

From the oldest minerals to largest monoliths

An Australian geoconservation story

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Foreword -

These slides will work best when used as an accompaniment to the presentation made on November 26th, 2022 in the Oceanic Geodiversity workshop.

The presentation featured a number of video examples.

Please contact myself or the workshop organisers to obtain a copy.

THE AUSTRALIAN GEODIVERSITY STORY

Oldest living first nations culture

Representation of every climate geomorphological control on landforms,
every geological unit and time period, all worlds major soil groups

Australians were some of the first people to contribute to the concept of
'geodiversity'

Australia initiated the treaty of Antarctica for geoconservation purposes

Australians have been proactive in making extensive geoheritage inventories

Oldest minerals, largest sandstone monolith

DESPITE THIS...

No federal or state-specific statutory protections

No national strategy that consistently organises and indexes
'geoheritage'

Geoheritage only represents some of Australia's geodiversity – not all,
not even most!

The issues related to geodiversity recognition and conservation are
global. Here's how we are exploring these in Australia.

What is geodiversity?

什么是地质多样性？

Open Access Review

Old Processes, New Movements: The Inclusion of Geodiversity in Biological and Ecological Discourse

by Anne Boothroyd and Melinda McHenry*

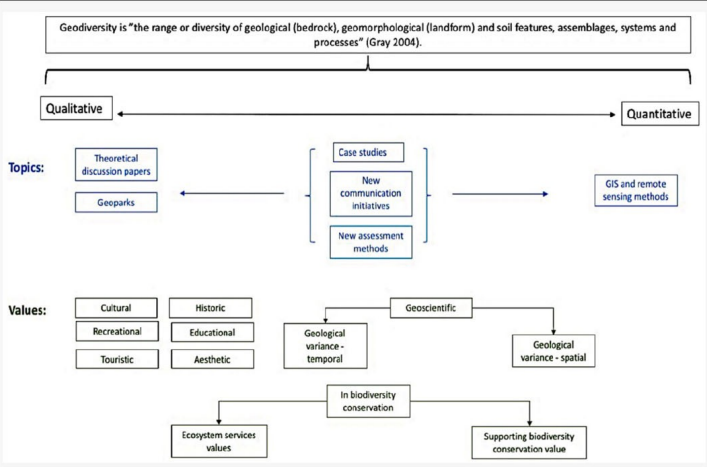
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Diversity 2019, 11(11), 216; <https://doi.org/10.3390/d11110216>

What is geodiversity?

什么是地质多样性？



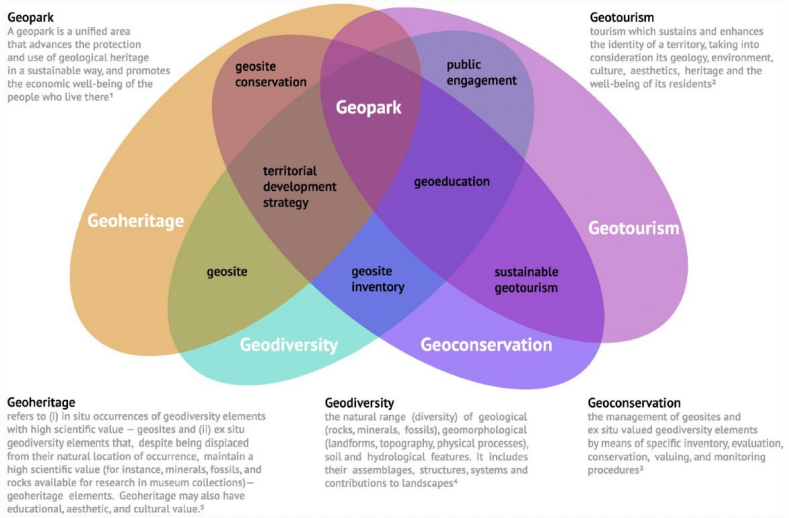
Original Article | Published: 07 July 2020

Geoconservation and Geotourism: Challenges and Unifying Themes

Mark A. Williams, Melinda T. McHenry & Anne Boothroyd

Geoheritage 12, Article number: 63 (2020) | [cite this article](#)

Geodiversity can therefore be found in many places



But the elements and values are sometimes hard to define...

Elements –

rocks, minerals, fossil casts, landforms, associated processes, soils

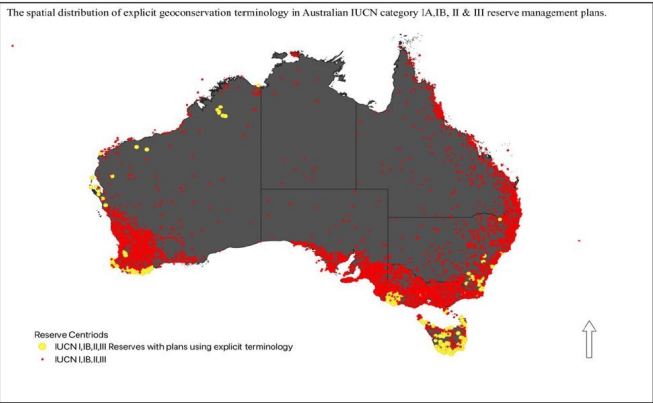
Values –

scientific (rare, representative, intact, notable, associated with other values of significance such as cultural heritage or edaphic controls)

Cultural/spiritual

Educational

Geotouristic



From McLaine, McHenry & Adams in prep
“Geodiversity in Australian protected areas management plans”



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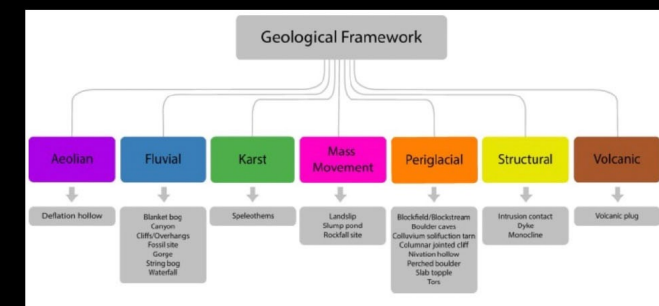
Is there a meaningful unit of geodiversity? The problem of scale.

是否存在有意义的地质多样性单位？尺度的问题。

Scale is a challenge
for
protected areas
conservation

Boundary detection

Representativeness within
the reserve, across the
country/world



Geological Framework represented by 7 themes and 24
landforms (after Bradbury, 2014) in an inventory of periglacial
geosites and prospective geodiversity sites in Wellington Park,
Tasmania

Digital tools assist boundary detection and monitoring of geodiversity



Organ Pipes

3D Model



UTas TAAARN

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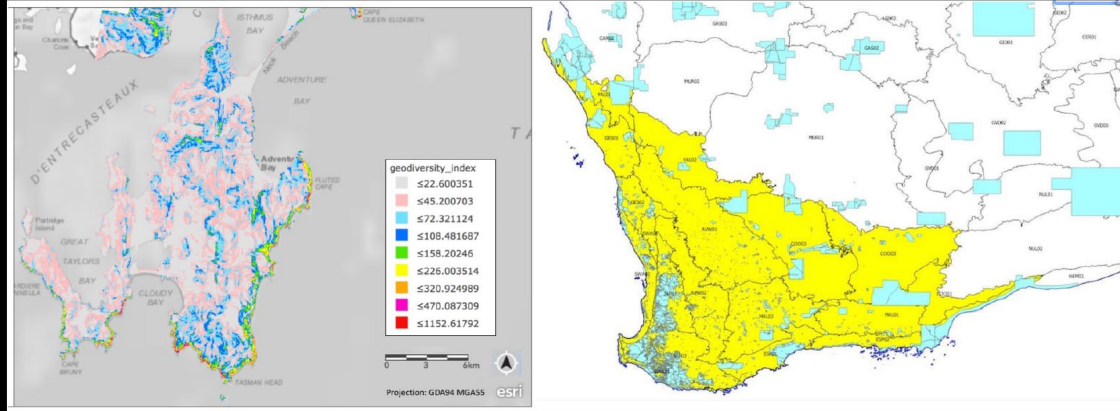
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Report

Triangles: 1.3M Vertices: 642.1k [More model information](#)

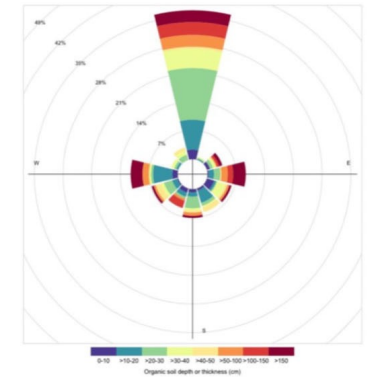
Spatial geodiversity: relating geodiversity of
an area to other measures of value such as
biodiversity or topography is challenging for
Australia.

空间地理及地质多样性：将一个地区的地质多
样性与生物多样性或地形等其他价值衡量标准
联系起来，这对澳大利亚来说是一项挑战。



My research: understanding impacts of fire

- Organic soils are well reserved in Tasmania
- 98% of Tasmanian peat, comprising 75% of Australian stocks, is in reserve
- Lacking knowledge of depth and distribution of peat impedes our understanding of fire risk and organic carbon loss
- Our recent research answered these questions for Tasmania



From McHenry et al 2022



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Geodiversity values in Australia: do we choose the biggest rock, or the most special to the people?

澳大利亚的地质多样性价值观：我们是选择最大的岩石，还是对人们最特别的岩石？

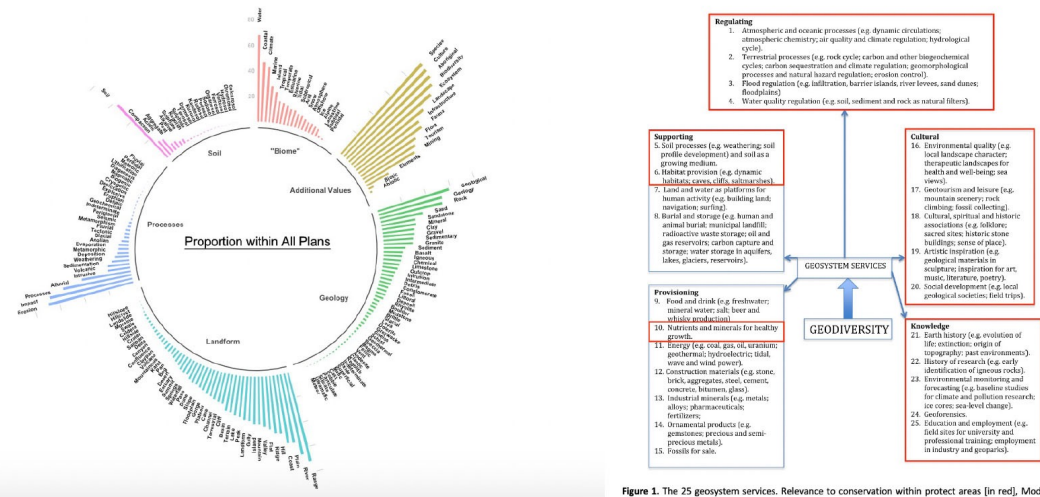
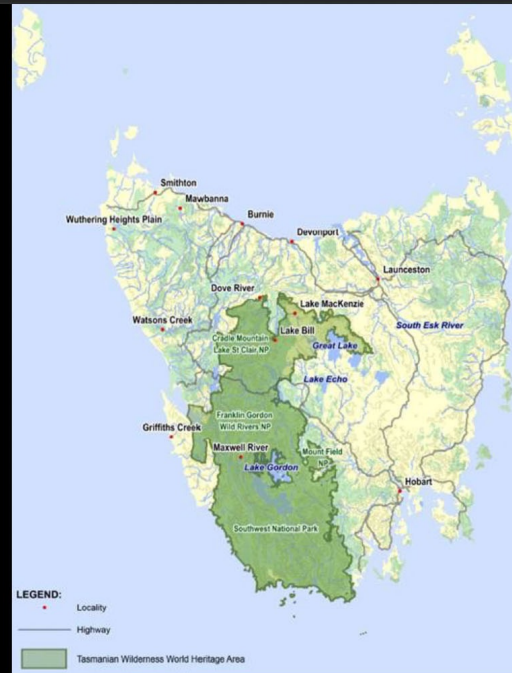


Figure 1. The 25 ecosystem services. Relevance to conservation within protect areas [in red]. Modified from Gray, 2019

UNESCO has OUV's

"Outstanding Universal Value means cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance.... The Committee defines the criteria for the inscription of properties on the World Heritage List."

Source: Operational Guidelines for the Implementation of the World Heritage Convention
WHC.19/01 10 July 2019



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Tasmanian geodiversity values

- **Outstanding reference:** the site is an exceptionally unambiguous example or demonstration of an aspect of geodiversity.
- **Representative reference:** the site is a clear example of the typical expression of an aspect of geodiversity. Representative reference sites should be selected with consideration of i) how well they typify an aspect of geodiversity, ii) condition, iii) security and iv) appropriate accessibility.
- **Key site:** the site displays or demonstrates a feature, event or process that is fundamental to understanding an aspect of geodiversity within a specified context area. This includes but is not limited to formally defined type sections and localities.
- **Well studied:** the site has been the subject of considerable geoscientific investigation, providing data and analysis valuable to the understanding of an aspect of geodiversity.
- **Minimally impacted condition:** the site is one of the least disturbed examples of an aspect of geodiversity.
- **Rarity:** the site constitutes a significant proportion of all sites representing a particular aspect of geodiversity within a given context area. If the site were to be destroyed or degraded then much of the entire population would be lost.
- **Outlier:** the site is marginal to or isolated from similar features, in either space or time or both. It therefore provides additional information about the range of an aspect of geodiversity, its process of formation or the prior distribution of a formerly more extensive entity or process.
- **Information Repository:** the site contains or is likely to embody detailed information that has significantly improved, or has the potential to improve, understanding of an aspect of geodiversity within a specified context area.

Soils are geodiversity elements with values subject to inadequate or unbalanced reserve protection

Best 'carbon' soils are Organosols and Vertosols.

Organosols – 75% are in Tasmania, 95% in world heritage protections.

Vertosols – 6% conserved nationally, 99% cleared and under pasture or cropping in Tasmania, have a tendency to become sodic.

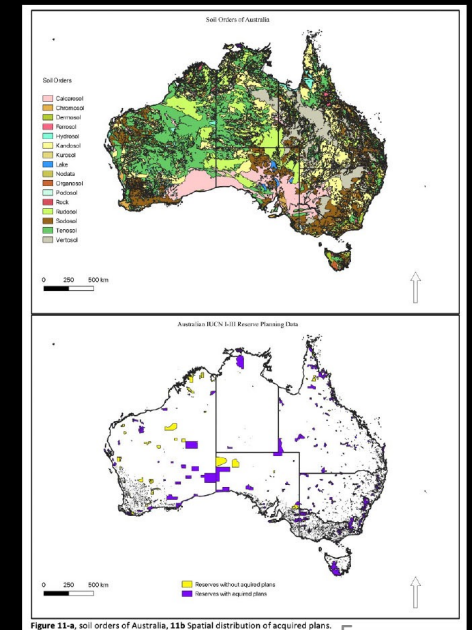
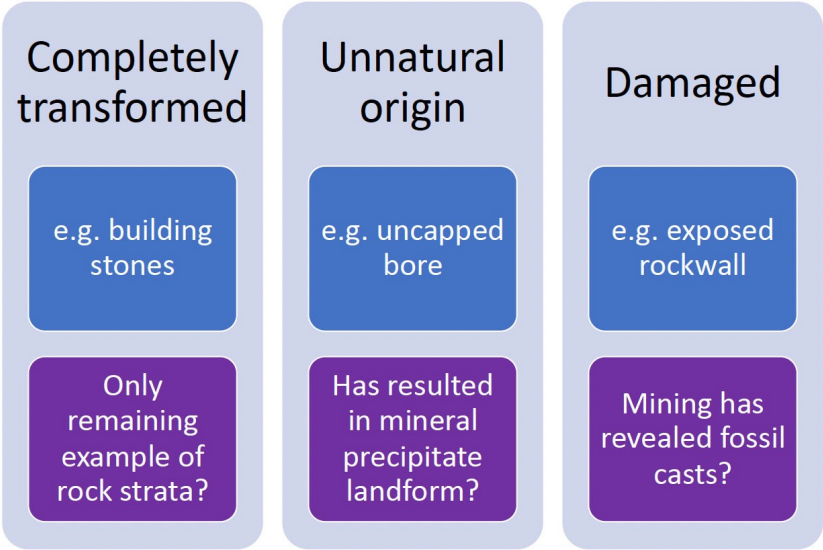


Figure 11-a, soil orders of Australia, 11b Spatial distribution of acquired plans.

Nation Soil Orders	Defining characteristics	Dominant Associated Values	Agricultural potential	% in IUCN I-III reserves	% of Australia by extent/area (Ha)
Calcarosol	Soils dominated by carbonate	System support	Low to moderate	10.5	9.20246594
Chromosol	Neutral to alkaline soils with a sharp increase in texture with depth	System support	Moderate	7.1	3.00830822
Dermosol	Structured B-horizons, with slight changes in texture with depth	Economic	High	21.0	1.59708196
Ferrosol	High Iron levels with slight changes in texture with depth	Economic	High	8.2	0.81659038
Hydrosol	Wet or regularly inundated soils	System support	Low	10.7	2.21610519
Kandosol	Strongly weathered earths with slight changes in texture with depth	System support	Low-moderate agricultural potential	6.1	16.7118435
Kurosol	Acid soils with sharp increases in texture with depth	System support	Low agricultural potential	11.5	0.87867803
Organosol	Soils with high organic content	System support	Low agricultural potential	75.8	0.11013894
Podosol	Soils with accumulated organic matter, iron and aluminium	System support	Low agricultural potential	19.6	0.36703155
Rudosol	Minimally developed soils	System support	Low agricultural potential	8.5	14.1022426
Sodosol	Soils with sodic subsoils	System support	Low agricultural potential	4.3	13.0177317
Tenosol	Slightly developed soils	System support	Low agricultural potential	9.4	26.4194317
Vertosol	Cracking clays	Economic	High agricultural potential	2.3	11.5523504

Secondary and composite geodiversity – unnatural geodiversity



- Created by humans
- Shaped by geomorphic processes
- Tell an informative story about Holocene climate and sea level
- Comprised of ‘natural’ materials





Geodiversity?????

What else are we missing out on?



The poorly understood



The modified



The urban landform

Geodiversity in motion: the challenge of natural processes in landscapes.

运动中的地质多样性：景观中自然过程的挑战。

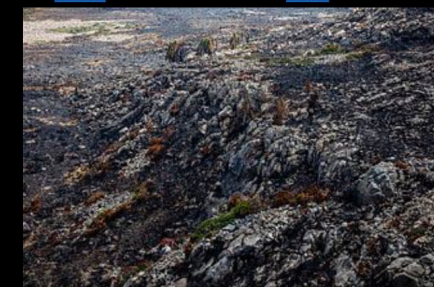
Australian biologists deal constantly with the issue of fire and how it modifies plant communities. But we don't yet have a good way to conserve changing geological diversity that is part of natural...and unnatural...cycles such as erosion, transport, climate change in many Australian protected areas.



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澳大利亚生物学家不断处理火灾问题以及如何改变植物群落。但是我们还没有很好的方法来保护不断变化的地质多样性，这是自然.....和非自然.....循环的一部分，例如澳大利亚许多保护区的侵蚀、运输、气候变化。



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So what do we know...?

We are aware that by 2100, less than 30% of the worlds glaciated features in protected areas will no longer exist (1)

In the 2019-2020 Australian bushfires, we lost an estimated 1 billion native animals (2), and we are concerned that we have only limited understanding of geodiversity loss

50% of coastal protected areas will experience at least some inundation from coastal storm surge, and heightened erosion, over the next century (3)

1. <https://www.iucn.org/news/world-heritage/201904/almost-half-world-heritage-sites-could-lose-their-glaciers-2100#:~:text=The%20authors%20predict%20glacier%20extinction,be%20ice%20free%20by%202100;>
2. Heaton, McHenry & Kirkpatrick (2022 in press); 3. Epachin-Niell et al (2017)

...And what do we do?

- Pure basic research on tangible effects of climate change
- Model future impacts
- Consider modifications and time limits on reserve design
- Consider 'museum' sites that we artificially keep maintained for their features
- Substitute form for function

My research: understanding impacts of fire

Management issues - fire

Metamorphic transition in some rock types

Can destroy natural values and regulatory functions

Fire in peats and in karst forming landscapes is catastrophic

Geodiversity element	Altered component	Criterion	Value	Impact
Exposed rock	Structure	Surface weathering: spalling \downarrow , fracturing, vertical, irregular linear or cordlinear \downarrow	High	High
		Altered aggregate stability \downarrow	Moderate	Moderate
	Structure	Increased bulk density \downarrow	Mild	Mild
		Exposure to mechanical erosion processes (blast heave, wind and water erosion) \downarrow	Moderate	Moderate
		Increased susceptibility to slope failure \downarrow	High	High
Hydrology	Desiccation \downarrow	Desiccation \downarrow	Mild	Mild
		Reduced infiltration capacity \downarrow	Moderate	Moderate
	Reduced water retention capacity \downarrow	Reduced water retention capacity \downarrow	Moderate	Moderate
		Hydrophobicity, alteration and transport of hydrophobic substances \downarrow	Mild	Mild
	Watershed processes	Increased occurrence of mass failure, overland flow, rill and gully formation \downarrow	High	High
Soil	Mineralogy	Alteration of mineral assemblage ($>500^{\circ}\text{C}$)	Moderate	Moderate
		Recrystallisation of Fe and Al oxides \downarrow	Mild	Mild
	Decrease in total N \downarrow	Decrease in total N \downarrow	Mild	Mild
		Increased nitrification \downarrow	Mild	Mild
	Nutrients/chemical attributes	Increase in available forms of nitrogen and other elements at the A horizon \downarrow	Mild	Mild
Karst	Reduced rate of mineralisation \downarrow	Reduced rate of mineralisation \downarrow	Mild	Mild
		Increased pH \downarrow	Moderate	Moderate
	Organic matter	Transformation and reduction of organic matter, substrates and residues \downarrow	Mild	Mild
	Biomass	Reduced or removal of biomass \downarrow	Moderate	Moderate
	Altered microbial, fungal and invertebrate assemblages \downarrow	Altered microbial, fungal and invertebrate assemblages \downarrow	Moderate	Moderate
Drip water geochemistry	Increased occurrence and variability of some elements and isotopes \downarrow	Increased occurrence and variability of some elements and isotopes \downarrow	Mild	Mild
		Increase in some metal concentrations \downarrow	Mild	Mild
	Hydrology	Increased absorption of water into system \downarrow	Moderate	Moderate
Deposition regime	Increased sedimentation \downarrow	Increased sedimentation \downarrow	Moderate	Moderate

Thank you for reading!

Please don't hesitate to contact me for more information