The Victorian Naturalist
is published six times per year by the

Field Naturalists Club of Victoria Inc

Registered Office: FNCV, 1 Gardenia Street, Blackburn, Victoria 3130, Australia.
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ISSN 0042-5184

Front cover: The change-over during incubation. The Grebe at the top of the photo is leaving the nest, while the one at the bottom is arriving. Photo Jurrie Hubregtse. See page 118.
Imported geological material in natural areas: impacts and management

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Abstract
Imported geological material is a critical issue in maintaining natural areas. Foreign anthropogenic geomaterial is not consistent with site geology, geomorphology, soils and hydrology. We review case studies, discuss alternatives and propose management guidelines. (The Victorian Naturalist 135 (4), 2018, 108–118)

Keywords: geodiversity, geomaterial, geoconservation, nature conservation

Introduction
Geodiversity and biodiversity are central to the understanding, appreciation, protection and management of natural areas. Geodiversity underpins biodiversity. Natural areas have land surfaces, stream beds, lake beds or seabeds largely unmodified geomorphically by human activity. Their age, diversity, scientific interest, aesthetics and other important values drive nature conservation.

Analogous to invasive species in bioconservation, geological material introduced into an area, deliberately or accidentally, is a critical issue in geoconservation. Anthropogenic geomaterial is any geological material, natural or synthetic, that occurs where it does due to human activity, having been placed there or having moved from where it was placed. It is mostly in the form of exotic geomaterial, that is, geomaterial which is not of the same geology as the receiving site. We refer to this as alien or exogenous geomaterial. Most is of industrial age (19th to 21st Century) origin and large quantities may be involved. By comparison, Aboriginal stone tools and waste flakes involve small amounts of material and have cultural value in situ.

Alien anthropogenic geomaterial is not consistent with site geology, geomorphology, soils and hydrology and creates a management issue in natural areas. It does not reproduce but it may spread, and can disaggregate and/or consolidate to form a surface that is biologically inhospitable.

Here we review case studies, discuss alternatives and propose management guidelines on the use of imported geomaterial in the conservation management of natural areas.

Conservation geology
The geosphere is innermost of the concentric interwoven spheres of the Earth system (Fig. 1). The outer spheres depend on the geologically active geosphere for their existence. The magnetosphere is the only sphere that cannot be influenced by humans.

Geodiversity is ‘the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landforms, topography, physical processes), regolith (including soil) and hydrological features. It includes their assemblages, structures, systems and contributions to landscapes.’ (Gray 2013). ‘Geodiversity provides the foundation for life on Earth and for the diversity of species, habitats, ecosystems and landscapes.’ (Crofts and Gordon 2015).

Fig. 1. Earth system.
Geoheritage consists of ‘elements of the Earth’s geodiversity that are considered to have significant scientific, educational, cultural or aesthetic value’ (Crofts and Gordon 2015). The Australian Heritage Strategy aims to ‘better identify, protect and manage Australia’s geoheritage with a grand objective of truly celebrating and caring for all of our natural heritage, both abiotic and biotic’ (Commonwealth of Australia 2015; Worboys 2015).

Conservation geology is applied internationally to protect geodiversity and geoheritage, and to support geotourism (O’Halloran et al. 1994; Marinos et al. 2001; Reynard et al. 2009) through geoconservation, which is ‘the conservation of geodiversity for its intrinsic, ecological and (geo)heritage values’ (Sharples 2002). Geoconservation aims to maintain representative diversity of geological, landform and soil features, and to allow their continued use as research and teaching sites with minimal alteration by humans.

The geodiversity of much of Victoria has been assessed at local and regional scales (e.g. Rosengren 1984, 1988; Rosengren and White 1997; Sharples 2002) and receives a level of statutory protection on public land within the land use category of nature reserve, which is an area of land or wetland of particular importance for its significant flora, fauna, natural habitat, geology or geomorphology … includes nature conservation reserve and natural features reserves sub-categories cave, geological and geomorphological features area (VEAC 2017: 29).

Geodiversity may be overlooked by management plans and during ground operations, even in national parks, due to factors such as fixation on biodiversity, lack of geological awareness, and priority given to infrastructure for managers and visitors over the natural values on which a reserve is based. However, when these areas are viewed as dynamic examples of local and regional natural history, the importance of geodiversity in underlying, complementing and interacting with biodiversity is clear. Biodiversity is draped across the geomorphic surface.

**Imported geological material**

Imported geological material comes in many forms and includes consolidated concrete and bitumen placed *in situ* and unconsolidated material such as boulders, landfill, hard waste, gravel and sand used in path and track construction. It is usually alien to the site geology. This anthropogenic geomaterial is introduced to make or stabilise infrastructure and is now widespread in many environments including saltmarshes, mangroves and estuaries (Boon et al. 2011). Consolidated material can be removed if necessary while unconsolidated material can go feral to become ‘lithic weeds’.

Loose surface material from boulders to sand often cannot be contained in the long term. It can readily mobilise and move downslope across adjacent surfaces to become incorporated into soils and landforms, the remaining material forming a lag deposit while it lasts. Washouts of gravel are common. Where placed along waterways and shorelines, loose material can spread offshore and alongshore to adjacent beaches.

Various pressures give rise to proposals to construct breakwaters, dams, roads, bridges, housing and other major infrastructure intrusions into natural areas. These economic-based projects generally involve importing of geomaterial on a large scale and have high impact.

Anthropogenic geomaterial can impact adversely on geodiversity, biodiversity and other environmental values in several ways:

- **Covering of geologic, geomorphic and palaeontologic features:** natural surface features may be buried under imported geomaterial;
- **Covering of biological substrates:** biodiversity may be buried and the new surface may be ecologically hostile to native species;
- **Imported geomaterial generally detracts from the visitor experience in natural areas.** For example boulder walls on coastlines built to protect inland assets from marine inundation form new disfigured landscapes that may not succeed in the long term. Gravel or crushed rock on paths provide a temporary trafficable surface but prevent contact with the soil which can be particularly missed in urban areas with their extensive hard surfaces, and can limit understanding of vegetation patterns where changes in soil type are buried under geomaterial. They are hard or crunchy to walk on, often of a colour unlike local rocks and soil, and can be visually distracting;
• Spread of material into adjacent areas: Most unconsolidated material eventually disperses into adjacent downslope areas, rendering their geomorphic surfaces and soil profiles modified and thereby reducing their natural integrity. Imported gravel may be topped up repeatedly during long-term track maintenance, resulting in repeated permanent increases. Once escaped, imported geological material is useless for its intended purpose, difficult to retrieve and may be a permanent introduction. Dispersing redundant alien geomaterial is effectively anthropogenic lithic litter in the environment;

• Alteration of hydrology: roads, tracks and dams made with imported geomaterial can alter local hydrology by retaining, diverting or concentrating water runoff, sometimes on a large scale. Water quantity may change on particular sites, resulting in effects such as erosion and/or sedimentation of both natural and imported material, and increased growth of introduced plants. Breakwaters have a long history of modifying coastal morphology; sometimes with adverse consequences (Bird 1993);

• Alteration of soil chemistry: change in soil chemistry may be caused by imported geomaterial, such as rise in soil pH in acid soil by leachate from imported alkaline limestone gravel. Most Victorian soils are naturally acidic (VRO 2015) including those of many woodlands and forests on and south of the Great Divide. Adverse effects on acidophilous native vegetation are suspected but not investigated, with a possible example in the Mount Lofty Ranges of South Australia. Increased nutrient content in urban water runoff and then soils stimulates and generally favours weeds;

• Introduction of weeds and pathogens: gravel may contain weeds and pathogens. Weed seeds can be in gravel that has not come directly from a quarry or been stored well. Undisturbed gravel stockpiles eventually grow coloniser weeds and accumulate their seeds, resulting in weed introductions into new areas when the gravel is placed. Gravel also may contain the major introduced pathogen of native vegetation, the water mould *Phytophthora cinnamomi*. The spread of *Phytophthora* from infected sites into parks and reserves is a listed potentially threatening process in Victorian legislation (DSE 2008). An area in Kinglake National Park has been infected by imported gravel, killing grass-trees;

• Contamination of sites of archaeological or cultural value: alien rocks and gravel can interfere with the understanding and appreciation of Aboriginal archaeology and cultural heritage where they are confused with genuine artefacts. The manufacture of gravel by jaw crusher produces impact patterns on gravel identical to those produced by a human striking rocks together (GVines, pers. comm.). This often challenges researchers and can have consequences: cultural heritage is either not recorded, or places are recorded when they should not be. If a cultural heritage site is pristine, it is better to keep it that way;

• Risk to health and safety: loose geomaterial may spill onto adjacent soils and vegetation and become a slip, trip or eye injury hazard to land managers when maintaining vegetation beside tracks, such as when operating a herbicide spray knapsack or brush cutter. Gravel also may contain silica dust which is a hazardous material made by the manufacturing process (Cancer Council Australia 2017);

• Impacts on geomaterial source areas: geomaterial may be extracted from its source in an unsustainable way, impacting on that site and surrounds. Many quarries are located in environmentally sensitive areas. Granitic sand, for example, may come from an area of remnant native vegetation such as the You Yangs.

Practical issues may warrant the import of geomaterial, such as rock riffles to stop accelerated stream erosion, or gravel for boggy or eroded management vehicle access tracks on conservation area boundaries. However, in managing natural areas, alien geomaterial should be limited to buffer zones, leaving internal core areas and walking tracks in natural condition as far as possible. Locally sourced gravel of the same geology is not alien and can be appropriate, and has been applied in Kinglake National Park, Mornington Peninsula National Park and elsewhere.

Anthropogenic geological material is a geo-heritage issue. We contend that this geomaterial can impact on geodiversity, biodiversity and other values and unless it has cultural value it
should not necessarily be accepted as just more Anthropocene deposits. Nature conservation reserves in particular should not be deliberately or accidentally modified in this way. By analogy, if someone were to spray paint on an artistic masterpiece we would regard that as an issue, even though no one would be harmed in the process. Here we have natural masterpieces of nature with land managers in a curatorial role. Some examples of the use and misuse of imported geomaterial, mostly in natural areas and particularly in nature conservation reserves, are provided in Table 1.

**Case studies**
The following case studies explore the use of imported geomaterial.

**Examples of good practice**

**Schnapper Point, Mornington**
Created from local sandstone, a set of rock steps and pathway leads to and blends with a natural rock outcrop of the same geology at Schnapper Point, Mornington. The local council undertook the state-funded restoration project to solve erosion problems in 1985 (Fig. 2). There is no quarry for this red sandstone despite its extent in southern Victoria, so rocks in the form of surface and buried floaters that surfaced during roadworks were collected by the council over 20 years. Three stonemasons then cut and installed the slab pavers with sand-cement mortar. Grooves between pavers were kept free of mortar for 25 mm and filled with crushed stone and dust from the cutting process. This ensured that spaces between pavers were red in colour when finished. Indigenous plants have colonised the site, adding to the transition from built to natural. The durable rockwork is as good as on the day it was completed. The result is effective and spectacular.

**Moondah Beach, Mount Eliza**
Moondah Beach is significant for its diverse geology, geomorphology and palaeontology (Rosengren 1988). The beach has ten types of natural free rock, partly due to the transfer of material around Manyung Rocks from the adjacent Sunnyside North Beach, which has the most geologically complex single kilometre of coastline in Victoria (Neil Archbold, pers. comm., 2002). Transported by wave action, the many rounded, angular or flat rocks and pebbles include fresh red sandstone, case-hardened brown sandstone, quartz, granodiorite, basalt, carbonate concretions with included fossils, ironstone attracted to magnets, sand solidified into beachrock, and pumice from a submarine volcano in the Pacific Ocean (ABC 2015). Each rock differs in size, shape and colour, and is gradually becoming smaller through abrasion as it travels on a unique trajectory from its source outcrop, which may be on a coastal headland or along a creek such as Gunyong Creek in Gunyong Gorge, which enters the beach. Some have travelled hundreds of metres from recognisable outcrops on Sunnyside. Many are arrested on their journey in stranded beach terraces formed by the mid-Holocene marine maximum in Port Phillip Bay. All were

![Fig. 2. Excellent use of local rock forming steps and pathway leading to natural rock outcrop, with designer Douglas Evenden, Schnapper Point, Mornington, February 2016.](image)
Table 1. Use of imported geomaterial (BR = Bushland Reserve; FFR = Fauna and Flora Reserve; NP = National Park; SP = State Park)

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<thead>
<tr>
<th>Site</th>
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<tr>
<td><strong>Importation</strong></td>
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<td>Schnapper Point, Mornington</td>
<td>Local sandstone steps and path</td>
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<td>The Esplanade, Mount Martha</td>
<td>Local granodiorite retaining wall beside road</td>
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<tr>
<td>Mornington Peninsula NP, Sorrento</td>
<td>Local crushed limestone on path to beach</td>
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<td>Half Moon Bay, Black Rock</td>
<td>Foreign sand removed from beach</td>
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<td>Black Rock Point, Black Rock</td>
<td>Concrete slabs and rubble removed from beach (Bird et al. 1973)</td>
</tr>
<tr>
<td>Earimil Bluff, Mount Eliza</td>
<td>Foreign gravel on path replaced with beach sand</td>
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<td>Moondah Beach, Mount Eliza</td>
<td>Foreign boulders and cobbles replaced with beach sand</td>
</tr>
<tr>
<td>Earimil Creek BR, Mount Eliza</td>
<td>Foreign gravel on path replaced with organic mulch</td>
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<td><strong>No importation</strong></td>
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<td>Lava blister, Williamstown</td>
<td>Saved from development after description by Blackburn (1969)</td>
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<tr>
<td>Eastlink Freeway cuttings, Ringwood–Donvale</td>
<td>Spectacular geological cross sections left exposed, not covered by concrete</td>
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<tr>
<td>South East Track, Wilsons Promontory NP</td>
<td>Onsite granite used for walking track construction</td>
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<tr>
<td><strong>Site</strong></td>
<td><strong>Examples of poor practice</strong></td>
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<td>Warrnambool Coast, Warrnambool</td>
<td>Basalt gravel on walking tracks on limestone coast</td>
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<td>Grassland reserve, Caroline Springs</td>
<td>Granitic sand on reserve perimeter instead of natural basalt, advocated in a grassland reserve design manual (Marshall 2013)</td>
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<tr>
<td>Railway cutting, Royal Park</td>
<td>Training ground for generations of geology students has one face covered with foreign material (Blackburn 1969)</td>
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<td>Red Bluff, Black Rock</td>
<td>Broken concrete/asphalt slabs and landfill over coastal cliff</td>
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<tr>
<td>The Pines FFR, Frankston</td>
<td>Gravel on vehicle tracks throughout sandy dunefield terrain</td>
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<tr>
<td>Fossil Beach, Mornington</td>
<td>Foreign rocks, bricks and concrete obscure natural geology</td>
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<tr>
<td>Mornington Peninsula NP, Point Nepean</td>
<td>Granitic gravel on paths on limestone coast, spilling onto orchid site</td>
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<tr>
<td>Mornington Peninsula NP, Greens Bush</td>
<td>Gravel on internal vehicle tracks</td>
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<tr>
<td>Bittern Coastal Wetlands, Hastings</td>
<td>Gravel path placed directly on saltmarsh clay surface instead of making an elevated boardwalk</td>
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<tr>
<td>Wilsons Promontory NP</td>
<td>Basalt boulders at Darby River bridge, basalt gravel on walking tracks to Whisky Bay, Picnic Bay and elsewhere</td>
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<tr>
<td>Mitchell River, below Bairnsdale</td>
<td>Large quantity of rockfill covers riverbank</td>
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<tr>
<td>Ropers Lookout, Alpine NP</td>
<td>Crushed river gravel on viewing platform covers natural volcanic rock</td>
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<tr>
<td>Australian Alps Walking Track, Alpine NP</td>
<td>Large stone blocks and crushed rock paving across stone-free grassland</td>
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stranded inland for some 1800 years when the bay was evidently almost dry, starting from around 2800 years BP (Holdgate et al. 2011).

The beach has one vehicle landing which was damaged by a storm surge in June 2014. The maintenance department of the local council subsequently placed loose material on the site for beach cleaner access (Fig. 3). As it was within the storm surge zone, the material was soon being mobilised and swept along the beach, affecting the beach’s geological integrity and depositing sharp material on the beach, reducing its amenity. The access was temporary while the contamination would have been permanent if not removed—not a solution at all.

Nine months later the council removed the new rock material and replaced it with beach sand (Fig. 4). This is the appropriate material in this sensitive area though it too needs regular replenishment. More underlying alien material forming the landing remains and will eventually need removal if the natural integrity of the beach is to be preserved with sea level rise.

**Half Moon Bay, Black Rock**

Even beach renourishment has a potential downside if sand of inappropriate texture and colour is used. Half Moon Bay in Black Rock was partially renourished in October 2011 using coarse-grained red sand from a South Gippsland quarry (Fig. 5). The contrast in colour and texture with the existing beach aroused considerable local opposition. A group of influential conservation groups pressured various levels of government to desist and the imported sand was subsequently removed.

**Earimil Creek, Mount Eliza**

Pale granite gravel was applied to the main walking path in Earimil Creek Bushland Reserve, Mount Eliza, by the local council in the 1990s, whereas the natural geology is red sandstone which produces dark organic topsoil. Although well meant, it was removed and replaced with tree mulch by community volunteers (Fig. 6). Clean tree mulch is reapplied by the council every five years or so, and is sometimes obtained from the site itself, to good effect.
Examples of poor practice

Wilsons Promontory

As part of the repair of Darby River bridge in Wilsons Promontory National Park after the 2011 flood, alien basalt rocks were used to stabilise the bridge footings. Basalt rocks are in the river and will spread down to the estuary and onto Darby Beach which has dune limestone geology (Fig. 7).

The Whisky Bay and Picnic Bay areas have been degraded in recent years by basalt gravel laid on white granitic sandy walking tracks leading to the beaches. The basalt soon started leaking into the environment (Fig. 8). It has also been laid on the yellow calcareous sandy track to Cotters Beach.

The Prom once had a dune limestone quarry and a granite quarry for gravel production but in a short-sighted move they were closed as they were considered incompatible with conservation. Unless the same material can be obtained from nearby, a park as large as the Prom could and should have small gravel pits and quarries to produce gravel and stone for internal use. Once retired, recovering extraction sites add habitat diversity in large natural areas, and may support rare species.

Warrnambool Coast

At Warrnambool in western Victoria, basalt gravel has been placed on paths along the dune limestone coast (Fig. 9). The appropriate material was local limestone, which is available. The current management plan specifies local limestone (Yugovic and Arbor 2012).
**Fossil Beach, Mornington**

A bluestone sea wall and granite boulder wall obscure the geology of part of Fossil Beach, Mornington. Constructed in the 1960s, the sea wall was not necessary as the foreshore reserve is wide in this area. North of the boulder wall is a spread of introduced granite, bluestone, concrete, brick, limestone and other rocks which are mixed with the naturally occurring carbonate concretions and former basalt capping natural lag deposit. The geology is obscured by the muddle of other material giving the area the appearance of a dump site (Vines and Yugovic 2011; Fig. 10).

Fossil Beach is a site of national geologic and palaeontologic significance and is partly protected by an environmental significance overlay in the local planning controls. Although sometimes referred to as Fossil Beach Geological Reserve, there is no statutory framework for such a reserve. The site needs rehabilitation (Rosengren 1988:106).

Coastal protection and cliff stabilization works have reduced the outcrop area available for sampling and fossil search. Further coastal protection works or other foreshore or offshore works (including vegetation management, drainage, access) should be designed only in consultation with geological groups with specialist knowledge of the site.

**Alpine National Park**

Stone imported from the lower Kiewa River valley has been used as pavement surface for walking tracks in the Alpine National Park in many places. An example is the use of this light-coloured rounded material at Ropers Lookout where it is in stark contrast geologically and aesthetically with the large, dark, angular basalt blocks that outcrop at this pinnacle (Fig. 11).

There are many instances along the Australian Alps Walking Track where crushed exotic gravel or large angular blocks have been used as pavement across areas that have no surface stone (Fig. 12).

Washouts of foreign gravel have also occurred in the park (Fig. 13).

**Alternatives**

The import of foreign anthropogenic geology into natural areas may be avoided through the use of stone and gravel of the same local geology, by appropriate design and construc-
tion using stable synthetic or biodegradable material, or by alternative approaches to management issues and infrastructure development proposals. Planned coastal retreat strategies may be appropriate. Importation becomes the last resort rather than the first resort.

Walking track erosion may be controlled by installing local stone or timber steps, or by breaching and barring — construction of shallow channels and levees diagonally across tracks to divert runoff. Boardwalks can be appropriate. Soil from a nearby site may be imported to fill ruts and cover exposed surfaces for revegetation, and tracks can be closed and relocated to be managed properly.

A range of sensitive erosion control measures can be seen on walking tracks in Victoria such as in Great Otway National Park (Point Addis boardwalk), Werribee Gorge State Park and Wilsons Promontory National Park. Synthetic material as a pavement is preferred to inappropriate geological materials (Fig. 14). At least future researchers will be able to identify the material as synthetic rather than go through geological hoops to try to explain the occurrence of exotic geology.

In Tasmania, local rock is recommended for walking tracks in national parks (DPIPWE 2011: 38, 45):

Field staff in some areas have in recent years favoured the use of local rock for hardening tracks, in some cases flying rock to work sites from several kilometres away. When undertaken by experienced trackworkers, the use of rock can be cost-competitive with other hardening techniques such as duckboard and even double planking. Like all track infrastructure rock steps and paving require regular maintenance, but they are resistant to fire damage and could potentially last for centuries. (Note that gravel tracks can suffer a degree of fire damage if timber edging is burnt or if underlying root structures are damaged, and even rock can be damaged by extremely hot fires.

It is recommended that tracks be stabilised and upgraded using local rock, stone and gravel as far as possible, as these materials blend in well with the natural environment, are relatively low-maintenance and are largely immune to fire damage.

Skilled Tasmanian track workers were brought in to construct the South East Track in Wilson Promontory National Park, using hand winches and onsite granite (The Age 1998).

Access and erosion may be addressed through application of organic mulch. Mulch contains nutrients which could increase weed growth adjacent to paths but if the mulch is sourced from the site itself this may not be significant. Clean mulch is a benign biodegradable biomaterial. It generally integrates better into the substrate than gravel, remains for longer, and is less expensive. Not being permanent, it may need periodic reapplication, as does gravel, but is cheaper. The ideal mulch is made from tree prunings from the site itself, especially in areas of low soil fertility. Organic mulch is soon compacted by walkers, making it suitable for wheelchairs and baby strollers.

The lining of rivers and creeks with concrete or rock beaching extending from top to bottom of the bank degrades the natural values of streams but is used much less than in former times. Now incised and/or laterally unstable
Contribution

1. Streams mainly receive graded rockfill placed as bed control riffles (to restore bed stability) and as lower bank toe protection (to resist bank erosion), which means less imported geomaterial. Constructed riffles, which maintain fish passage and limit flow turbulence, are now preferred to vertical drop structures (large stacked rocks or concrete/timber/steel structures) on stream beds. Rock used in riffles and bank protection works 'must match the local area's natural geology' and existing geomorphic features 'should be maintained' (Melbourne Water 2009). There is less concern for geological compatibility of rockwork on banks in urban and industrial areas.

2. Many significant exposures of geological materials occur on river and coastal cliffs as a result of ambient recession or erosion of slopes, e.g. Eagle Point Bluff on the lower Mitchell River. These are often in places where the recession threatens natural and built 'assets' and may create a hazard for users, but it is this very process that creates or maintains the significant feature. A case-by-case assessment of the perceived and actual hazard is necessary before a sometimes counterproductive hard-engineering response is applied.

3. Consolidated foreign geomaterial such as concrete or bitumen is easier to manage than unconsolidated material as it is more stable and more easily retrieved. However, if left alone it too will eventually break down and be mobilised. While they last, installed structures also blend in with the environment better when stained with pigment similar to the local rock colour.

Management guidelines

The following guidelines are proposed to promote the appropriate use of imported geomaterial in the protection and management of natural areas.

1. Develop and maintain an inventory of geoscience values and their sensitivity in nature conservation reserves.

2. Include geodiversity values in management plans.

3. Avoid the importation of alien geomaterial where possible.

4. Consider non-intrusive means of addressing access and erosion issues.

5. Evaluate proposals to import geomaterial, considering (a) proposed use, (b) alternatives, and (c) costs and benefits for geodiversity and biodiversity with regard to source and recipient sites.

6. Consider use of materials such as gravel sourced from local geology, or organic mulch.

7. Consult with experts for advice on the type and source of suitable matching geomaterials.

8. Ensure that public artwork, monuments, pathways and other infrastructure involving imported geomaterial match the site geology or are geologically compatible with the site.

9. Remove inappropriate imported geomaterial where practicable.

10. Take measures to protect and interpret the geoheritage of natural areas.

Acknowledgements


References


Department of Sustainability and Environment (2008) Victoria’s public land Phytophthora cinnamomi management strategy. (Department of Sustainability and Environment: Melbourne)
Some observations of Australasian Grebes *Tachybaptus novaehollandiae* on and near a flood-retarding basin in Clayton, Victoria, together with comments on the habitat

Introduction

The Australasian Grebe *Tachybaptus novaehollandiae* is the smallest grebe found in Australia. It is widely distributed in Australia, and inhabits a variety of fairly shallow bodies of fresh water, generally with some fringing vegetation. It is secretive and wary, and usually occurs singly or in monogamous pairs. Water-courtship can occur at any time, and nesting takes place up to three times per year. The nest consists of a soggy platform of water weeds, and is concealed amongst vegetation. Both sexes incubate the eggs for a period of about 23 days. The young birds are fed by the parents until they are old enough to find their own food, and are fully independent at eight weeks of age. Juveniles from one brood sometimes feed smaller siblings from the next brood. Breeding losses are thought to be high because of fluctuating water levels, weather and predation. Grebes attack intruders by skidding across the water towards them, or by diving and biting from under the water (Marchant and Higgins 1990).

Australasian Grebes have been breeding at the flood-retarding basin located at Monash University’s Clayton campus, in suburban Melbourne, Victoria, every year since 2006, and three times per year since 2009. The basin (Fig. 1) is approximately 180 m north-west of another freshwater body in Jock Marshall Reserve, also inhabited by Australasian Grebes. At the basin, bulrushes *Typha* sp. grow at the eastern and western ends and along part of the northern side. The water weed *Vallisneria gigantea* (Fig. 2) is well established, except in deeper water. Only one pair of Grebes at a time occupies the territory.

From October 2006 to March 2018, through opportunistic observations made during walks around the basin, as well as more frequent observations during 2017 and 2018, it has been...