will need to be developed which specifies the georegion, the level of detail at which it has been defined, and the significance level of a feature within that georegion (i.e., high to low, or unknown).

In such a georegional context, significance levels of high to low (or unknown) for a particular phenomenon can be defined as follows, based on the assessment of each phenomenon against criteria of significance which have been chosen as described in 'Judging Significance' (above):

HIGH:
Amongst the best expressed or developed examples of its type within its georegion, and/or of critical importance in maintaining ecological processes of high significance.

MEDIUM:
Moderately well developed or expressed example of its type, comparable in quality to other examples within its georegion, and/or important in maintaining significant ecological processes.

LOW:
A poorly developed or expressed example of its type compared to other better examples within its georegion, and/or of minimal importance in maintaining significant ecological processes.

UNKNOWN:
Inadequate data on the feature in question, or on other examples elsewhere in its georegion, to allow a comparative assessment to be made.

In the use of this proposed system for assigning levels of geoconservation significance, the final outcome would be inventories of phenomena defined as being of high or medium significance in particular defined spatial contexts, thereby assigning levels of significance in both the senses - conservation priority and spatial context - which have been outlined above. Features of 'low significance' would not of course be listed in such inventories; however it is necessary to have a category of low significance for use in the systematic process by which features of high significance are identified and differentiated from those of low significance.

(2.3.5) PRACTICAL IMPLEMENTATION OF GEOCONSERVATION

Five major areas need to be addressed to provide a basis for successful practical management of geoconservation values based on the foregoing theoretical principles and concepts:

- Legal and Administrative Instruments and Procedures
- Awareness of Issues
- Identification of Significant Sites and Processes
- Development and Implementation of Management Prescriptions
- Monitoring and Indicators

The following sections discuss each of these areas, and provide illustrations of the progress which has been made in each area in Tasmania. Experience to date has highlighted some needs for further improvements, which are also noted. The following discussions are partly based on Sharples (1998) and Dixon *et al.* (1997a), together with more recent commentary.

Legal and Administrative Instruments and Procedures

Although much can be achieved without specific legislative backing, the existence of legislation requiring the implementation of geoconservation management can both:

- provide an argument and a basis for allocating funds and administrative facilities to geoconservation; and

- make it easier to achieve uniform implementation of appropriate procedures.

In part, specific political events in Tasmania (see 'History of Geoconservation in Tasmania' section 2.2) have provided an atmosphere in which it has been possible to advocate specific legislation and administrative procedures dealing with geoconservation. However, such legislation and procedures were only advocated because committed geoconservation professionals took such opportunities as they arose. The lesson is that those desiring geoconservation to be given a higher profile must be pro-active and look for opportunities to make political and administrative progress.

In the absence of specific legislation, many National Parks Acts and other Land Management legislation contain wordings which can be broadly interpreted to encompass geoconservation; such legislation can be used to make a case for better geoconservation management and the establishment of administrative instruments dealing with geoconservation.

As examples of all the above, means by which geoconservation management has been incorporated into Tasmanian legislation and administrative instruments include:

Legislation

The Tasmanian *Regional Forest Agreement (Land Classification) Act 1998* made 'conserving geological diversity' a statutory management objective in all categories of conservation reserves in Tasmania. The inclusion of this objective in the legislation resulted directly from lobbying by Tasmanian geoconservation professionals[1].

The *Tasmanian Mineral Resources Development Act 1995* contains punitive provisions to protect speleothems ('cave decorations') from uncontrolled destruction by collectors.

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[1] Note that the term 'geological diversity' was used in the legislation rather than the preferable term 'geodiversity' because the latter term does not yet appear in major dictionaries and thus is not yet acceptable to parliamentary lawyers; however 'geological diversity' has been defined in the legislation in the same fashion as 'geodiversity' - see also the 'Glossary of Geoconservation Terminology')

However, the Land Classification legislation only requires that the conservation of geodiversity be a management objective within conservation reserves; and apart from the speleothem provisions of the Mineral Resources Act there is as yet no legislation explicitly requiring the conservation of geodiversity outside reserves. At the present time, geoconservation in off-reserve situations relies on administrative instruments including those listed below:

Administrative Procedures
Although Tasmanian legislation has only recently explicitly incorporated the concept of conserving geodiversity (see above), the wording of several relevant previous acts was already sufficiently broad to allow the establishment of administrative instruments and procedures dealing with geoconservation. These include:

- The Forest Practices Code (Forest Practices Board 2000), which governs the environmental management of forestry operations in Tasmania, was established under the *Forest Practices Act (1985)*. This Code recognises the importance of landform conservation (an aspect of geoconservation), and makes specific provisions for the protection of karst. A 'Geomorphology Manual' (Kiernan 1990) and 'Forest Sinkhole Manual' (Kiernan 2002) have been written to provide more detailed advice supplementing the Code. The Code applies to commercial forestry activities on both public and private lands. There is now considerable scope to update both the Code and the Geomorphology Manual to take account of more developments in geoconservation management, and Dixon *et al*. (1997a) made specific recommendations aimed at achieving this.

- The Tasmanian Parks and Wildlife Service in 1995 drew up a Geoheritage and Geoconservation Policy to require and formalise geoconservation policies on public lands administered under the National Parks and Wildlife Act (1970). This policy is now explicitly supported by the *Regional Forest Agreement (Land Classification) Act 1998* (see above). There is scope for updating this policy.

- The fourth edition (1999) of the Tasmanian Mineral Exploration Code of Practice (Mineral Resources Tasmania) includes provisions for the protection of geoheritage (under the term 'geological heritage).

Other than in the course of commercial forestry activities, there are no current procedures for protecting significant aspects of geodiversity on private land. An Agricultural Code of Practice has been widely advocated (eg, Sustainable Development Advisory Council 1996), and if implemented should incorporate geoconservation principles. This will only occur if geoconservation professionals make the effort to be involved in the drafting of such a Code.

However, a significant advance for implementation of geoconservation objectives in off-reserve situations in Tasmania occurred during 2000-2001, with the drafting of a *Nature Conservation Strategy* for Tasmania (DPIWE 2001), which was commissioned by the Tasmanian Government to meet the State's obligations under the 1996 Commonwealth of Australia *National Strategy for the Conservation of Australia's Biological Diversity*. The committee which was assigned with the task of drawing up the State strategy took the important step of fully integrating geoconservation into the strategy in order to produce a *Nature Conservation Strategy* which is arguably a more logical approach to conservation than the limited *Biodiversity Strategy* that was originally envisioned would have been. Whilst the Strategy (DPIWE 2001) has yet to be adopted by the State Government, it includes broad – ranging approaches to integrating geoconservation into nature conservation such as advocating the establishment of standard guidelines for Environmental Impact Assessments and Environmental Management Plans which would require that significant and vulnerable geoconservation values be identified and managed for in all development proposals.

A further important area requiring more attention is the incorporation of geoconservation objectives into Local Government planning schemes and management plans. Progress in this area has been made with a number of local government councils in Tasmania.

Awareness of Issues

In order to gain support for the implementation of geoconservation objectives, and to ensure effective practical management of geoheritage, it is necessary to cultivate an awareness of geoconservation issues at two levels:

- The general public and their political representatives; and

- On - the - ground managers responsible for the practical implementation of management policies.

Cultivating such awareness basically requires various forms of education. Approaches which have been implemented to date in Tasmania and Australia more generally include:

Raising Public Awareness

Legislative and bureaucratic support for geoconservation ultimately requires support from the public. Such support can only be generated if the public is aware of the issues involved. Approaches to raising public awareness include:

- Interpretation of significant features. Traditionally this has involved explanatory signs, which is still an important approach. More recent initiatives include cave guides explaining the sensitivity of the cave environment to tourists, and audio-visual presentations at National Park visitor centres, such as that at Lake St. Clair (Tasmanian Central Highlands) which explains the glacial landforms of the area.

- Inclusion of a geodiversity /geoheritage section in the Tasmanian State of the Environment Report (Sustainable Development Advisory Council 1996), which will be read by a wide cross-section of the public and politicians.

- Full integration of geoconservation into the Australian Natural Heritage Charter (AHC 2002). This document, which is intended to guide conservation actions at all levels from professionals to community groups, should bring an awareness of geoconservation to a wide cross-section of those members of the public with a serious interest in conservation principles.

In both the latter two cases, voluntary involvement by geoconservation professionals was crucial in ensuring that geoconservation received appropriate mention.

Raising the Awareness of On - the - Ground Managers

The practical on - the - ground actions which are needed to conserve significant elements of geodiversity are, in the final analysis, the responsibility of those field managers (eg, foresters, park rangers, local government officials, private landowners, miners, etc) who undertake the day - to - day management of areas of land. The small group of professional earth scientists concerned with geoconservation could not hope to personally monitor every activity that might impact on a feature of geoconservation significance; hence there is a need to ensure that on - the - ground managers:

- are aware of geoconservation issues;
- have access to information on the location and management implications of significant features; and:
- know when and how to obtain specialist geoconservation advice if necessary.

A difficulty which exists is that many professional land managers tend, because of the historically biocentric focus of land management and conservation, to have a greater awareness of biological issues than of geoconservation. Notable exceptions may be found amongst the managers of cave and karst reserves.

Approaches to raising field managers awareness of geoconservation, and providing them with information on features of geoconservation significance, include:

- *An administrative requirement* (as discussed above:' Legal and Administrative Instruments and Procedures') that features of geoconservation significance be protected is a potent means of making land managers aware that geoconservation issues exist; however, more is required to enable field managers to actually recognise and appreciate geoconservation issues.

- *Training courses and seminars* are one of the most important formal means of raising the awareness of managers. In Tasmania, examples include the provision of compulsory courses on landform conservation during the training of Forest Practices Officers, the inclusion of material on geoconservation in the Park Management Course undertaken by many Parks and Wildlife rangers, and occasional seminars run for field staff by geoconservation workers in both the Tasmanian Parks and Wildlife Service and Forestry Tasmania. Unfortunately, little provision for similar awareness raising courses amongst other categories of land managers (especially private landowners) is yet available.

- *Regular informal discussions between geoconservation professionals and field managers*, both in the field and elsewhere, are an important means of raising awareness. In some cases such discussions may be initiated by geoconservation workers contacting field managers to express concerns regarding features that may be impacted by a proposed activity. Such initial contacts may lead to a cycle of field managers recognising other similar cases in the future and contacting geoconservation workers for advice.

- *The existence of standard manuals which field managers are expected to be aware of* can contribute to improved appreciation of geoconservation issues by providing a source of information for managers to refer to. Of course, somebody first needs to take the time to write such manuals! However, foresters in Tasmania have access to manuals describing landform conservation principles (the *Geomorphology Manual*: Kiernan 1990; and the *Forest Sinkhole Manual*: Kiernan 2002), and to a series of reports describing the geoconservation management issues specific to each administrative Forest District (Sharples 1994a to 1997b).

- *The provision to field managers of actual databases and inventories of significant geoconservation features requiring management consideration* is of particular importance, since field managers cannot always be expected to be aware of everything that might require attention in their field area. The provision of such data is described further below ('Identification of Significant Sites and Processes').

The approach taken by Forestry Tasmania is worthy of brief note here: In the Forestry Tasmania system, inventory data compiled by geoconservation specialists is mapped onto GIS - based *Management Decision Classification* (MDC) maps (alongside a range of data on other management and conservation issues). These maps must be consulted during the preparation of the Forest Practices Plans (FPP's) that are required for all commercial logging activities, thereby ensuring that any significant sites which have been recorded on the MDC maps will automatically come to the attention of the field manager.

Mineral Resources Tasmania similarly holds a database on sites of geoconservation significance which is referred to in considering exploration and mining lease applications, whilst an inventory of conservation values associated with or affected by roads - including road cutting exposures of significant geological features - is being developed by the Tasmanian Department of Transport.

During the course of the Comprehensive Regional Assessment for the Tasmanian Regional Forest Agreement, all existing Tasmanian geoconservation databases were amalgamated into a single comprehensive *Tasmanian Geoconservation Database* (Dixon & Duhig 1996). Ongoing maintenance and updating of this database is being undertaken by the Tasmanian Department of Primary Industries, Water & Environment (DPIWE) in conjunction with an advisory panel comprising Tasmanian geoconservation workers. The database is intended to be available to all interested parties and will provide a common source of data for use by all land managers.

By the use of the above approaches, significant progress has been made in raising the awareness of field managers about geoconservation in Forestry Tasmania, the Tasmanian Parks and Wildlife Service and Mineral Resources Tasmania. Progress is also being made in some local councils and other government bodies; however the task of raising the awareness of private landowners regarding the importance of protecting elements of geodiversity on their land has in many cases barely begun.

Identification of Significant Sites and Processes

The practical implementation of geoconservation requires that significant and sensitive elements of geodiversity - those requiring special management prescriptions - be identified on the ground. The conceptual identification of things as being significant and/or sensitive has been discussed elsewhere in these pages (see sections 2.3.2 &2.3.4). The following discussions focus on the practical procedures for actually compiling lists and maps - inventories - of significant things, whilst the practical assessment of sensitivity, and development of suitable management responses, is dealt with in the following section ('Development and Implementation of Management Prescriptions').

The identification of significant phenomena can proceed in one of two ways, namely an ad hoc approach or a more desirable strategic approach:

Ad Hoc Identification of Values

The ad hoc approach involves the assessment of geoconservation values at a particular site or area during the planning or assessment of specific activities or projects that may disturb that area (such as the assessment of individual logging coupes or development sites immediately prior to development taking place).

This ad hoc approach is a short term strategy which has a number of disadvantages:

- It may be difficult to make reliable assessments of the significance of features at a particular site in isolation from a systematic comparison between similar sites over a much broader region.

- The initiation of ad hoc assessments of geoconservation values often depends upon field managers or planners being able to recognise the possible existence of geoconservation issues and then request specialist advice. This approach cannot be totally reliable since it depends upon the knowledge of non-specialists, who cannot be expected to unfailingly recognise possible geoconservation issues at the outset of a planning process.

- Perhaps most importantly, the ad hoc approach doesn't allow for long term planning and regional zoning with geoconservation values in mind. The assessment of values will typically come after a decision to undertake a development has been made, so that the discovery of highly sensitive features may require the alteration of long term plans at short notice or, if development activities have already reached a committed stage, may result in degradation of the significant features anyway.

Continued use of the ad hoc approach is inevitable in many areas due to the lack of more comprehensive databases upon which a more strategic approach could be based. However the limitations of the ad hoc approach mean that an ongoing effort to develop a more strategic approach, involving early systematic identification of geoconservation values over broad regions, and appropriate zoning that indicates areas of highest priority for conservation, is most desirable as a means of minimising potential conflict between conservation and development goals.

Strategic Identification of Values - Inventories
A strategic approach to the identification of geoconservation values involves the systematic and comparative assessment of geoconservation values over broad regions, allowing appropriate zoning to be developed to indicate features of high conservation significance, and areas more or less suitable for various types of development or management activities. Although the strategic approach inevitably requires a significant commitment of time, money and personnel to the collection of data and the development of geoconservation inventories, in the long term these costs are likely to more than offset the cost of the sorts of development vs conservation debacles that result from inadequate identification of values prior to planning and undertaking development projects.

The strategic approach can only be applied in areas where an adequate scientific database of basic geological, geomorphic and soil information exists, so that the collection of such basic data is a necessary component of a strategic approach to the identification of geoconservation values.

In Tasmania, a good start has been made on the strategic identification of geoconservation values, although much further work is required before the data coverage will be comparable to that which has been achieved for biological species and communities. In Tasmania, strategic identification of geoconservation values has been and is being undertaken in the form of compiling inventories of significant elements of geodiversity at three levels of detail, namely:

- Reconnaissance Inventories
- Systematic or Thematic Inventories
- Detailed Inventories

These three levels are described further below:

1. RECONNAISSANCE INVENTORIES
Reconnaissance Inventories are 'first pass' inventories which identify significant features on the basis of (generally) literature reviews, consultation with experts and only minor fieldwork. These inventories are valuable in providing a comparatively quick means of identifying the major geoconservation issues in a region, and in highlighting features of known priority for conservation management and/or more detailed study.

In Tasmania, reconnaissance inventories of significant geological (bedrock) and landform features have been compiled by State Government agencies during the 1990's for all State forest districts (Sharples 1994a, b, 1995b, 1996a,b, 1997b), and most State Reserves and other public lands (Bradbury 1993, 1994, 1995; Dixon 1991, 1994, 1996). The information in all these inventories was combined and reviewed to establish the *Tasmanian Geoconservation Database* (Dixon & Duhig 1996). A number of other reconnaissance inventories have also been prepared by private consultants as parts of management plans for lands controlled by Commonwealth and Local Government bodies.

However, no substantial inventories of significant soil sites and associations have been compiled for any land tenures in Tasmania, nor have any inventories of any sort been attempted for private lands, apart from a small number of sites included in inventories mainly aimed at public land tenures.

2. SYSTEMATIC AND THEMATIC INVENTORIES

The preparation of systematic or thematic inventories involves making a comprehensive comparative assessment of all the features and systems in a specific region, or in a given theme (eg, fossil sites, stratigraphic sites, karst, glacial, fluvial, organic soils, etc), so as to systematically identify the most significant elements of geodiversity in the region and/or theme. This approach involves assembling data on all the relevant known features in the region or theme, and systematically comparing them all so as to identify which are the best representative examples of their type (i.e., the best developed and/or expressed).

The preparation of systematic inventories is fundamentally based on the idea that the best approach to geoconservation management is to aim at protecting geodiversity by first identifying the best *representative* examples of each element of geodiversity (see 'The Concept of Significance' section 2.3.4).

Although time consuming, a systematic and thematic inventory approach provides comprehensive data over large areas, and allows more rigorous and defensible assessments of the significance of particular features to be made. A systematic inventory covering the whole of Tasmania has so far only been compiled for karst phenomena (Kiernan 1995b). Aspects of geodiversity in Tasmania which have particularly high priority for future systematic and thematic inventory work, due to their importance in Tasmania and to their commonly high sensitivity to disturbance, include fluvial, periglacial and aeolian landforms, soils, and sensitive bedrock site types such as fossil and mineral occurrences. A thematic state-wide assessment of fluvial landform systems, using a georegional analysis (see below), is currently in progress (Jerie *et al.* 2001).

Two approaches to the preparation of systematic and thematic inventories are being used in Tasmania, which can be referred to as the '*Classification - based Approach*' and the '*Geo-Regional Approach*'. The underlying rationales of these approaches are essentially the same, but they differ by analysing data at different levels of detail and in, respectively, a primarily list-based and a primarily spatial (map-based) format. These two approaches are outlined below:

The Classification - based Approach

The most detailed approach to developing systematic thematic inventories involves:

- developing or adopting a classification scheme for a theme under consideration (eg, fossil types, glacial phenomena, etc);
- using available data and further fieldwork as necessary to identify all known examples of each classified group of phenomena within a defined study area or 'context area'; and then:
- comparing all the known examples in each classified group to identify which are the best expressed or developed examples of their type (i.e., which have the greatest *representative* significance).

This systematic process has been described by Sharples (1993, 1995a). In slightly more detail, the process involves:

1. *Classification*

Although the use of a classification imposes more or less artificial divisions onto natural phenomena, some means of grouping phenomena is necessary in order to allow us to manipulate data about the natural world. A classification is needed to delineate specific groups of phenomena which we can then compare for significance assessment purposes.

Any broad category of phenomena can be classified in a variety of ways, depending on the purpose for which we wish to use our data. The use we have in mind determines the choice of criteria in terms of which we group phenomena in our classification. For example, if we wish to investigate the origin of things, we might classify them according to genetic criteria, whereas if we are interested in their engineering uses we would classify them according to their physical properties. In the case of geoconservation, we require a classification which focuses upon the explicit identification of diversity (i.e., *geodiversity*) in terms of those particular criteria by which we judge geodiversity to have conservation significance (see 'The Concept of Significance' section 2.3.4).

In Tasmanian geoconservation classification work to date, Soutberg (1990) noted that attempting to base a geomorphic classification system primarily on the *genesis* of landform types is problematical, since genesis is sometimes unclear, and instead proposed a system based on classifying landforms by their form, fabric and genesis in that order of priority. Unfortunately this logical system proved too complex for practical use. More recently, Kiernan (1995b, 1996, 1997b, 1997c) has developed a detailed landform classification system which revolves around classifying landforms at four semi-hierarchical levels, namely in terms of :

- Landform System Controls (lithology, climate, etc);
- Landform and Landform Assemblage types;
- Landform Contents (sediments, biota, speleothems, etc); and
- Human Use and Aesthetic values of Landforms.

This classification approach is described in more detail in the cited references (above); fundamentally, however, it has been explicitly designed to highlight those aspects of geodiversity which Kiernan considers the most important from a conservation perspective

2. *Identification of Context Area*

It is necessary to draw some boundary to the area or region which will be considered in any practical inventory exercise. In many cases political, practical or administrative considerations will define the boundary of a study project. However, a more logical boundary for a geoconservation inventory exercise can be defined in terms of identifying the *context area* for the theme or classes of phenomena which are being inventoried. This context area (which is essentially a 'geo-region' as discussed below) is the area over which the phenomena in question occur, or that they are characteristic of.

Clearly, if we wish to make a rigorous comparative assessment of the conservation significance of a particular feature, then we must assess it against all comparable features. To locate those comparable features we must search the full area in which that type of feature occurs. This full area is the context area (or geo-region), and its size will vary depending on the degree of detail to which we are classifying features. Thus, if we use a very broad classification, and simply wish to identify the best representative example of 'a mountain', then our context area is global and our best example may be something outstanding like Mt Everest! However, if we use a more detailed classification appropriate to regional geoconservation concerns, then we might consider a more detailed class of mountain such as 'formerly glaciated dolerite mountains', in which case our context area is limited to parts of Tasmania and perhaps a few limited areas elsewhere.

Where the context area for the class of phenomena we are considering is larger than the area over which we can - for practical reasons - conduct our systematic inventory study, this fact should be noted as a limitation on the study.

3. *Data Collection*

From our classification, we choose those classes of phenomena that we are going to assess for significance. Again, the number of classes of feature we choose to assess and inventory depends upon the level of detail to which our classification is drawn up. For practical reasons it may be necessary to limit the level of detail we go to. Thus for example, Kiernan (1996, p. 104) classifies seven different classes of end moraine; ideally we should consider each of these separately and look for the best examples of each of the seven types. In practice, however, various constraints may limit us to simply considering all 'end moraines' as a single class. Such limitations on the level of detail achieved in an inventory process should be noted.

For each of the classes of phenomena we have chosen to inventory, we identify their context area, and then within those context areas we identify and list each known example of the class of feature. In most cases we rely here on existing basic scientific data and mapping, although an ideal systematic inventory process would involve additional basic mapping and research as required in portions of the context areas that have not yet been examined or mapped to a satisfactory level of detail. The search for examples of a class of phenomenon within its context area should not be restricted to particular land tenures, as these have little relevance to the distribution of natural phenomena, good examples of which may occur on any tenure.

Each identified example of the phenomena we are considering is evaluated in terms of the excellence or otherwise with which it displays the characteristics of its type (see 'Criteria of Significance' (section 2.3.4) re type profiles), and the degree of any degradation or disturbance which has taken place is also recorded.

4. *Comparative Assessment*
Having compiled our list of all known examples of a given class of phenomena, we compare these against each other to identify those which are of the highest quality in terms of:

- the excellence with which they display the characteristics of their type (i.e., we identify the best developed or best expressed representative examples of the class or type); and

- their condition, i.e., the degree to which their geoconservation values have or have not been degraded by artificial disturbances.

The best developed or expressed examples, in the best condition, are thereby identified as the examples of highest conservation significance. Note that this approach does not necessarily rule out partly degraded features as being significant; where all available examples of a class of phenomenon have been degraded to some extent, those which still display the relevant characteristics to the best degree available may be considered significant as the best remaining examples of their class.

It is also important not to become too reductionist in identifying significant features. For example, where individual classified landform types are integral parts of broader landform assemblages, these should be considered together. Thus, it may be less useful to identify a significant moraine in one glacial assemblage and a significant cirque in another, than it is to identify a particular assemblage whose component cirques and moraines are both of at least moderate significance (see 'The Aims of Geoconservation: Features and Assemblages' section 2.3.3).

5. *Replication*
In making our comparative assessment of a class of phenomenon to identify the best (most significant) examples, it is generally appropriate to identify more than just a single example in each class as significant. The need for identifying replicated significant examples of a class of phenomenon is discussed in 'The Aims of Geoconservation: Replication' section 2.3.3).

6. *Sensitivity Assessment*
The final stage of a systematic inventory process is to assess the sensitivity to disturbance of those phenomena identified as significant (see 'The Sensitivity of Geodiversity' section 2.3.2). This stage is the essential prelude to defining the management requirements and prescriptions needed to ensure the conservation of the identified significant phenomena. Sensitivity assessment requires some

understanding of the nature of the phenomena and the natural processes to which they are subject, and is discussed further below ('Development and Implementation of Management Prescriptions').

Beyond Tasmania, Rosengren (1992, 1994) has applied a similar systematic inventory approach to assessing the significance of volcanic features in Victoria.

In Tasmania, work on the development of systematic classification-based geoconservation inventories is most advanced in the case of karst landforms. Kiernan (1995b) has developed a detailed classification for karst systems, has collated data in a standard format on all known karst landform systems in Tasmania, and has provided a comparative assessment of the degree of karst development in each of these known systems. Sharples (1997a) has used Kiernan's classification and database, together with further data collected in the field, to prepare a comparative assessment of the geoconservation significance of karst landform systems in the Tarkine region of north-western Tasmania. Detailed classifications have been prepared for glacial and coastal landforms (Kiernan 1996, 1997c), although the collation of a comprehensive database on these landform types is less advanced to date. Dixon (1997) has provided a preliminary database on aeolian landform types and distribution in the eastern half of Tasmania.

The Georegional Approach

The georegional approach to the systematic identification of significant elements of geodiversity is described in detail by Dixon & Duhig (1996), Houshold *et al.* (1997) and Duhig *et al.* (1998). The georegional approach is currently being tested in projects aimed at coastal and fluvial landform conservation being conducted by the Nature Conservation Branch of the Tasmanian Department of Primary Industries, Water and Environment (DPIWE) (Jerie *et al.* 2001). The following is a brief synopsis of the approach, highlighting several important aspects.

The Georegional approach is a relatively quick method of classifying and mapping the *broad* elements of geodiversity, such as areas containing groups of *related* landform assemblages. Whilst a classification-based approach (above) is more appropriate for analysing geodiversity in detail (i.e., for identifying individual significant landforms or sites), georegional analysis is an efficient means of identifying and classifying the broad outlines of the geodiversity of a region, and thereby highlighting groups of phenomena which are not well represented in existing geoconservation inventories.

The following description concentrates on the use of the georegional approach in identifying the elements of geomorphic (landform) diversity, but it is also applicable to other aspects of geodiversity including soils and at least some classes of bedrock features (indeed, the georegional approach is closely related to the "Land Systems" approach to classifying soil associations).

In essence, the georegional approach as applied to landforms involves mapping out regions in which *particular combinations of system controls* (eg, lithological substrate type, climatic conditions, existing topography) have operated *at particular times* to produce characteristic landform assemblages. In other words, the georegional approach focuses on classifying geodiversity at the 'Systems Control' level of Kiernan's geomorphic classification system (described above: see 'Classification - Based Approach'), and does so by actually mapping out the regions affected by particular combinations of system controls to give spatially - defined "Georegions", each of which is characterised by a particular combination of system controls. It is then implicit that each georegion will have developed its own characteristic classes of landforms or landform assemblages (the second level of Kiernan's classification) in response to those specific system controls.

The georegional method is most reliably applied to the grouping and mapping of present day active geomorphic process systems according to the (readily measurable) distribution of present day system controls. However, the method can be used to define georegions for relict (inactive) landform systems, provided we have a reasonable idea of the spatial distribution of the relevant system controls during the periods of time when the now-relict landforms were actually forming. For example, the georegional approach has been used in this way to identify Pleistocene glacial georegions in Tasmania by analysing the system controls operating during the Last Glacial Stage and at the Maximum Glacial Stage (Dixon & Duhig 1996).

The Georegional Method in Brief

In the first attempt to utilise the georegional approach in Tasmania (Dixon & Duhig 1996), georegions were mapped at 1:500,000 scale. The system controls that were considered to most profoundly influence Quaternary and present day landform development in Tasmania were:

Time

Time was treated as a system control so as to allow for the effects of changing environmental conditions over time, which have produced different types of landforms at different times. Time was dealt with by drawing up a different georegional map, using the other four system controls (below), for each important period of time during which differing system controls were active. Thus, by drawing maps for the present day time slice, we get georegions representing presently active geomorphic systems, whilst by drawing maps for (say), the Last Glaciation, we get a georegion map indicating the potential distribution of different groups of (now relict) glacial landform assemblages produced by the system controls which were active at that time.

Bedrock Geology

Bedrock geology is a fundamental system control on landform (and soil) development, in that the lithological (including chemical) and structural characteristics of bedrock determine the types and form of the landforms and soils which are produced under other given system controls. Using the GIS capabilities of Tasmania Development and Resources, the bedrock geology of Tasmania was divided into 11 categories, each having similar structural and lithological characteristics (rather than into primarily stratigraphic sub-divisions as is more normally the approach in geology; in a georegional approach, the physical characteristics of bedrock are more important than its age). Although bedrock geology will obviously be different further back in time, for the purposes of analysing Quaternary georegions in Tasmania there has been little appreciable bedrock change over that period.

Climate

Climate provides a major independent system control on geomorphic (and soil) processes, most importantly by determining the quantity and physical state (liquid or solid) of water available in the environment to drive weathering, erosion and depositional processes. Although a more detailed georegional analysis might consider several climatic parameters, for the purposes of the initial analysis Tasmania was divided into 3 categories (regions) of significantly different annual precipitation, with the boundaries between each precipitation region chosen to co-incide with significant thresholds of change for the effect of precipitation on Tasmanian land forming processes, and to mirror steep environmental gradients in the natural landscape. Sufficient data exists to prepare such precipitation maps for several past glacial stages during the Quaternary (based on a climatic index derived from cirque floor heights and ice thicknesses), as well as for the present time (Bureau of Meteorology data).

Topography

The existing topography, which may result from prior tectonic and/or geomorphic processes, is primarily relevant as a control on landform and soil processes insofar as it determines the degree to which gravitational, solar and other energies can perform work at a given location (through the effects of slope steepness, aspect, etc). Although several topographic variables are relevant, for the purposes of defining topographic regions at 1:500,000 scale it is not possible to characterise large regions in terms of highly variable characteristics such as slope aspect. At the map scale used, topography was characterised in terms of 4 topographic categories, each *dominated* by a different range of slope angles. The categories were defined partly on observed slope angle thresholds for mass movement processes in Tasmania. A generalised slope angle map of Tasmania at 1:500,000 scale (gridded with 200m cells) was prepared by the Parks and Wildlife Service from their GIS databases.

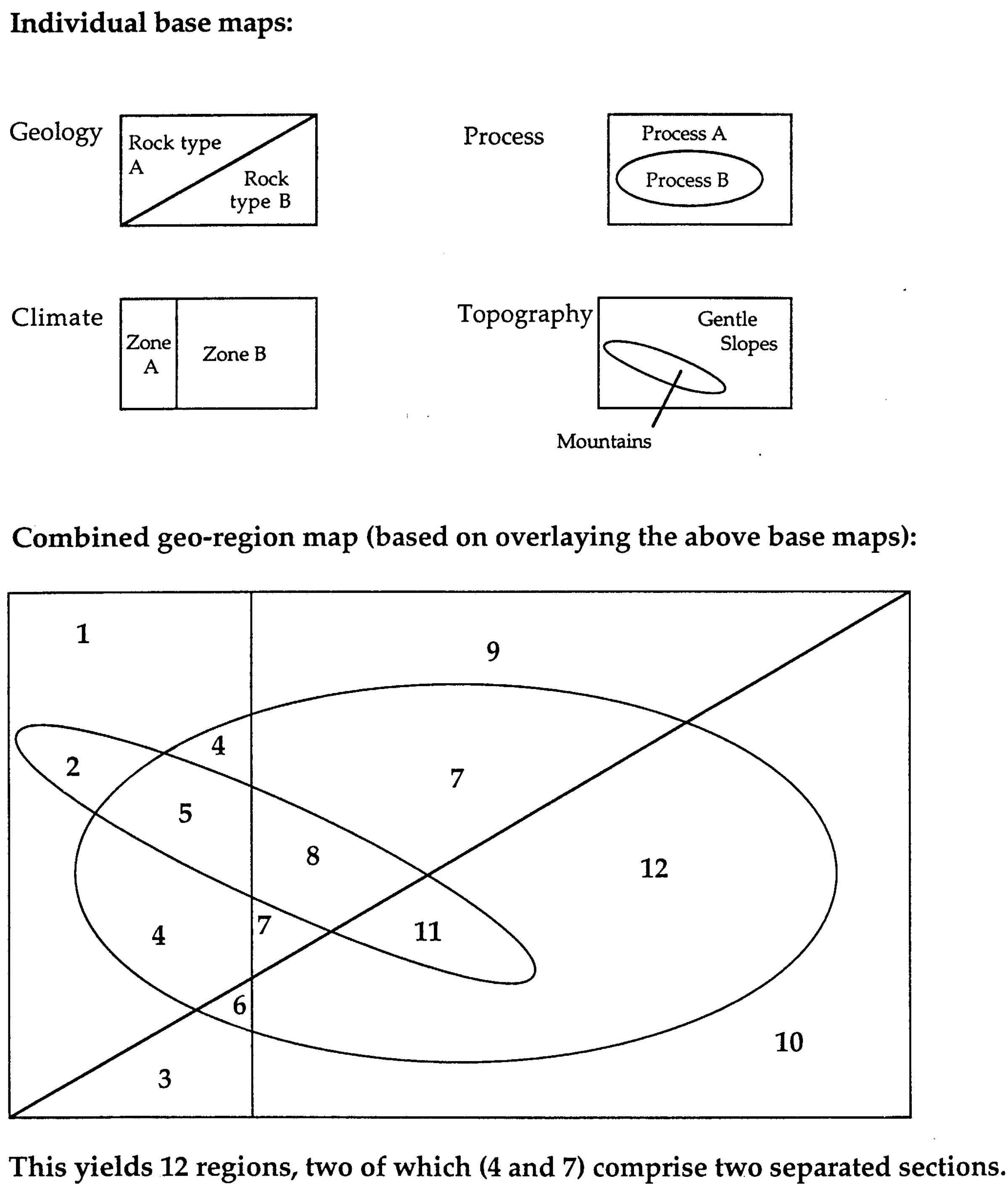

Figure: An (imaginary) example of a geo-region map drawn for a particular time slice.

Processes

Although geomorphic processes are themselves essentially a function of the above bedrock, climatic and topographic controls, treating them as a system control in their own right provides a simple method of integrating some of the major aspects (eg, temperature, altitude) of the other controls which cannot easily be dealt with as separate independent variables. The major geomorphic processes (karst, fluvial, glacial, periglacial, aeolian, coastal/marine) which have controlled Tasmanian landform development during the Quaternary were mapped as regions in which each process played a major role at the particular time being considered. The boundaries of the process regions were based on the professional knowledge of Tasmanian geomorphologists.

Geo-region maps of Tasmania were prepared for several important Quaternary times, including the present day, the Last Glaciation, and the Maximum Glaciation. For each chosen time period, the maps showing the distribution of bedrock, climatic, topographic and process regions for that time were overlain. Each unique combination of a bedrock, climate, topographic and process category region could then be traced to yield a unique 'Georegion'. In practice, it was found to be simpler to draw a separate georegional map for each process category at each time period. As might be expected, it was commonly found that a given georegion comprised several spatially separated cells in each of which the same combination of system controls existed. In order to avoid confusion during the mapping procedure, a code was developed to label each georegion 'cell' according to the system control categories by which it is characterised.

The end result of this procedure was a map (and accompanying list) delineating the distinguishable georegions of Tasmania at each chosen time period. Each georegion will contain landforms characteristic of the combination of system controls defining the georegion, and distinct from the landforms produced in other georegions. Thus, each georegion constitutes a distinct element of geodiversity at a 'system control' level of classification.

It is important to note that the degree of detail to which the georegions are defined (and thus, the number and size of individual georegions) is dependant upon the degree of detail to which the system controls are divided into different mappable categories. The degree of detail described above, although ostensibly quite coarse, nevertheless divides Tasmania into several hundred present day active process georegions, suggesting that the degree of detail used is probably appropriate to the sort of broad scale inventory process for which the georegional approach is intended (below).

Recent Advances in Georegion Analysis (2002)

A major project currently (2002) in progress within the Nature Conservation Branch of the Tasmanian Department of Primary Industries, Water & Environment is building upon the principles outlined above to produce a map of Tasmanian fluvial georegions (Jerie *et al.* 2001). This project is developing GIS-based methods of analysing fluvial geomorphic diversity which represent a considerable advance on the basic procedure presented above (Houshold *et al.* 1997), although the essential principles remain the same. It is envisaged that the fluvial georegions map, and the characterisation of fluvial landforms and processes characteristic of each georegion, will provide a powerful tool in assessing fluvial landform and process conservation priorities in Tasmania, and in identifying characteristic management issues associated with each fluvial georegion.

Some of the purposes that it is envisaged georegional maps will serve are identified below;

The Use of Georegional Maps

For a given study area, a georegional exercise such as that described above can allow us to produce maps, and a corresponding list, of the different broad categories of presently active geomorphic processes and landform assemblages (if we georegionalise the study area in terms of system controls acting in the present day time period), or of relict landforms (if we georegionalise the same area in terms of the different system controls that were active during particular past times), that are found in the area. Each such georegion will be defined spatially, as a mappable region, and each will contain its own distinctive assemblages of landforms belonging to a particular broad element of geodiversity.

In effect, the georegional maps we produce in this way constitute a systematic and *complete* inventory of the geodiversity of a study area *at the level* of system controls and their associated broad classes of landform assemblages.

We can use such geo-regional maps in several ways:

- *Comprehensive Inventory Development*
  A georegional map constitutes a comprehensive classification of the geodiversity of an area at the level of detail defined by the system controls used to draw up the georegions. It follows that if we are to aim at ensuring that representative examples of all aspects of the geodiversity of a given area are identified in geoconservation inventories, then we must identify features, assemblages and processes representative of each of the georegions that can be defined in the area. Thus, we can use our defined georegions as a guide to the various representative elements of geodiversity which we need to identify in the process of drawing up a comprehensive inventory of representative examples of the elements of geodiversity in a given area.

- *Gap Analysis*
  By comparing the elements of geodiversity identified in existing geoconservation inventories with a georegion map, we can identify which georegions have representative features already identified in inventories, and which do not. This provides us with a list of georegions for which no representative features have yet been identified for geoconservation purposes; consequently we then have a list of gaps in our inventories to guide our priorities in searching for further representative elements of geodiversity to complete those inventories.

- *Context Areas for Classification-Based Inventory Processes*
  The actual identification of the best representative landform features, assemblages and process areas characteristic of each georegion is most practically carried out by a classification-based approach *within* each georegion, as described above (see 'Classification - Based Approach[' above). Note that, although the georegional method is in principle capable of grouping and differentiating elements of geodiversity to any arbitrarily great degree of detail - by mapping variations in system controls to arbitrarily fine levels of detail - in practice this approach would be extremely difficult to apply at the level of identifying individual representative landforms due to the enormous complexity of the system control information that would be necessary.

  Nevertheless, the value of conducting a georegional analysis *prior* to more detailed classification-based inventory exercises is that the georegions conveniently and logically define the *Context Areas* which delimit the areas that need to be surveyed in a detailed classification-based inventory exercise (see 'Classification - Based Approach' above). In effect, each georegion is the context area for the broad class of landforms defined by the combination of system controls that characterise that georegion.

  In other words, the Classification-based and Georegion-based systematic inventory approaches are not alternatives, but are rather complementary approaches which ideally should both be applied, in their appropriate roles, in the course of a comprehensive systematic geoconservation inventory process for a given study area.

- *Process and Sensitivity Analysis*
  In the all-important context of maintaining natural rates and magnitudes of change in presently active geomorphic and soil systems (see 'The Aims of Geoconservation' section 2.3.3), a present-day georegions map defined using present-day system controls has a useful role to play in helping to identify the particular management prescriptions appropriate to protecting various categories of active natural systems. Because the system controls which characterise present-day georegions are intimately related to the types of natural geomorphic and soil processes occurring in each georegion, the differences between georegions will to some extent relate to the differing sensitivities and differing management requirements of the features and processes operating in each region.

Thus, although a georegional analysis will not provide all the fine detail needed to design specific management prescriptions for various geomorphic and soil systems, it will go a long way towards helping to define the broad sensitivities and environmental management requirements of differing natural systems.

- *Significance Level Assessments*
  The potential to use georegions as more logical context areas for geoconservation significance assessment has been discussed elsewhere on this website (see 'Assigning Levels of Significance' section 2.3.4). In brief, in order to assess the comparative significance of a feature we need to compare it with the quality of other features of its type. The georegion of which a given type of feature is characteristic provides a more logical context within which to locate equivalent features for comparison than does the present standard system of assigning the significance of a feature within an arbitrary subdivision such as a state or national boundary.

3. DETAILED INVENTORIES

Detailed geoconservation inventories consist of information about a particular significant and sensitive system at a level which is sufficiently detailed to make specific management prescriptions. That is, whilst a systematic inventory may identify, say, a particular karst system as being significant, nonetheless we may still need detailed information on hydrology, cave locations and inter-connections, catchment conditions, etc, in order to define the actual management requirements on the ground. Such detailed information comprises a 'Detailed Inventory' for geoconservation purposes. Where the significant phenomenon or system is a complex one, the preparation of a detailed inventory may require substantial field mapping and research into active natural processes (see 'Development and Implementation of Management Prescriptions' below).

Most detailed geoconservation inventories in Tasmania to date have been directed at karst systems, including the Mole Creek Karst (Kiernan 1984, 1989a, Eberhard *in prep.*), the Bubs Hill Karst (Houshold & Clarke 1988), the Exit Cave Karst (Houshold & Spate 1990, Kiernan 1991b, Houshold 1992), and the Junee-Florentine Karst (Eberhard 1994, 1996). Soutberg (1991) also prepared a detailed conservation-oriented inventory of fluvial landforms on the Lower Gordon River, which is supplemented by Bradbury's (1994) inventory of significant sites.

Due to the cost and time involved in preparing detailed inventories, high priorities for such work will generally be determined by using reconnaissance or systematic inventories to identify poorly known complex and sensitive systems in areas likely to be disturbed, or already partly disturbed. Examples of such priorities in Tasmania include the significant and highly sensitive Henty Dunes system and the poorly known glacial landforms of the Picton River valley, both of which are subject to ongoing disturbance by forestry activities.

Making Inventory Data Available to Land Managers

Whereas most geoconservation inventories are typically published (or at least printed), such formats will not necessarily make the relevant data available to field managers, who may be unaware of them, or may have neither the time nor inclination to wade through voluminous documents in search of information relevant to their areas of responsibility. Whilst the publication of inventories in the form of reports is highly desirable as a means of ensuring that the data collected is preserved, in order to ensure that the data will be acted upon in practice it is essential to collate and present inventory data in a simple and unified format. Such a unified database should be readily accessible to all those who may require information on significant features - that is, to planners and managers in all relevant government agencies, to field managers such as park rangers and foresters, and to private land managers including landowners and commercial enterprises such as forestry and mineral exploration companies.

At the present state of information technology, the best available means of presenting geoconservation data in a unified and easily accessible format is to use computerised Geographical Information Systems (GIS) in which the data is presented in a mapped form with a linked database. Two GIS-based approaches to unified geoconservation data presentation- which hopefully will ultimately be linked - have been developed in Tasmania, namely the *Tasmanian Geoconservation Database* and Forestry Tasmania's *Management Decision Classification* system. These are described below:

The Tasmanian Geoconservation Database (TGD)

Funding provided in 1996 under the State - Commonwealth Governments Regional Forest Agreement (RFA) process enabled the collation of all existing Tasmanian geoconservation inventories into a consolidated database known as the *Tasmanian Geoconservation Database* (TGD) (Dixon & Duhig 1996). The TGD is a computerised database with some listed sites and areas also mapped into a GIS format. The database is currently administered by the Tasmanian Department of Primary Industries, Water & Environment (DPIWE), and is subject to regular reviews and updating on the advice of an advisory panel comprising Tasmanian geoconservation workers.

It is intended to make the database available to all interested users, and a version is currently available on the World Wide Web at http://www.gisparks.tas.gov.au (the Parks and Wildlife service GIS server), and at http://atlas.tas.gov.au (the Tasmanian node of the Australian Coastal Atlas). The TGD is envisioned as providing the unified repository for all Tasmanian geoconservation inventory data in a readily usable format.

The Management Decision Classification system (MDC)

The primary tool used by Forestry Tasmania in planning forestry operations is the Management Decision Classification (MDC) system. This is a GIS system in which zones within State forest requiring differing management prescriptions are mapped at 1:25,000 scale. Areas containing sensitive conservation values (including geoconservation values) are mapped onto the MDC as either *Protection Zones* (where no logging is permitted) , *Special Management Zones* (where logging is permitted with special prescriptions according to the nature of the conservation values present), or *Conditional Zones* (where logging is deferred pending further investigation of the conservation values).

The value of the MDC system is that it must be consulted in the planning of all forestry activities, so that any values mapped onto the MDC database will come to the attention of forest planners. The existing MDC system has proven useful, and forest planners and managers have been responsive to it. However, a number of areas for improvement can be identified, of which some major areas relevant to geoconservation (Dixon *et al.* 1997a) include:

- Whilst the MDC maps indicate the location of sensitive features they do not provide details of the nature of the features and the appropriate management response; obtaining such information still requires consultation with experts, and cases could arise where the original reason for a feature being mapped onto the MDC is obscure. To alleviate this problem, the MDC GIS maps could be electronically linked to more comprehensive data, and ideally to the Tasmanian Geoconservation Database.

- The current MDC covers only State forest, but not private land on which logging may occur. The extension of the MDC, or an equivalent system, to private land is desirable, albeit there may be political difficulties inherent in such an extension.

- The MDC does not allow planners to distinguish between areas for which no information on geoconservation values is available, and areas which have been surveyed for geoconservation values and none were found to be present.

Development and Implementation of Management Prescriptions

Once features and systems of significant geoconservation value have been identified (see 'Identification of Significant Sites and Processes' above), appropriate prescriptions for the management of their values can be determined by consideration of site attributes including their sensitivity to disturbance (see 'The Sensitivity of Geodiversity' section 2.3.2).

The 'nitty - gritty' of determining specific on-the-ground management prescriptions appropriate to the various types of significant and sensitive geological features, landforms and soils is a large and detailed topic well beyond the scope of the present discussion. However, a large literature exists on many aspects of these practical management issues. The purpose of the present discussion is merely to outline the broad options and procedures which can be applied in order to determine the details of appropriate management prescriptions for specific sites or systems.

The following subsections discuss the broad management options available for the management of geoconservation values, and the means of determining the most appropriate management options and prescriptions for particular cases.

Geoconservation Management Options

Management options for sites and areas of geoconservation significance can be broadly grouped under four headings as below. Whilst these options were originally identified in the context of forestry planning (Dixon et al. 1997a), they are probably broadly applicable to regions subject to a wide range of human activities. Determination of the appropriate option for a given feature depends on its degree of significance, its sensitivity to disturbance, and on the nature of any other associated conservation values (e.g., biological, wilderness and landscape values, etc). The numerical sensitivity ratings referred to below relate to the 10 - point scale of sensitivity described elsewhere in this document (see 'The Sensitivity of Geodiversity' section 2.3.2). Determination of the sensitivity of a site depends upon knowledge of its nature and response to processes and disturbances affecting the values of the site.

The four broad management options are:

1. *Protection*

The exclusion of artificial disturbances from a significant site or area is appropriate when the geoconservation values are of sufficiently high significance as to warrant preservation, and of sufficiently great sensitivity that disturbance is likely to degrade the values.

This management option may apply to significant places with a sensitivity rating of 1 to 4 and, in the case of some highly significant features, to places with a sensitivity rating of 5 or 6. Examples may include parts of major active karst or fluvial systems, some classes of aeolian landforms, and fossil deposits of limited extent.

2. *Special Prescriptions*

Some significant features exhibit a lesser degree of sensitivity, so that their values can be preserved in the context of some development activities provided these are conducted with special modifications (prescriptions) to avoid degradation of the significant values. Examples of special prescriptions include:

- *Buffer Zone Retention*: Exclusion of disturbance from localised zones around specific features. This may be appropriate for some places with sensitivity ratings 4 to 6, such as some geological features and erodible but relict features such as glacial moraines or inactive karst landforms (see 'The Aims of Geoconservation: Relict ('fossil') Features' section 2.3.3).

- *Catchment Management*: This option is appropriate to places with sensitivity rating 4, whose integrity depends on undisturbed natural runoff and water characteristics. Major examples are significant active karst and fluvial landform systems. Special prescriptions required may include vigorous application of measures to avoid soil erosion and disturbance of riparian zones in the catchment of the significant features.

- *Reduced Intensity Operations*: Certain significant features such as some relict landforms and some soil types with sensitivity ratings 5 to 7 may be capable of maintaining their geoconservation values in the context of development activities conducted at lower intensities than normal. In the case of logging operations, for instance, suitable 'reduced intensity' operations might include selective logging, extended rotation times or cable logging.

3. *General Prescriptions*

Some significant features may have values that are relatively robust to many artificial disturbances. The values of such features can be preserved in the context of a variety of development activities. The appropriate management prescriptions are those general prescriptions to maintain overall environmental quality which should apply to any responsibly - conducted development activities, such as normal provisions to minimise soil erosion, water turbidity, and so on. In Tasmania, many of the provisions of the Forest Practices Code (Forest Practice Board 2000) are general prescriptions of this sort which apply to the conduct of roading and logging operations.

This management option may apply to significant features with sensitivity ratings of 8 to 10. Examples may include significant large scale structural landforms or medium to large scale geological features.

4. *Precautionary Management*

Further work required to establish Management Requirements.

The management requirements of some places may be unknown, due either to poor understanding of the natural processes affecting the response of a significant phenomenon to disturbance, or because there are indications that significant and sensitive features may be present but insufficient survey work has been done to confirm or refute the existence of such features.

In accordance with the Precautionary Principle of conservation practice (see for e.g., AHC 2002) appropriate management in such places involves deferring disturbing activities, or at least reducing their intensity to an unproblematic level, until necessary investigations have been undertaken to determine the appropriate management option (see 'Determination of Appropriate Management Options and Prescriptions below').

Sensitivity Zoning
Where sufficient information exists on the spatial distribution of phenomena of significant geoconservation value in a region, and the processes controlling their response to disturbance are sufficiently well understood, areas can be zoned according to their sensitivity to disturbance. The ability to zone regions in this fashion provides an important planning tool which can be used to minimise conflict between conservation and development values at an early stage of planning, so avoiding unnecessary conflict and wastage of time and money (see also 'Ad Hoc Identification of Values' above).

In a major sensitivity zoning exercise of this sort, Eberhard (1994, 1996) has zoned Tasmania's extensive and significant Junee - Florentine Karst System into High, Medium and Low Sensitivity Zones, for which he recommended, respectively, Protection, Special Prescription and General Prescription management options as described above. Since a large portion of the Junee - Florentine karst system lies within State forest, this zoning scheme has the potential to greatly reduce future conflict over the conduct of forestry operations in the area. Baichtal *et al.* (1996) have used a similar system of '*Karst Vulnerability Zoning*' in Alaskan karst areas for the US Forest Service, which is related to Eberhard's zoning scheme.

Determination of Appropriate Management Options and Prescriptions
As noted above, the ability to determine the appropriate management options and prescriptions for a feature or system of geoconservation significance depends on knowledge of its sensitivity to disturbance, which in turn is dependant upon knowledge of its nature and the processes determining its response to artificial disturbances.

At the broadest level, some general distinctions can be made between the sensitivities of significant bedrock, landform and soil features to disturbance, and these may imply a need for differing management options (see 'Some General Distinctions between the Sensitivities of Bedrock, Landform and Soil features' section 2.3.2). However, there are numerous exceptions to such generalisations, and it is necessary to consider each case on its own merits. Furthermore, even where such broad generalisations apply to a specific case, there is still a need to determine specific details of the management prescriptions relevant to each site. Sensitivity to disturbance may vary even within a given class of phenomena, depending upon local environmental conditions, so that rule of thumb principles may not always be applicable.

As noted above, difficulties may occur where insufficient information is available to determine appropriate management options for a site, and it may be necessary to apply the Precautionary Principle in the interim. Information may be deficient in one or both of two ways:

1. Lack of certainty as to whether or not significant and sensitive features are present, especially where there are indications that significant features may be present. The solution here is to conduct the necessary research and mapping to establish the presence or otherwise of such features, and document their characteristics (see 'Identification of Significant Sites and Processes' above).

2. Lack of understanding of the processes controlling the response of the feature or system to artificial disturbance. In general, this means a lack of understanding of the natural processes occurring at the site, and the ways in which artificial disturbance may alter these processes. The remainder of this sub-section considers this aspect.

The Need for Process Studies
Whereas relict landforms and most significant bedrock geological features are the product of past natural processes which are no longer active, many significant landform and soil phenomena are actively forming features and systems whose continuing development is controlled by ongoing natural physical and biological processes. In addition, some relict (inactive) landforms such as old vegetated

dunes are also highly sensitive to degradation if current environmental processes affecting them are changed. It is one of the major aims of geoconservation to maintain natural rates and magnitudes of change in such processes so as to preserve the integrity of the landform and soil features themselves, as well as to maintain the role they play in broader ecological and environmental processes (see 'The Aims of Geoconservation' section 2.3.3).

Thus, in order to identify appropriate management options and prescriptions for significant landform and soil systems, it is necessary to understand the natural processes governing those systems so as to be able to:

- understand how such processes respond to disturbance;

- determine the thresholds of disturbance (or "Limits of Acceptable Change"; see 'Judging Significance: Ecological or Natural Process Values' section 2.3.4) beyond which unacceptable acceleration (or deceleration) of natural rates and magnitudes of change (i.e., degradation) will occur; and

- to identify management options and prescriptions which can be used to keep disturbance below acceptable thresholds.

Although relevant process studies may have been undertaken elsewhere, it is important to remember that no two systems will be identical, so that some degree of local study will always be necessary to determine how geomorphic and soil systems behave under the local environmental conditions.

The Georegional Approach described above may also provide a useful guide to designing geoconservation management prescriptions for active systems, since a georegional analysis can provide a guide to broad variations in process types and sensitivities between regions which may imply broad differences in the sorts of management required between those regions (see 'The Georegional Approach: Process and Sensitivity Analysis' above).

In Tasmania, most basic earth science research to date has been directed towards bedrock geology issues of economic (mining and engineering) relevance, although some studies of groundwater, soil erosion and slope stability have been undertaken which are relevant to environmental management. However, little is known of many aspects of geomorphic and soil processes in Tasmania, and a greater research effort in these directions is needed from a geoconservation perspective. Whilst some karst process studies have and are being conducted by both Forestry Tasmania and the Tasmanian Parks & Wildlife Service (Eberhard & Kiernan 1990, Houshold 1997), research into fluvial geomorphic processes (as distinct from hydrology per se) in Tasmania has been quite limited, with the most detailed work being research by the Parks and Wildlife Service into the erosion by boat wakes of the banks of the Lower Gordon River (Bradbury *et al*. 1995). However, current georegional assessment of fluvial landform systems in Tasmania (Jerie *et al.* 2001) will greatly improve understanding of regional variations in fluvial processes across Tasmania. Similarly, whilst studies of soil erosion have been undertaken, little is known of soil formation rates, or the impact of various activities on soil structure and pedological processes. Without such information, it may be impossible to say whether a given measured rate of soil erosion or degradation is above or below an acceptable threshold of disturbance (i.e., sustainable or not).

In order to be able to arrive at appropriate management options and prescriptions for sensitive elements of geodiversity, then, local studies of geological, geomorphic and soil processes need to be conducted at a level which will allow the impact of disturbance on significant features and systems to be understood. Whilst the amount of research necessary for this purpose may vary widely, in the case of Tasmania it is evident that geomorphic and soil process studies to date are in many instances inadequate to allow confident identification of appropriate management prescriptions, so that some application of the Precautionary Principle is necessary.

Monitoring and Indicators
It is essential in any environmental management program (such as geoconservation management) to be able to determine the effects of the management strategies, options and prescriptions that have been implemented, so as to evaluate their success or otherwise and make changes if necessary. Two aspects of this can be distinguished, namely monitoring and indicators.

Monitoring
Monitoring consists of taking regularly repeated measurements of critical parameters at a site to determine whether the integrity of a feature or process is being adversely affected by disturbance, or alternatively is being maintained or restored by appropriate management practices. Ideally, pre-disturbance (and/or pre-restoration) baseline measurements of the critical parameters should be available to evaluate any changes against. Monitoring programs may form a part of the sorts of process studies described above.

In Tasmania only a handful of monitoring programs are currently being funded for geoconservation purposes:

- A Parks and Wildlife Service monitoring program in Exit Cave, in the Tasmanian Wilderness World Heritage Area, is measuring physical, chemical and biological parameters to track the progress of natural process restoration following the closure and rehabilitation of a limestone quarry whose operation was degrading the cave system (Houshold 1997).

- Forestry Tasmania is monitoring natural karst processes in Little Trimmer Cave (Mole Creek) as part of a study of the effects of logging on caves (Eberhard & Kiernan 1990).

- The Parks and Wildlife Service is monitoring bank erosion on the Lower Gordon River to determine the effects of restricting tourist boat speeds and access (Bradbury *et al.* 1995).

A number of other monitoring programs are desirable to evaluate the success or otherwise of current management prescriptions, including monitoring selected fluvial landform systems to evaluate the success of the Forest Practices Code in maintaining their integrity, and monitoring the effects of logging activities on the Henty Dunes pine plantation in Western Tasmania.

Indicators
Indicators consist of some quantitative and easily measurable attributes which can provide a measure of the success or otherwise of geoconservation management programs generally, and which can point to priorities for ongoing geoconservation work, in a broader context (eg, state-wide) than the individual features or systems measured by specific monitoring programs. Conservation status indicators are a widely used tool in 'State of the Environment' reports and the like, whose purpose is to determine the degree to which current or past conservation strategies have been achieving their aims, and to highlight deficiencies in such strategies which require attention.

No geoconservation status indicators have yet been developed to the point of being used in Tasmania. However, three broad categories of potential indicators relevant to geoconservation may be identified:

- *Data Coverage Indicators*: Indicators of knowledge of the geodiversity of a region, as measured by the degree of coverage of the region by basic geological, geomorphic or soils mapping, and by the compilation of inventories of significant elements of geodiversity at various levels of detail.

- *Site Integrity Indicators*: Indicators of the condition and conservation status of sites or assemblages of features of geoconservation significance.

- *Process Integrity Indicators*: Indicators of the natural integrity of the processes upon which the condition of significant sites and assemblages depend, and through which geodiversity and biodiversity are inter-related and inter-dependant.

Sharples (2001) has undertaken an initial study aimed at developing indicators of the state of geodiversity in Tasmania, for the purpose of State of the Environment reporting. In essence, the approach envisaged involves using georegional maps (see discussion above) to provide a spatial mapping of the various elements of geodiversity distinguishable at a state-wide level within a particular theme (eg, fluvial landforms, karst systems, etc). These maps are then intersected with a variety of condition indicators relevant to the sensitivities of the features and processes in the particular theme (eg, vegetation clearance, river channel modification, roading, etc). The end result is a state-level indicator of which elements (georegions, at this level of analysis) in the particular geodiversity theme are in the best condition, and which are in the most generally disturbed or degraded condition. This then provides an indication of geoconservation priorities, in that the geodiversity elements which are most generally degraded should be given the highest priority for the conservation of such good examples of those elements as remain.

It is envisaged that the first real trial of this approach to developing indicators of the state of geodiversity will be undertaken using the fluvial georegion map currently in preparation by Jerie *et al.* (2001).

(2.4) GLOSSARY OF GEOCONSERVATION TERMINOLOGY

(2.4.1) INTRODUCTION

Because geoconservation is a discipline which is still in its infancy, a plethora of terms have been used to describe various aspects of the discipline, and there remains no universal agreement on terminology. Because of this confusion, a number of workers in the field have in recent years made an effort to weigh up the various terms on offer. Tasmanian workers have settled on the terms which are presented below. Most of the adopted terms are already in use elsewhere (e.g., the terms 'geoconservation' and 'geodiversity' are widely used in Europe). We present this glossary of our adopted terminology here in the hope of:

- convincing others to adopt a unified and consistent terminology for use in the field of geoconservation; and

- encouraging debate and further development of appropriate terms to use in geoconservation work.

(2.4.2) GLOSSARY OF GEOCONSERVATION TERMINOLOGY

This glossary is not a general glossary of standard geological, geomorphic or pedological terms, although these are of course used in geoconservation work. Instead, this is a brief glossary of terms pertaining specifically to geoconservation; for definitions of the numerous other more standard geological terms used by geoconservation workers, users should consult any standard dictionary or text on geology.

Due to its brevity, the terms in this glossary are presented in a thematic rather than alphabetical order. Because of the lack of universal agreement on geoconservation terminology, the glossary provides not only a definition of each word, but also a brief explanation of why the use of the word is recommended.

CONCEPTUAL TERMS

This first group of words are those used broadly to refer to the field of geoconservation. It is important to recognise the distinctions between three of the words discussed below - geodiversity, geoconservation, and geoheritage - in order not to confuse them with each other. 'Geodiversity' is a *quality* we are trying to conserve, 'Geoconservation' is the *endeavour* of trying to conserve it, and 'Geoheritage' comprises those *concrete representative examples of features and processes* to which we direct our management efforts in order to conserve it. These three words are not synonyms, but rather complementary terms

Geodiversity

A brief definition of 'geodiversity' has been given by Sharples (1995a) as:

The range (or diversity) of geological (bedrock), geomorphological (landform) and soil features, assemblages, systems and processes.

This brief definition implicitly includes hydrological and climatic (atmospheric) processes, insofar as these are involved in geological, landform and soil processes; however a longer and more explicit definition is provided by Eberhard (1997, p. v):

The natural range (diversity) of geological (bedrock), geomorphological (landform) and soil features, assemblages, systems and processes. Geodiversity includes evidence for the history of the *earth (evidence of past life, ecosystems, and environments) and a range of processes (biological, hydrological and atmospheric) currently acting on rocks, landforms and soils.*

A similar definition of 'geodiversity' is provided by the Australian Natural Heritage Charter (AHC 2002).

The usefulness of the term 'geodiversity' is that it highlights the idea that one of the fundamental aims of geoconservation should be to *at least* conserve suites of features and processes representative of the full *diversity* of natural geological, landform and soil processes and features. In this respect, the term is analogous to the term 'biodiversity', which bioconservationists use to highlight the importance of conserving biological genetic, species and community diversity. However, it is important to note that the only analogy implied between 'geodiversity' and 'biodiversity' is that both involve a *diversity* of phenomena; beyond this self-evident similarity, no further analogies between the detailed nature or workings of biological and geological processes are expressed or implied.

An alternative term, *geological diversity*, is less useful because its common usage does not generally encompass soils, and also because in common usage 'geological' is more often interpreted to mean simply bedrock features rather than landforms, albeit geomorphology is commonly defined as a part of geology. In other words, the use of the root prefix 'geo' rather than the full word 'geological' reduces the likelihood of misunderstandings over the intended scope of the word Geodiversity - it is less likely to be mis-interpreted as meaning only bedrock features, and can more easily be understood as encompassing soils and landforms as well as bedrock.

At least two slightly different usages of the term 'geodiversity' can be discerned in recent Australian geoconservation literature:

1. *A broader, less value-laden meaning*
The most straightforward usage is that the term 'geodiversity' refers to the *total* range or diversity of geological, geomorphic and soil phenomena (e.g., Sharples 1995a, Dixon 1995b, Kiernan 1995b, 1997b, Houshold *et al.* 1997. This usage is not value-laden, and simply states that there objectively exists a range or diversity of earth phenomena (which may include phenomena that are in themselves uniform systems of low 'internal' diversity). Under this usage, the simple existence of geodiversity does not automatically imply either high or low conservation significance for any particular things; rather, 'geodiversity' is an objective, value-neutral property of the world, whilst the different term 'geoheritage' (see below) is reserved for use as a value-laden word to identify particular elements of geodiversity that are judged to be of high conservation value.

2. *A narrower, more value-laden meaning*
A second, subtly different, usage which has appeared in recent literature is the idea that 'geodiversity' refers specifically to particular geological, geomorphic and soil systems that are in themselves diverse or complex ('geodiverse'), and thus does not apply to systems which are uniform or have low 'internal' diversity (e.g., Joyce 1997, Stock 1997, Semeniuk 1997). Under this usage, a glacial landform system comprising a wide variety of cirques, moraines, eskers, outwash deposits, kettle holes and other features might be regarded as displaying 'high geodiversity', whilst an extensive dune field containing only one repetitive type of sand dune might be considered to have 'low geodiversity'. This meaning of the term geodiversity seems to be taken in a somewhat value-laden way, in that there appears to be an implication that more diverse systems are more worthy of conservation than systems having lower diversity, which may not necessarily be the case since systems of low diversity may be important for other reasons (Joyce 1997).

Whilst the second usage outlined above provides a tool for comparing the diversity of particular systems, it is important to appreciate that the word 'geodiversity' has a simpler and broader meaning in which it refers to the total range of phenomena which exist, some of which may themselves be 'internally' of either high or low diversity. The first usage above is less value-laden since it simply identifies the fact that a wide diversity of phenomena exists. Tasmanian workers have tended to prefer the first usage of the term 'geodiversity', since this allows a useful distinction to be maintained between the objective, value-neutral quality of 'geodiversity', and the subjective, value-laden attribute of having 'geoheritage' value.

It is suggested that when the term 'geodiversity' is being used in the second sense above, it should be made explicit that this is the case. To not do so can create confusion over whether an objective statement or a value judgement is being made, and also since to claim that a certain thing is 'not an example of geodiversity', as can consistently be done under the second usage, sounds quite bizarre in terms of the first usage, under which all non-living things are necessarily elements of geodiversity.

Geoconservation

Briefly defined by Sharples (1995a) as:

The conservation of geodiversity for its intrinsic, ecological and (geo)heritage values.

A longer and more explicit definition is provided by Eberhard (1997, p. v):

The identification and conservation of geological, geomorphological and soil features, assemblages, systems and processes (geodiversity) for their intrinsic, ecological or heritage values.

The concepts of 'intrinsic', 'ecological' and 'geoheritage' values are described below.

Alternative approximately synonymous terms include 'Geological Conservation', 'Earth Science Conservation', and 'Earth Heritage Conservation'. However, each of these latter terms implies a more limited scope than 'Geoconservation':- 'Geological Conservation' is most likely to be interpreted as referring mainly to bedrock features rather than also soils and landforms (as explained under 'geodiversity' above); 'Earth Science Conservation' and 'Earth Heritage Conservation' imply conservation of features only for their scientific (research/education) or heritage values to humans, and do not properly encompass the conservation of features for their other natural values including their integral roles in ecological processes.

Thus, Tasmanian workers have adopted the term 'Geoconservation', since it is the only term which can be readily construed to encompass not only bedrock but also landforms and soils, and because it can be construed to encompass ecological and intrinsic values in addition to the scientific and heritage value of geodiversity to humans.

Intrinsic Value

The value of a thing in itself.

See also 'The Value of Geodiversity' (section 2.3.2). A thing may have either (or both) intrinsic or utilitarian value: *intrinsic* value is it's value in itself (its value simply for what it is), whereas *utilitarian* value is its value as a useful thing to be put to some other purpose. Geodiversity has traditionally been regarded as having purely utilitarian value, as a resource to be used for human purposes such as industry or agriculture. More recently, the conservation of Geological Heritage has been justified on the (essentially utilitarian) grounds that geodiversity has value to humans for scientific, aesthetic or inspirational reasons. In contrast, to say (for instance) that a particular element of geodiversity may have significant intrinsic value is to say that it should be conserved simply because it is a good representative example of its type, regardless of whether humans actually use it, scientifically study it, or even look at it.

The term 'Existence Value' (AHC 2002) is equivalent to 'Intrinsic Value'', and means that the existence of a thing is of value in itself, regardless of any uses we might put it to.

Ecological Value (or 'Natural Process Value)
The importance of a thing or process in maintaining natural systems and ecological processes of which it is a part.

See also 'The Value of Geodiversity' (section 2.3.2). Noting that 'ecosystems' are understood as comprising both biotic and abiotic components which interact and are interdependent, the 'ecological value' of geodiversity can be understood as its importance in both maintaining geological, geomorphic and soil processes in themselves, and also in maintaining biological processes which depend upon those physical systems.

One example commonly given is the extreme dependence of cave-adapted organisms on the continuity of natural karst geomorphic processes and habitats. However, the same general principle holds true for all geomorphic and soil processes.

Geoheritage
Those particular examples or elements of natural geodiversity which are of significant value to humans for non-depleting purposes which do not decrease their intrinsic or ecological values.

An alternative definition given by Eberhard (1997, p. v) is:

Those components of geodiversity that are important to humans for purposes other than resource exploitation; things we would wish to retain for present and future generations.

See also 'The Value of Geodiversity' (section 2.3.2). The purposes for which geoheritage may be valued include: scientific research, education, aesthetics, inspiration, non-destructive recreation, contribution to the Sense of Place experienced by human communities, and other non - depleting cultural values derived from geodiversity. It is fundamental to note that 'geoheritage' refers to the *conservation* values of rocks, landforms and soils, as distinct from the utilitarian *resource* values derived from the removal, processing or manipulation of rocks, landforms and soils by means such as mining, engineering or agriculture.

Alternative approximately synonymous terms include 'Geological Heritage', 'Geological Monuments' and 'Significant Geological Features'. These terms are more restrictive because the use of the word 'Geological' is more readily interpreted as referring only to bedrock geological features and will less readily be interpreted as encompassing landforms and soils; use of the shorter prefix 'geo-' is more readily interpreted as encompassing all of these.

"The Missing Word"
Those particular examples or elements of natural geodiversity which are of significant value for their intrinsic, ecological or heritage values.

Although the term 'geoheritage' is sometimes loosely used to refer to all specific features or processes that are considered to have any sort of geoconservation value, in a pedantic sense it does not properly encompass features considered to have significant *intrinsic* or *ecological* values. This is because the term 'heritage' properly implies only 'inheritance' value *to humans*, and so does not properly include the ecocentric (ecological) value of geological, geomorphic and soil processes in maintaining natural ecosystem processes, nor the philosophical idea that things may have intrinsic value ('existence value') apart from their direct value to humans.

There is therefore a need for a word similar to 'geoheritage', but without the restrictive connotations of the suffix 'heritage'. A suitable definition of such a word is provided in italics above; now all we need is the word itself! One possible candidate which has been similarly defined is the word 'Geotope' (Wiedenbein 1994), however the meaning is not immediately obvious from this word which may therefore appear obscure. Non-intuitive terms such as 'geotope' may be best restricted to more technical discussions, such as its potential use in the process of georegionalisation (see Houshold *et al*. 1997).

Significance
The importance of a geological, geomorphological or soil feature, assemblage, process or system to the realisation of one or more of the aims of geoconservation, namely the maintenance of geodiversity and the maintenance of natural rates and magnitudes of change in earth systems.

The concept of significance can be a difficult and problematical one to define, and a fuller discussion is provided elsewhere in this document (see 'The Concept of Significance' section 2.3.4). Essentially, the assignment of significance to an element of geodiversity is the means used in geoconservation to identify those things worthy of special recognition and management to protect their natural values. Hence, any definition of significance must be framed in terms of the values of geodiversity or the aims of geoconservation.

Replication
The identification of multiple examples of particular features, assemblages or system as having geoconservation significance and being worthy of protection as necessary (Sharples 1993, 1995a).

This specific use of the term in the context of geoconservation can be distinguished from a more broader usage in which 'replication' simply refers to the actual number of examples of each feature (etc) that exist. See discussion elsewhere in this document ('Replication': section 2.3.3).

MANAGEMENT – RELATED TERMS
The following terms refer to aspects of the management of geodiversity. Only a small number of terms are noted here, whose meanings have nuances particularly relevant to geoconservation. A much more comprehensive glossary of terminology relating to nature conservation management generally can be found in the Australian Natural Heritage Charter (AHC 2002).

Robustness
The degree to which a feature, process or system can withstand disturbance caused by human activities without degradation or loss of its geoconservation values.
(see also 'Sensitivity')

The term 'ruggedness' is sometimes used synonymously, but is less preferable since 'rugged' properly refers to topographic unevenness or difficulty of terrain, rather than imperviousness to disturbance.

Sensitivity
The inherent susceptibility of a feature, process or system to degradation resulting from disturbances caused by human activities, irrespective of any existing threats of such disturbance actually occurring.
(See also 'Vulnerability')

Although the terms 'sensitivity' and 'vulnerability' are sometimes used interchangeably, a useful distinction is adopted in these definitions, based on the widely accepted use of the term 'vulnerability' in the IUCN Criteria for threatened, vulnerable and endangered biological species. The distinction employed here is that 'sensitivity' refers to the inherent susceptibility of a feature to damage, whereas 'vulnerability' refers to the actual (contingent) likelihood of damage occurring, given existing or likely land use.

Thus, fine gypsum hairs growing on a cave wall are inherently highly sensitive, since even a human breath may destroy them, but may not be considered vulnerable if they occur in a wild and difficult cave which is only rarely visited by even the most experienced cavers. The same features would be considered highly vulnerable in a cave passage subject to regular uncontrolled visitation.

Vulnerability
The degree to which a feature, process or system is actually threatened with degradation due to disturbances caused by existing or likely human activities, given its inherent sensitivity.
(See also 'Sensitivity')

The same explanatory comments apply as for 'sensitivity'.

Disturbance
Any change to a natural feature, process or system caused by human activity, whether or not a particular value under consideration is thereby degraded.
(see also 'Degradation')

A useful distinction can be made between 'disturbance' and 'degradation'. 'Disturbance' refers to any change to a natural feature or process caused by human activity, whether or not particular values are substantially affected, whereas 'degradation' refers to an actual decline in the quality of particular natural values, caused by disturbances.

Thus, the cutting of a walking track into a natural area constitutes a 'disturbance', but may not necessarily result in tangible 'degradation' of specific natural values of the area. Whether degradation is considered to have occurred as a result of disturbance depends upon the particular values under consideration. Thus, the disturbance of a walking track is unlikely to substantially degrade the geoheritage value of a large glacial moraine, but will by definition degrade the wilderness value of a previously untracked remote region.

Degradation
A reduction in the quality, integrity or viability of particular natural values of a feature, process or system, resulting from disturbances caused by human activity.
(See also 'Disturbance')

The same explanatory comments apply as for 'disturbance'.

Conservation Status
The condition of the natural values of a feature, process or system, and the degree to which current land uses and land management practices are likely to protect those natural values given their inherent sensitivity.

The term 'conservation status' implies two aspects, namely the actual current condition or integrity of the relevant natural values of a feature, process or system, and the degree to which land management or land tenure is actively or passively protecting those values. That is, conservation status depends upon the current degree of *degradation*, if any, which has occurred, and the degree to which the *sensitivity* of particular values is recognised and managed for under current land use practices pertaining to the relevant places, so as to minimise their *vulnerability*. A highly robust feature will require little specific management attention to retain a high (or 'secure') conservation status, whereas a highly sensitive feature may require specific land tenures and management prescriptions in order to retain a secure conservation status.

Five broad categories of Conservation Status have been used by Dixon *et al.* (1997a), from which report the following definitions are adapted:

Secure
Sites, processes or systems whose geoconservation values are not degraded, and are likely to retain their integrity, because the values are robust or their protection is provided for under existing management arrangements.

Potential Threat
Sites, processes or systems whose values are not being actively degraded, but which are sensitive and whose protection is not specifically provided for under existing management arrangements.

Threatened
Sites, processes or systems whose values have been or are subject to degrading processes, although the values remain largely intact at the present time.

Endangered
Sites, processes or systems whose values have been or are subject to degrading processes that have had significant impact on the values.

Destroyed
Sites, processes or systems whose values have been lost due to degrading processes.

Consideration could be given to modifying the definitions of 'Secure' and 'Potential Threat' to take into account sites which have in the past been partly degraded, but which are not currently being degraded and which remain the best available representative examples of their class of phenomenon. Thus a partly degraded feature which retains much of its original value, and has now been adequately protected from ongoing degradation, might be considered 'secure'.

(3.0) BIBLIOGRAPHY OF GEOCONSERVATION

This bibliography is an attempt to list all printed material (published and unpublished) that addresses geoconservation issues, and which is (at least in theory) available to the public. However, in order to keep the size of this bibliography within reasonable limits, the policy has been adopted of generally not listing:

- Reports of an essentially internal or confidential nature, such as geoheritage assessments prepared for commercial companies with land management responsibilities.

- Descriptive and research papers and reports on geology, geomorphology or soils which, whilst they may provide an important source of data for geoconservation studies, do not in themselves specifically address geoconservation issues.

In addition to what it is hoped will be reasonably close to a comprehensive bibliography of Australian material on geoconservation, a list of selected overseas references is also provided; however, no attempt has been made to make this latter list comprehensive.

This bibliography was initially compiled by Rolan Eberhard, with additions and modifications by Chris Sharples.

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