ecology and endemism

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Serpentine plant ecology and endemism are compared between upland and lowland landforms in the largest (1000 km^2) serpentinite region in eastern Australia. The plant communities and soils of serpentine upland outcrops (older *in situ* soils) and lowlands (younger depositional soils) are described. High Ni soil groups in the uplands recorded more endemic taxa than lower Ni soil groups in the lowlands. Species richness decreased across soil groups as soil Ni concentration increased. Plant communities on soil groups with Ni concentration >0.4% had a species richness of 18–33 species per 0.1 ha compared to communities on soil groups with <0.3% Ni, which had a species richness of 26–47 spp./0.1 ha. The Central Queensland endemics *Stackhousia tryonii* and *Pimelea leptospermoides* are the two hyperaccumulators of Ni occurring on ultramafic soils. *Callistemon* sp. nov. is a serpentine endemic recorded on lowland wet sites with high soil Mg concentrations.

Introduction

In many parts of the world, serpentine vegetation and floristics have proved to be distinctive.[1–3,5–11] The features frequently associated with serpentines include characteristic soil chemistry properties, stunted vegetation, abundance of shrubby-sclerophyllous plants, reduced species richness and the presence of serpentine endemics.[1–5,7–11] In Australia, research on serpentine soil–plant relationships dates from the 1967 discovery of the first Australian Ni-accumulating species, *Hybanthus floribundus*.[12,13] Early literature[12–14] described the vegetation of serpentine outcrops as open and stunted with an abundance of shrubs such as *Xanthorrhoea* spp. and grasses such as *Triodia* spp. New South Wales researchers have provided a comprehensive description of serpentine vegetation in the Coolac Serpentine Belt and the Woko-Glenrock region.[14–16] These studies identified the serpentine endemics *Allocasuarina ophiolitica*, *Eucalyptus ophiolitica* and *E. serpenticola*. Gibson *et al.*[17] characterized the serpentine vegetation of central and western Tasmania and identified *Epacris glabella*, *Micrantheum serpentinum* and *Tetratheca gunnii* to be serpentine endemics.

Serpentine soil-plant research in Queensland dates from the 1989 discovery of the second Australian Ni hyperaccumulator, *Stackhousia tryonii*, in Central Queensland.[18,19] The published lists[11,18–21] of serpentine indicator plants include two Ni accumulators, *Pimelea leptospermoides* and *Stackhousia tryonii*, as well as other currently known serpentine endemics: *Acacia* sp. nov. (Canoona), *Brachychiton bidwillii* vel aff. (Batianoff 9812233), *Bursaria reevesii*, *Callistemon* sp. nov. (Marlborough Cr.), *Capparis thozetiana*, *Chamaesyce ophiolitica*, *Corymbia xanthope*, *Cycas ophiolitica*, *Eucalyptus fibrosa* subsp. nov. (Glen Geddes), *Hakea trineura*, *Lissanthe* sp. nov. (Marlborough), *Macrozamia* sp. nov. (Marlborough), *Macrozamia longispina*, *Neoroepera buxifolia*, *Olearia* sp. nov. (Glenavon), *Pultenaea setulosa* and *Scleria tryonii*.[11,18–21] Queensland serpentine endemics, with the exception of *Macrozamia longispina* (Widgee Mt, Gympie District),[18] are currently found only in the Marlborough-Rockhampton region of Central Queensland.

The Central Queensland serpentine flora is the most diverse

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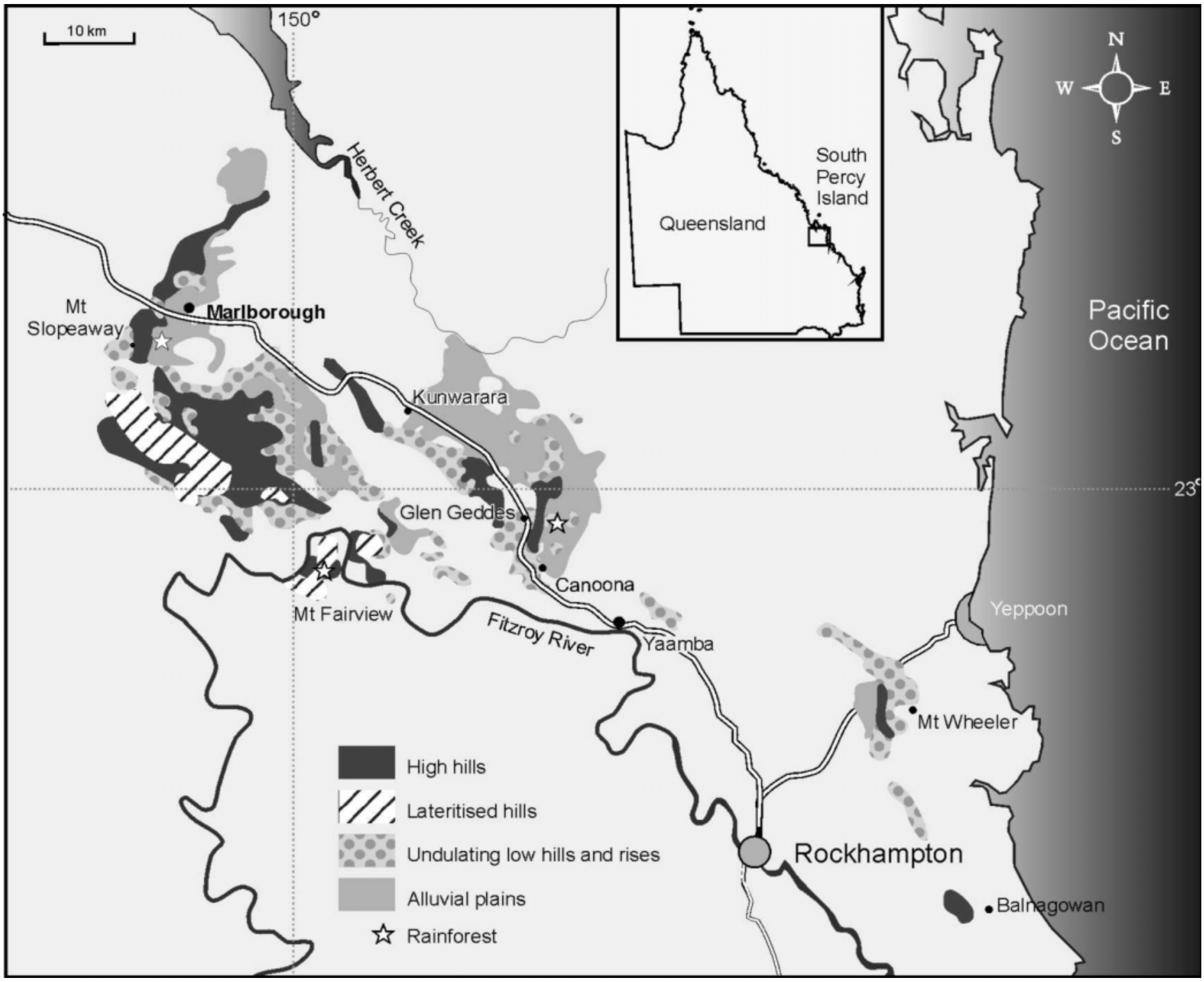

Fig. 1. Locality map showing the serpentine upland and lowland landforms in Central Queensland.

on Australian ultramafic soils.[11,14–23] The flora comprises 553 native species in 322 genera and 94 families.[11] Nineteen are endemic species and 20 are listed or proposed in the schedule of the Queensland *Nature Conservation Act 1992* (Rare & Threatened). The predominant land uses in this area are cattle grazing and mining. Commercial interests such as mining and settlement in the lowlands are increasing. For example, the Marlborough Nickel Project has recently been approved for open-cut mining, while other mines are operating at South Mt Slopeaway (chrysoprase, Gumigil Mine and Cobra Resources) and Kunwarara (magnesite). Since the early 1990s, this area has also been of great interest to researchers, conservationists and the public at large.[11,18–23] The entire serpentine study area of Central Queensland is recently listed as an Area of National Significance by the Australian Heritage Commission.[23]

This paper describes the Central Queensland serpentine plant communities and soils. It compares soil–plant associations between the older *in situ* soils of upland landforms (mountains and hills) with the younger depositional soils of lowland landforms (colluvial fans, alluvial plains and swamps). The soil and floristic data used in this report are detailed elsewhere.[11,22,23]

Methods

The serpentines in Central Queensland cover about 1000 km^2, forming a discontinuous patch some 110 km long from Marlborough south to Balnagowan.[22] Figure 1 illustrates the study area and landforms. This region has a subtropical climate with an average annual rainfall of 900 mm. The geology is thought to have originated during the Mid to Late Permian period.[17–22]

Seventy-three sites from various sources were grouped and examined. Site description included a classification of vegetation communities on the basis of structural and floristic criteria as proposed by Specht.[24] The structural criteria included canopy height and percentage foliage projective cover (FPC).[20,24] The dominant plant species commonly found in the overstorey, mid-understorey and understorey strata defined the floristic criteria. Rainforest classification follows Webb and Tracey.[25] Site descriptions included recordings of soil groups,[22] habitat and landform.

Mean soil Ni concentrations and area estimates of uplands and lowlands were derived using data from Forster and Baker.[22] Additional soil analyses were conducted by S.D. Bidwell (pers. comm., 2000). Herbarium specimen labels were used to obtain additional site information. The uplands and lowlands landform classification in this study is an adaptation of Land Systems mapping provided by B.A. Forster (pers. comm., 1999). The uplands include all areas of Marlborough Land Systems (34 300 ha, high hills 250–400 m a.s.l.), Tungamull Land Systems (22 200 ha, low hills 100–200 m a.s.l.), Yeppoon Land Systems (4500 ha, hills 100–300 m a.s.l.) and offshore deposits[18,19] of serpentine (250 ha, hills and others) occurring at South Percy Island National Park northeast of Rockhampton. The lowlands encompasses Kunwarara Land Systems (33 000 ha, depositional soils), Marlborough Land Systems (3000 ha), Tungamull Land Systems (2500 ha) and Yeppoon (500 ha).

Results

Appendix 1 provides detailed descriptions of 14 discrete plant communities recorded within the six soil groups described by Forster and Baker.[22] The different soil groups vary in their soil chemistry and location within the serpentine landforms (B.A. Forster, pers. comm., 1999). Table 1 summarizes some of the main differences between upland and lowland serpentine landforms. Lowland serpentine soils have higher levels of Mg and P than the upland soils (Table 1). Approximately 60% of the study area is uplands (100–400 m), which support nine plant communities, including semi-deciduous rainforest. The remaining 40% of the area is lowlands with five associated plant communities. Uplands recorded all of the serpentine endemic plant species with the exception of one riverine species (*Callistemon* sp. nov.), whereas lowlands support only 65% of the total endemic taxa.

Upland soils generally have higher levels of Ni than lowland soils. High Ni soil groups in the upland open-forest communities had higher numbers of species of endemic taxa than the lower Ni soil groups in the lowland open forests (Fig. 2). Figure 2 indicates that the presence of endemic taxa has a strong positive association ($r = 0.95$) with surface soil Ni concentration. Conversely, examination of total species richness across all of the soil groups indicates a negative association ($r = -0.87$) with surface soil Ni concentration (Fig. 3). Serpentine open-forest communities on soils with high nickel (>0.4%) recorded lower species richness (18–33 spp./0.1 ha) than communities on soils with lower nickel (<0.3% ~26–47 spp./0.1 ha). There are 115 more species (mainly grass species) in lowland open-forest communities than in upland open-forests (Fig. 4). The number of the open-forest overstorey tree species on lowlands exceeds upland areas by 28% (Fig. 4).

Figure 5 illustrates four different plant communities occurring along the north–south gradient at Mt Fairview. The structural differences of plant communities ranged from barren and stunted low woodland on xeric sites to tall open-forest and semi-deciduous rainforest (closed forest) on the more mesic sites. The locations of Mt Fairview soil groups 1, 2 and 3 indicate some of the prevailing conditions associated with changes in topography and aspect (Fig. 5). The upland rainforests comprise

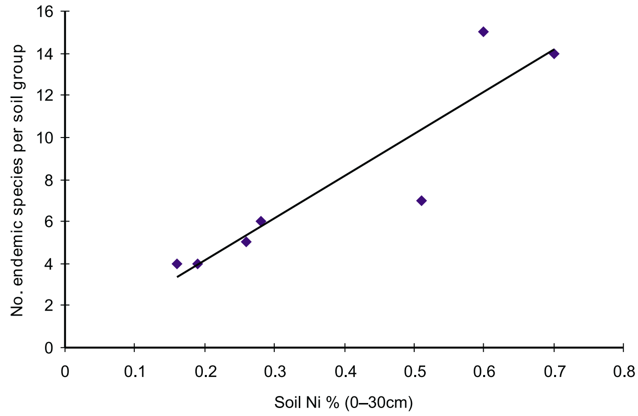

Fig. 2. Association between endemism and soil Ni concentrations in Central Queensland serpentine open forests.

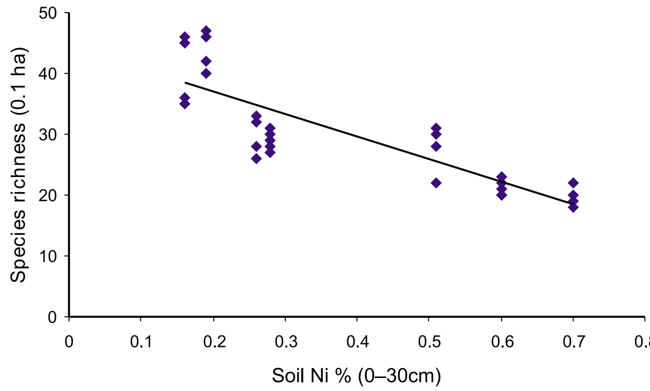

Fig. 3. Association between species richness and soil Ni concentrations in Central Queensland serpentine open forests.

Table 1. Summary of characteristics of serpentine uplands and lowlands. Soil chemistry after Forster and Baker.[22] Plant communities are listed in Appendix 1.

Characteristic	Upland	Lowland
Landform	Estimated 61 250 ha of mountains, hills, plateau, crests, hillslopes	Estimated 39 000 ha of colluvium footslopes, plains, creek banks and terraces, swamps
	Height m a.s.l.: 100–400 m	Height m a.s.l.: <100 m
	Older *in situ* soils, particularly the saprolite-derived laterite.	Younger depositional soil, particularly serpentine alluviums
Soil chemistry	Group 1, 2, 3 (listed in Appendix 1)	Group 4, 5, 6 (listed in Appendix 1)
	0.34% Ni (0–0.3 m depth)	0.22% Ni (0–0.3 m depth)
	0.49% Cr (0–0.3 m depth)	0.38% Cr (0–0.3 m depth)
	13 meq% Mg (0–0.3 m depth)	41 meq% Mg (0–0.3 m depth)
	6 mg kg^{-1} extractable P	11 mg kg^{-1} extractable P
	(0–0.1 m depth)	(0–0.1 m depth)
	24% C:N ratio (0–0.1 m depth)	18% C:N ratio (0–0.1 m depth)
	mean pH = 6.9 (range 5.8–8.2)	mean pH = 7.5 (range 6.6–8.5)
Vegetation	Nine communities: grassland, heath, open-forests to closed-forests	Five communities: woodland to open-forests including riverine forest.
	Open-forest overstorey tree layer: 8–35 m; FPC 20–75% with grassy/heathy understorey: 0.2–2.5 m; FPC 15–40%.	Open-forest overstorey tree layer:11–25 m; FPC 20–35% with grassy understorey: 0.5–2.5 m; FPC 5–35%.
	Sampling: 41 sites	Sampling: 30 sites
Flora	Open-forest: 253 spp.	Open-forest: 366 spp.
	Grasses: 31 spp.	Grasses: 76 spp.
	Rainforests: 188 spp.	Riverine vine forest/rainforest: 62 spp.
	Total endemics: 23 spp. (including 3 possible endemics).	Total endemics: 15 spp.(including 2 possible endemics).
	Exclusive upland endemics: 9 spp.	Exclusive lowland endemics: 1 sp.