AUSTRALIAN GRANITE OUTCROPS: PLANTS AND COMMUNITIES FROM ISLAND-LIKE LANDFORMS

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INTRODUCTION

Granite outcrops are ubiquitous, found on every continent, occupying around 15% of the earth's land surface. They appear as diverse landforms from mountainous spires and towers, through dome-shaped emergences of massive rock on plains, to humble flatrocks scarcely emergent from the soil. By far the most common granite landforms in Australia are *bornhardts*, rounded domical hills of massive bedrock with bare rock exposed over most of the surface, and in which open fractures are few (Fig. 1). Less common are *inselbergs*, isolated steep-sided island mountains rising abruptly from surrounding plains. Two granite landforms encountered especially in arid areas are *nubbins* or knolls (block- or boulder-strewn outcrops) and *castle koppies* – angular and blocky castellated forms (from the Afrikaans *koppie*, for a head, applied to a small hill).

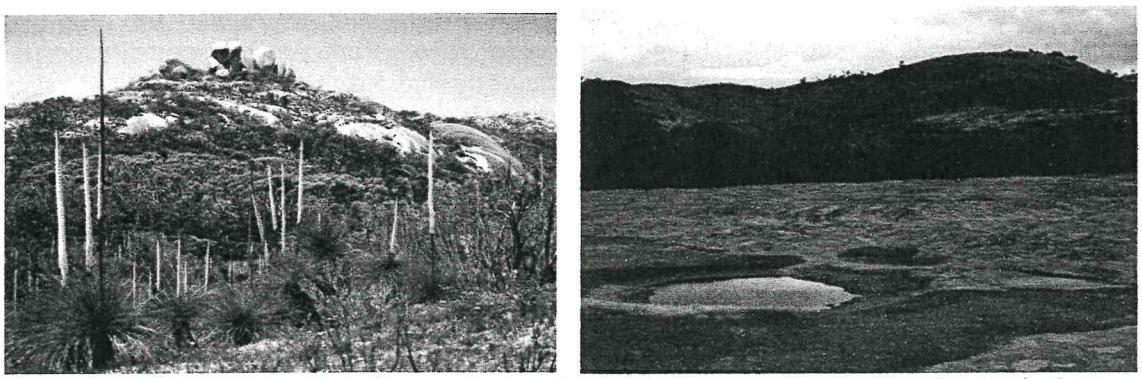

Figure 1. Two southwest Australian granite bornhardt landforms. Left – Mt Hopkins, Walpole-Nornalup National Park, with a castle koppie on its summit and *Xanthorrhoea platyphylla* in the foreground. Right – The Humps, with gnammas (rock pools) in the foreground.

The island-like nature of granite outcrops has evolutionary and ecological consequences. Islands are by definition isolated by water unsuitable for life for most terrestrial inhabitants. The spatial isolation is often a barrier to mating relationships, and leads to genetic isolation and divergence. Coping with inbreeding and adapting to persist in small populations is a key attribute of successful island dwellers. Ultimately, as Charles Darwin observed among Galapagos finches, each island may have a different species, clearly related to those on nearby islands but sufficiently different and reproductively isolated to be separate species.

Granite outcrops, too, are like islands in a sea of deep soil. Their insular nature is most apparent where rainfall is sufficient to support forest in surrounding country. Then the granite outcrops are like arid islands, experiencing greater exposure to the elements, higher temperatures, and lower humidity than the forest in which they are embedded. Moreover, the forest is a structural barrier to the dispersal of seeds by the wind, accentuating the isolation of plants living on the rocks.

Plants on granite outcrops exhibit many of the attributes of island life — small populations showing significant genetic divergence between outcrops, suites of closely related species or subspecies separated geographically, special ways of coping with inbreeding, and unique, often unexpected, adaptations that have evolved and persisted through the inherent isolation of granite outcrops (Withers & Hopper 1997, 2000; Nikulinsky & Hopper 1999; Porembski & Bathlott 2000).

In this paper I will briefly review plant communities found in habitats on granite highlighting interesting aspects of some plant species. Although there is yet to be a consensus reached among biologists, seven major habitats for plant life on granite rocks may be recognised — massive rock surfaces, fissures and clefts, exfoliated slabs and A-tents, boulders, gnammas or rock pools, soil-filled depressions and fringing vegetation. The following account has been abstracted from Hopper (1999), with some updating.

PLANT LIFE

Massive rock surfaces

These are the province of slippery black cyanobacteria, lichens, mosses, spike mosses (*Selaginella*), flowering plants able to live in the shallowest of soils and a special community confined to outcrops – monocot mats. In Australia the latter are confined to the tropics, and are formed by mats of the grass genus *Micraria*. In southern Australia large clumps of the resurrection pincushions (*Borya*) sometimes coalesce into prickly herbfields, but they do not form sprawling bodies rooted at one point as do true monocot mat formers.

Fissures and clefts

Fissures in massive rock provide opportunities for root penetration, albeit in just two plane. Nevertheless, there may be severe constraints on root growth, and the limited soil that may accumulate also leads to nutrient-deficiency and water stress. Root pruning naturally occurs, leading to bonsai formed shrubs and trees that are able to survive. Resurrection ferns (*Cheilanthes*) often will gain a foothold in cracks. Herbaceous flowering plants also may occur along linear fissures, such as grasses and rock isotome (*Isotoma petraea*). Rock cliffs provide vertical worlds where only the most tenacious of plants such as figs (*Ficus* spp.) gain a foothold and persist.

Exfoliated slabs and boulders

Flat slabs of exfoliated rock, sometimes pushed up as A-tents when cracked along the horizontal surface by lateral compression, provide deeply shaded and moist cool conditions suitable for few plants. Throughout the world, the junction between the foot of rounded granite boulders and the basement rock provides a special habitat for many plants, however, usually shaded for most of the day, with only narrow fissures and a shallow damp soil layer accumulated at the junction for providing sustenance. In temperate Australia, the shady base of boulders is preferred habitat for blanket ferns (*Pleurosorus rutifolius*), rock fern (*Cheilanthes austrotenuifolia*) and some soft annual herbs such as wild tobacco (*Nicotiana rotundifolia*).

Gnammas (rock pools)

Because most gnammas are shallow and seasonal, drying out completely for months at a time, annual flowering plants or perennial resurrection plants are best equipped to survive such conditions. Worldwide, there has been remarkable parallel evolution of a desiccation-tolerant lifestyle suited to gnammas developed in members of the snapdragon family Scrophulariaceae. The mudmats (*Glossostigma*) of Australia are typical of this group. Other interesting aquatic annuals of gnammas include the annual myriophyllums of southwest Australia, and quillworts (*Isoetes*). Victorian gnammas are the richest in Australia documented so far, with up to 18 species of aquatics recorded.

Shallow soil-filled depressions

Over the past few decades, botanists have examined the vegetation of soil-filled depressions on granite worldwide, discovering a rich diversity of strategies for dealing with seasonal or unpredictable drought. Among Australian herbaceous perennials on outcrops, pincushion lilies (*Borya* spp.) are abundant and remarkable in their capacity as resurrection plants to withstand desiccation to less than 5% of normal leaf moisture content, turning orange in the process, and rehydrating to normal green leaves within a two days of rainfall (Fig. 2).

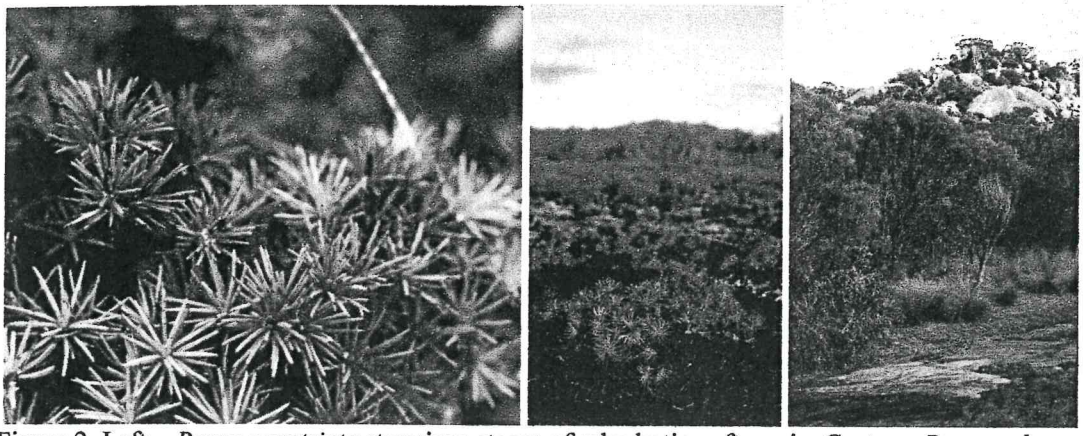

Figure 2. Left – *Borya constricta* at various stages of rehydration after rain. Centre – *Borya sphaerocephala*, Sullivan Rock WA. Right – classic zonation of plants on granite with lichens on bare rock, moss and *Borya* on shallow soil, the monotypic grass *Spartochloa scirpoidea* forming tussocks, *Eucalyptus caesia* (left) and *Acacia acuminata* on deeper soils at Mt Caroline, WA.

There are at least seven species of *Borya* found on Australian inselbergs, most in southwest Australia, where up to four species can be found on individual outcrops in the wheatbelt. Other resurrection plants commonly seen on Australian granites include the rock ferns (*Cheilanthes* spp.), blanket fern (*Pleurosorus rutifolius*), and the small grass of shallow soils *Tripogon loliiformis*.

Persisting underground as a tuber or corm during drought is a common strategy among granite outcrop geophytic herbs. In Australia, it is especially seen in species of wetter shallow soils (termed ephemeral flush vegetation by some botanists) such as lilioids (e.g. *Wurmbea*, *Bulbine*, *Chamaescilla*), orchids (*Caladenia, Thelymitra, Pterostylis, Diuris, Prasophyllum*) and sundews (*Drosera*), as well as the unusual fern ally the pigmy clubmoss *Phylloglossum drummondii*, the distant relative of kangaroo paws *Tribonanthes violacea*, butterfly flowers *Philydrella pygmaea* and some triggerplants such as *Stylidium petiolare*. On northern Australian outcrops, tuberous sedges tend to occupy this niche (e.g. *Cyperus bulbosa*). There is often clear zonation of these tuberous herbs, with the smallest plants such as pygmy clubmoss and *Chamaescilla corymbosa* occupying the shallowest soils, and larger herbs such as *Drosera gigantea* and *D. macrantha* appearing as soil deepens.

There are many other interesting life histories to be observed among granite outcrops plants on deepening soil pockets (Fig 2), including annuals, carnivorous plants, graminoids, rare succulents, woody shrubs, trees, climbers, epiphytes and parasites.

Fringing vegetation

On outcrops that have no soil filled depressions deep enough for tall woody shrubs and trees, the broad transition of fringing vegetation is the only place where some plants confined to inselbergs are found. In the wheatbelt of semi-arid southwest Australia, common woody species of the fringe include rock sheoak (*Allocasuarina huegeliana*), grey-leaved roadside tea-tree (*Leptospermum erubescens*) and long-leaved wattle (wilyurwur, *Acacia lasiocalyx*). Rarer woody species such as caesia (*Eucalyptus caesia*) also occur in such circumstances.

CONSERVATION OF LIFE ON THE ROCKS

Conservation of biodiversity on granite outcrops involves managing a range of threatening processes, including the invasion of weed species, mainly annuals, especially on rocks in the southwest and in South Australia (Withers & Hopper 2000; Porembski & Bathlott 2000). Moreover, because of their insularity, granite outcrops often have threatened species such as the critically endangered Western Australian Chiddarcooping myriophyllum (*Myriophyllum lapidicola*) from armchair gnammas, granite tetratheca (*Tetratheca deltoidea*) from mallee in soil pockets, cinnamon sun orchid (*Thelymitra manginiae*) from open woodland and Wongan

featherflower (*Verticordia staminosa* subsp. *staminosa*) from fissures. Restoration and management of granite rocks vegetation need much more research. Having lasted from the darkest shadows of antiquity, plant life on the rocks is now in our hands.

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