The Serpentine Ecosystem in The Livingstone Shire:

A Literature Review

A Report to the Livingstone Remnant Vegetation Study

Amy Cooper

Industrial Land Management Programme
Centre for Land and Water Resource Management
Central Queensland University, Rockhampton, Qld.

2002

ACKNOWLEDGEMENTS

The Natural Heritage Trust and Ergon Energy funded this report. Livingstone Shire Council and the Livingstone Remnant Vegetation Study Steering Committee provided valuable assistance throughout the project. We also thank Christine Fraser from Livingstone Remnant Vegetation Study, Ian Dare, Ian Denley and Leise Childs from the Livingstone Shire Council, and Rhonda Melzer (Queensland Parks and Wildlife Service) for their ongoing contribution to this project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The purpose of this literature review was to provide a background on the unique features of the serpentinite ecosystem in Central Queensland. This information was researched for a Natural Heritage Trust project on the serpentinite ecosystem in the Livingstone Shire.

This report is divided into two sections. The first section provides an overview of general serpentine ecology worldwide. This section discusses the extent of serpentinite ecosystems worldwide, geology, soil properties, vegetation, hyperaccumulating plants and practical applications for serpentine species.

Section two describes the serpentine ecosystem of the Livingstone Shire. This section gives an overview of the landscape's extent, history, geology, landform types, soil properties, vegetation, Regional Ecosystem classification, ecological values, hyperaccumulating plants and threatening processes. The review concludes with a brief discussion of conservation and management.

INTRODUCTION

A Natural Heritage Trust funded project was based on the serpentinite region in the Livingstone Shire. This project was initiated by the Livingstone Remnant Vegetation Study, and is entitled 'Community and Agency Action on a Serpentine threatened ecosystem'.

One of the objectives of this project was to review the existing data, and this literature review gives an overview of the available information on both general serpentine ecosystems and the Livingstone Shire serpentinite.

Serpentinite geology occurs in many areas of the world and has very distinctive chemical and physical features. The soil derived from serpentine rocks is affected by these distinctive features and forms a unique environment for the plants that grow in these soils. As a result, this flora is rare, endemic and of different races (Roberts and Proctor, 1992).

SERPENTINE ECOSYSTEMS OF THE WORLD; AN OVERVIEW

Extent of serpentine worldwide

The boundaries of serpentinite landscapes are determined by both the distribution of soils derived from ultramafic geology, and by flora characteristic of these soils. Serpentine ecosystems are found world wide, including North and Tropical America, Northwest Europe, Central and Southern Europe, Continental Asia, Japan, Africa, the Malay Archipelago, New Caledonia, Australia and New Zealand (Brooks, 1987). Although ultramafics are widespread, they still only occupy less than 1% of the earth's land surface (Baker, Proctor and Reeves, 1991).

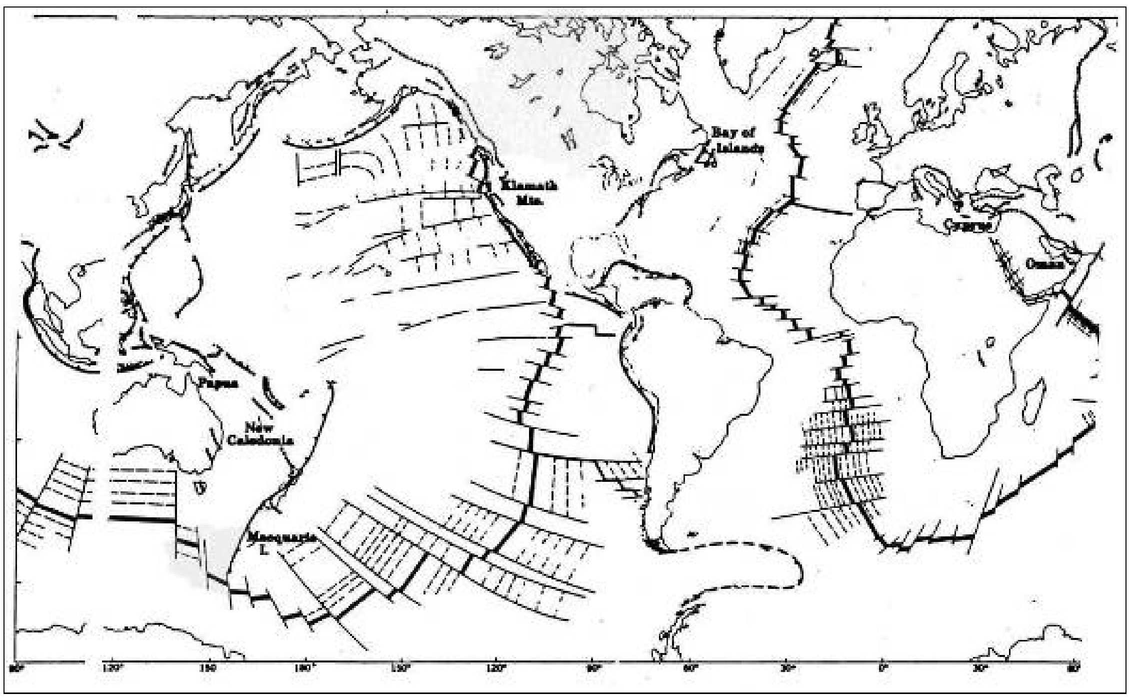

Figure 1 The distribution of ophiolitic belts throughout the world (Coleman 1977)

Geology

The term 'serpentinite' describes rocks and minerals, and there is a wide range of differences in the chemical composition of serpentinized rock. Serpentine is the name associated with a suite of rock types, which contain ferromagnesian materials (high levels of magnesium (Mg) and iron (Fe).

The term serpentine actually refers to the polymorphic minerals lizardite, antigorite and chrysotile (known for its asbestos form). These minerals are derived from the hydration of the ferromagnesian minerals of ultramafic rocks, at low temperatures and pressures, in conditions favourable for each mineral's formation. These low temperatures are usually less than 500°C, and fluid pH in excess of 10, and low CO_2.

Serpentine rocks are often rich in chromium, cobalt and nickel, and have relatively low concentrations of silicon, phosphorus, potassium and calcium (Brooks, 1987; Proctor, 1999; Roberts and Proctor, 1992).

Soil properties

Serpentine soils have unusual properties, a feature which is associated with the geochemical processes they have undergone. These soils are usually regarded as infertile, and are prone to drought, even in areas of high rainfall. (Batianoff and Specht, 1992, Roberts and Proctor, 1992).

Serpentinite soils contain elevated levels of nickel, magnesium, manganese, iron, cobalt and chromium. They are also characterised by low levels of nitrogen, phosphorous and calcium. (Brooks, 1987; Proctor, 1999; Roberts and Proctor 1992).

The high level of magnesium is important in two activities; firstly it occupies a high proportion of cation exchange sites, which enables the soil to maintain a high pH. Secondly, magnesium is generally a part of chemical interactions with nickel and calcium (Roberts and Proctor, 1992). Interactions between the magnesium, nickel and calcium are known to be significant to plant growth, and it is these interactions, which may explain the unusual flora and fauna of serpentinite areas (Proctor, 1999).

It is the high levels of magnesium and the low levels of calcium, which appear to cause infertility in ultramafic soils. Also, the elevated amounts of cobalt, nickel and chromium may result in soil toxicity (Proctor and Woodell, 1975; Proctor and Roberts, 1992). The lack of mineral plant nutrients nitrogen, phosphorous and calcium (in addition to the elevated levels of other chemicals) can reduce the extent of plant colonisation (Roberts and Proctor, 1992).

Vegetation

The combination of both adverse physical and chemical conditions in ultramafic soils poses a major challenge to plant growth. Batianoff and Specht (1992) also note that the chemical features of serpentine soils inhibit plant diversity.

Serpentinite plants have adapted to these adverse conditions through evolution. Research has shown that these plants possess inherited and correlated traits for both drought tolerance and ultramafic soil tolerance. The necessary survival traits which have evolved include; tolerance of high levels of magnesium and nickel and low levels of calcium in soils, slow growth rates, short narrow leaves, a compact habit, the ability to adjust to lower water potential than those in other soils, and good stomatal control over water loss (Proctor, 1999).

In addition, the deficiency or imbalance in plant nutrition in ultramafic soil may cause serpentinite vegetation to be stunted in arid to humid surroundings. Also, associated with the tendency for drought, the vegetation is prone to burning (Brooks, 1987; Proctor, 1999; Roberts and Proctor, 1992).

As a result of this challenge, the vegetation types have characteristic features. Firstly, the vegetation is characteristically open and of low stature, and secondly there is a high proportion of endemic or disjointedly distributed species. As a result, a high proportion of serpentine endemic flora is endangered (Proctor, 1999).

Hyperaccumulating plants

In response to the high levels of metals in serpentinite soils, some serpentine plants have adapted to such an extent they can accumulate the metals. This capacity to accumulate elevated concentrations of heavy metals in shoot tissues is known as hyperaccumulation (Baker et. al, 2000)

Hyperaccumulators have two main characteristics, the first being the ability to take up and translocate exceptionally large amounts of metals to their shoot tissues. Secondly, they have the capacity to tolerate very high concentrations of metals in the root environment, which is known as hypertolerance. These two features are necessary for a successful phytoextraction strategy. (Lombi *et al*. 2000).

Practical applications of serpentine species

It has been recognised that hyperaccumulators could be applied practically as a technique for "biological clean-up". This phyoextraction could be used in many polluted media, including metal-contaminated soils, composted materials, effluents and drainage waters (Baker and Smith, 1998). Phytoextraction is regarded as an environmentally friendly, cost-effective solution in the rehabilitation of heavy metal-polluted soils (McGrath *et al*. 1993). This ability to hyperaccumulate could also be exploited for phytomining, which is the cropping of hyperaccumulators to extract the elements absorbed (Baker *et al*, 2000).

However there is a major constraint to natural phytoextraction: the biomass of hyperaccumulator plants is generally low (excluding some nickel hyperaccumulators). To remediate metal-polluted soils successfully, the shoot biomass of the hyperaccumulators needs to be increased. Application of genetic engineering techniques could solve this problem, however more research in this area will need to be carried out (Lombi *et al*. 2000).

CENTRAL QUEENSLAND SERPENTINITE

Extent

In Queensland, there are three serpentinite areas (North Queensland, Central Queensland and South Eastern Queensland), and together they account for only 0.05% of the total area of the state (refer to Figure). The Central Queensland serpentinite is located in the Livingstone Shire, and is recognised as the largest single serpentinite area in Australia. (Batianoff and Specht, 1992).

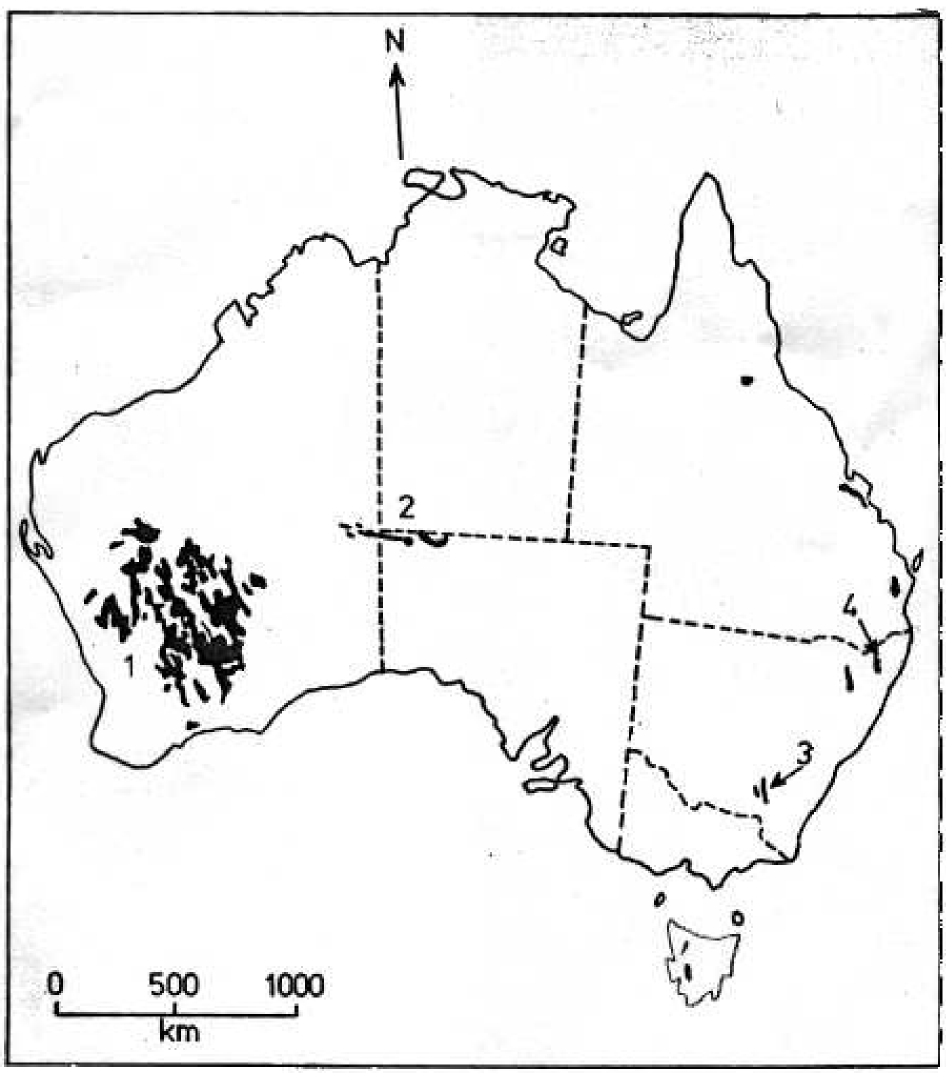

Figure 2 Serpentine areas of Australia (Brooks, 1987)

The Livingstone Shire serpentinite landscape is approximately 110km long extending from Marlborough in the north to Balnagowan in the south (Figure 1). Serpentinite outcrops are also found on South Percy Island near Mackay, Qld. The boundaries of the serpentinite ecosystem are defined by the distribution of serpentinite derived soils and in particular by vegetation associated with these soils.

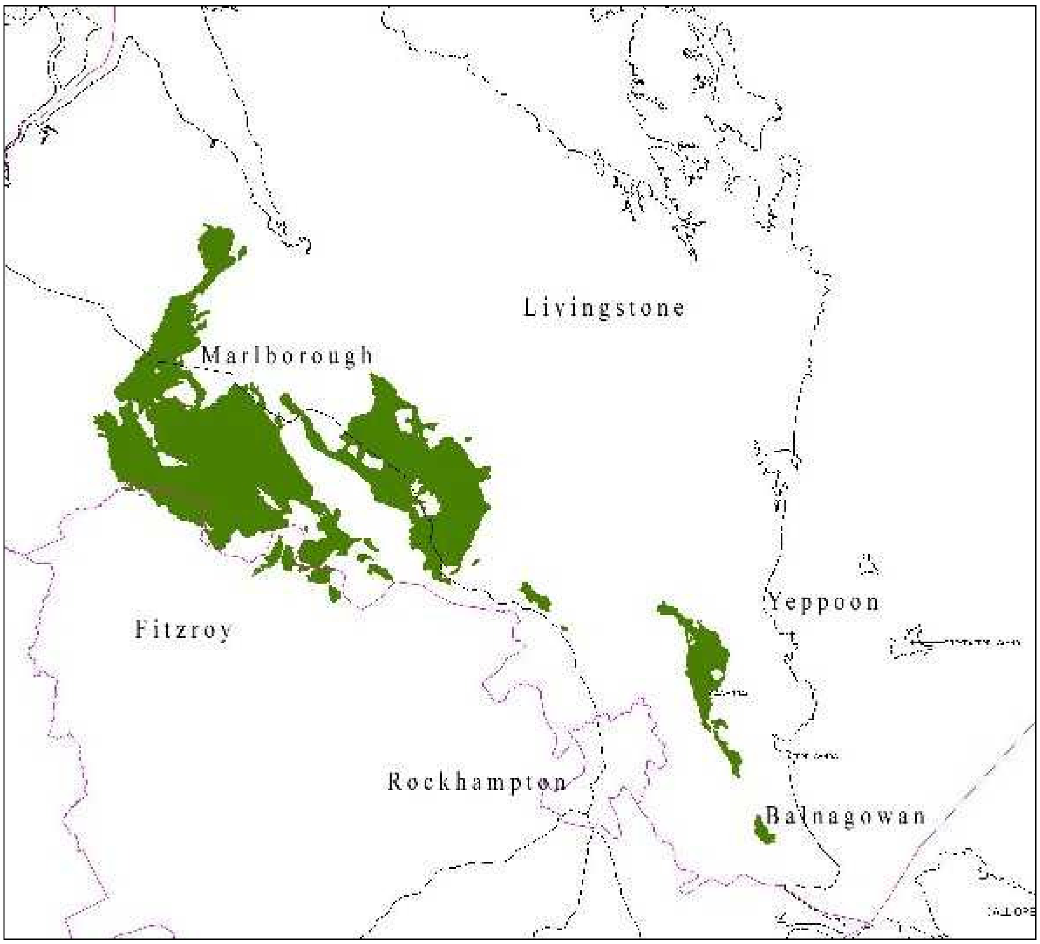

Figure 3 Distribution of Serpentinite vegetation in the Livingstone Shire

History of the Livingstone Shire

Today, most of the Livingstone Shire is devoted to farming, urban and urban-rural development. Significant areas of the shire are mined, for magnesite, chrysophase, nickel, cobalt and other base metals. Mining was also a major part of the Shire's history (refer to Table 1). Areas mined for gold included Canoona, Mount Chalmers, Cawarral, Limestone Creek and Marlborough (Forster and Baker, 1995).

The serpentinite belt was the location of the first gold rush in Central Queensland, in Canoona in 1858. Currently the northern end (the Marlborough area) is being used for mining and grazing, while small block development and urbanisation affect the southern end (the Cawarral area).

Geology

The Central Queensland serpentinite is derived from tectonic earth movement, which occurred at least 750 million years ago. The serpentinites have been deeply weathered and eroded over time into a terrain of mountains, hills, colluvial fans, alluvial plains and swamps.

Of the several ultramafic outcrops in Central Queensland, harzburgite was the original rock type, and it has now been serpentinized to different degrees in various areas. In this area, the two types of serpentine which occur are massive and schistose. Massive serpentine usually resembles the harzburgite in texture. Schistose serpentinites usually develop along margins of the larger ultramafic systems, and throughout some of the smaller ones. During the last 30 million years, the serpentinites have been greatly weathered and have eroded into steep mountains, rolling hills, colluvial fans, swamps and alluvial plains.

The weathering of ultramafic rocks at low temperatures has resulted in nickel laterite deposits in Marlborough. Extensive ultramafic intrusives have been mapped around Rockhampton and Marlborough and are shown to intrude rocks of Lower Devonian to Permian age (Murray, 1969).

Location of serpentinite masses within the Livingstone Shire

The Livingstone Shire possesses the largest outcrops of serpentinite rock in Eastern Australia. The three major serpentinite masses are the Marlborough mass, the Mount Etna-Glen Geddes-Kunwarra mass, and the Balgnowan-Cawarral-Bondoola mass Marlborough (Murray, 1969; Batianoff, Specht and Reeves, 1991). Serpentinite outcrops are also found on South Percy Island off Mackay, Queensland. This is registered on the National estate as a component of the Great Barrier Reef.

Marlborough mass

This is the largest mass of serpentinite in central Queensland, approximately 40 kilometres long and up to 10-15 kilometres wide. It outcrops between Marlborough and the Fitzroy River (on the property “Marble Ridges”), and is known as the Marlborough mass. This mass extends in a northwesterly direction to Mount Redcliffe and Mount Slopeaway, and outcrops again north of Marlborough (Murray, 1969; Batianoff, Specht and Reeves, 1991).

The Marlborough ultramafic intrudes moderate to steeply dipping sediments, the majority of which are achitose metamorphic derivatives of quartz-rich clastic and calcerous varieties. Harzburgite is the main constituent of the ultramafic, an olivine-orthopyroxene peridotite. It is dark grey in colour. The smaller lenses and the margins of the larger lenses of this material are usually serpentinized; the peripheral rocks of the intrusion have been entirely serpentinzed.

Mount Etna-Glen Geddes-Kunwarra mass

This mass is parallel to the Marlborough mass, and appears to be a thin strip from Spinifex Hill (near Mount Etna) through Canoona, Glen Geddes and Bonnie Doon Mountain to Princhester, stretching discontinuously for 50-60 kilometres, and 1-4 kilometres wide. There is an offshoot of this mass, reaching approximately 10 kilometres past Glen Geddes, and this forms the Pointers Range. This mass is almost completely serpentinized, of both schistose and massive types. The original rock variety was harzburgite, and it is dark green.

Balnagowan-Cawarral-Bondoola mass

The ultramafic mass outcrops as a narrow strip, and the rocks have been entirely serpentinzed. Ultramafics exposed in cuttings along the Rockhampton-Emu Park Road (near Tungamall) is massive rock, and mottled-grey in colour. Harzburgite was the original rock, and the serpentine has veins of chrysotile (asbestos) in it. Schistose serpentinite is the main rock type nearer Balnagowan and Mount Wheeler.

Landform types

In the Marlborough area, deep weathering has meant that laterite has developed in the very steep ridges and mountains. In some of these deeply weathered parts, veins of chrysophase are located, and mined. Below the mountains, low hills and rises are usually on partially or moderately weathered areas. Some areas of these low hills have strongly weathered profiles with nickel or cobalt enriched zones. Gravelly colluvial deposits at the bases of these low hills and rises have stretched out to form alluvial plains.

In the Cawarral area, the predominate landforms are partially weathered low hills and rises, and alluvial plains (Forster and Baker, 1995).

The difference in landforms between the two areas has given rise to the Department of Primary Industry's Land System classifications of Marlborough and Tungamall serpentinite types. The Marlborough Land System is steep mountains and ridges, and the Tungamall Land System is low hills and alluvial flats.

Soil properties

Serpentine soils in Central Queensland have the expected elevated levels of magnesium, manganese, iron, nickel, cobalt and chromium. They are also characterized by low levels of nitrogen, phosphorous and calcium. In Central Queensland the total concentration of iron is 4 times the concentration in non-serpentine soils (Batianoff and Specht, 1992).

Most serpentine land in Queensland is used for cattle grazing, and it is considered poor grazing land by agriculturists, an example is the estimation that one cow needs 15 hectares to graze. (Batianoff and Specht, 1992).

Soil chemical analyses also show that most soils that are found in serpentinite hills, or are derived directly from serpentinite, have very poor properties for agriculture. These soils have magnesium dominant over calcium throughout the soil profile, a feature which generally leads to poor soil structure (Murray, 1969).

Vegetation

Australian soils that are low in phosphorus and nitrogen and other plant nutrients, for example serpentine soils, support a dense sclerophyllous understorey composed of low shrubs, dwarf shrubs and perennial graminoids. The low shrubs are classed as nanopherophytes and their height varies from 1-2 metres. The dwarf shrubs are classified as chamaphytes which are under 25 centimetres tall, and the perennial graminoids are evergreen hemicryptophytes (such as sedges and lomandras).

When this understorey of nutrient-poor soils is compared to the understorey of nutrient-rich soils (composed of herbaceous annuals and perennials), a distinctive difference can be noted. These differences also include a definite boundary between soil and plant types, and this is as a result of ecophysiological responses of the plant species to the soils nutrient levels (Batianoff *et al* 1991).

Serpentine vegetation is found in the Livingstone Shire in the Rockhampton-Marlborough region and on South Percy Island. Located within the serpentinite landscape a range of diverse plant communities is found. These include dry woodlands, tall open forests, open forests, riverine forests, teatree forests and rainforests. These communities fall within the Brigalow Belt bioregion (Sattler and Williams, 1999).

The very distinctive serpentinite open forests and woodlands are distinguished by the presence of ironbarks, *Eucalyptus fibrosa,* which are found in 90% of the landscape, and one species of bloodwood, *Corymbia xanthope*. The distinctive understorey species are grass trees, wattles, cycads, perennial forbs and grasses. Of the grasses, spinifex is predominant in many areas. The different serpentinite ecosystem structural formations, and the percentage of the serpentine ecosystem they make up, are illustrated in Table 2 (Batianoff *et al* 1991).

Regional Ecosystems

Regional Ecosystem classification is a system where different areas are described according to landscape pattern, geology and landform, and vegetation. This classification can then be utilised in biodiversity and land use planning, and other land management planning activities.

The Serpentinite belt of the Livingstone Shire is classed as Regional Ecosystem 11.11.7, and the biodiversity status is classified as *of concern*. Usually, *of concern* indicates that less than thirty percent of the pre-European cover remains. However, the serpentinite ecosystem is regarded as *of concern*, due to its vulnerability to mining.

Sattler and Williams (1999) describe this Regional Ecosystem as:

'Complex of vegetation on serpentinite hills comprising woodland of *Eucalyptus fibrosa* subsp. Glen Geddes (M.I. Brooker 10230), *Corymbia xanthope*, ± *C. dallachiana*, shrubland, vine thicket and local riparian vegetation. *Acacia leptostachya*, *Triodia* sp., *Hakea trineura*, *Xanthorrhoea* sp. in understorey of woodland'.

Furthermore, Sattler and Williams (1999) comment that much of this area is under mining lease.

The latest addition to these Regional Ecosystem classifications is as yet unpublished. This update will include the addition of new serpentinite Regional Ecosystems 11.3.38 and 11.11.21 (see Appendix B).

Ecological values of Central Queensland Serpentinite

The Central Queensland serpentinite landscape has unique ecological values in that it provides a habitat for rare and threatened and vulnerable flora species. Batianoff et al. (2000) found that of the Rockhampton-Marlborough area, 18 plant species are endemic to the serpentine areas, with a further 3 possible serpentine endemics (poorly known) (refer to Tables 3 and 4). 13 of the 18 endemic plants have protected conservation status under the Queensland Government Nature Conservation Act. These include 11 vulnerable species and 2 rare species. Of the locally endemic plants, two species are nickel hyperaccumulators, and two species associated with high magnesium levels.

In addition, there are 6 other species (non-endemic) of conservation significance and 14 plants at their geographic limits.

There are also three vertebrate species found in Central Queensland serpentinite areas of conservation interest. The cotton pygmy goose is classified as rare, and the squatter pigeon and Fitzroy River turtle are vulnerable. A new *Diplodactylus* species of gecko was recorded in 1998.

A good example of the unique ecological values is Marlborough Creek, which provides a habitat for numerous plant and animal species, which are of conservation interest. These species include the rare endemic plant *Neoroepera buxifolia* of which Marlborough Creek and its tributaries provide almost its entire habitat. Also only found here is the giant *Callistemon* sp (refer to Plate 3 in Appendix C), which is pending listing as rare, threatened or vulnerable. Marlborough Creek is also a habitat for the vulnerable Fitzroy river turtle, and various fish species, which are accustomed to these mineral rich waters.

Hyperaccumulating plants

Three Australian serpentinite-endemic plants are classified as hyperaccumulators as they are able to accumulate high levels of nickel in their tissues. These are *Hybanthus floribundus* (Western Australia) and *Stackhousia tryonii* (refer to Plate 2 in Appendix C) and *Pimelea leptospermoides* (Plate 1) (both Central Queensland). *H. floribundus* concentrates nickel in its leaves up to 0.7% dry weight, and *S. tryonii* can accumulate up to 2% dry weight (Batianoff, Specht and Reeves, 1991; Batianoff, Neldner and Singh, 2000).

Threatening processes

Approximately 10% of the Central Queensland serpentine has been disturbed by fire, invasion of exotic species, grazing, clearing, timber cutting and mining. Of these disturbances, mining has the most potential for localised severe disturbance and downstream impact. Future mining impact is predicted in the Marlborough Creek area, which is currently under mining lease (Melzer *et al*. 1998, Batianoff *et al*. 2000).

Another major threat to this ecosystem is the sprawl of rural-urban development. This includes hobby farms and housing estates and associated infrastructure including roads, electricity and telecommunications. This type of impact results in disturbances like clearing, grazing, invasion of exotic species and fire, and is found predominantly in the southern end of the shire.

Conservation and Management

The Natural Heritage Trust project entitled 'Community and Agency Action on a Serpentine Threatened Ecosystem' was initiated by the Livingstone Remnant Vegetation Study. The aim of this study was to design the best practice management of this regionally threatened ecosystem. One of the final outcomes of this project will be an indication of gaps in the information on serpentinite ecosystems in the Livingstone Shire. This identification of gaps in the information will emphasise the areas that require more research.

REFERENCES

Baker, A.J., Whiting, S.N. and Smith, J.A.C. (2000) The 'Hows' and 'Whys' of Metal Hyperaccumulation. *Proceedings of Remade Lands*. (Eds A. Brion and R.W. Bell) pp 4-5. (Promaco Conventions Pty Ltd: Canning Bridge, Western Australia)

Baker, A.J. and Smith, A. (1998). Metal hyperaccumulator plants: biological resources for exploitation in the phytoextraction of metal-contaminated soils. *International Workshop Innovative Potential of Advanced Biological Systems for Remediation*. 77-80.

Batianoff, G. N., Neldner, V. J., and Singh, S. (2000). Vascular plant census and floristic analysis of serpentine landscapes in Central Queensland. *Proceedings of the Royal Society of Queensland*. 109, 1-30.

Batianoff, G. N., and Specht, R. L. (1992). Queensland (Australia) serpentine vegetation. In 'The vegetation of ultramafic (serpentine) soils: Proceedings of the First International Conference on Serpentine Ecology'.(Eds. A. Baker, J. Proctor and R. Reeves) pp 109-128 . (Intercept. Andover: Hampshire.)

Batianoff, G.N., Specht. R. L., and Reeves, R.D. (1991). The serpentinite flora of the humid subtropics of eastern Australia. *Proceedings of the Royal Society of Queensland*. 101, 137-157.

Bird, J.T.S. (1999). The Early History of Rockhampton. pp 98-104. (Central Queensland Family History Association Inc.: Rockhampton).

Brooks, R. (1987). Serpentine and its Vegetation. (Dioscorides Press. Portland, Oregon).

Carpenter, L. (1991). Livingstone: A History of the Shire of Livingstone. (Boolarong Publications. Yeppoon, QLD).

Centenary Booklet Sub-Committee. (1974). Cawarral State School: 1874-1974. (Cawarral, Qld).

Cole, M. (1992). The vegetation of the greenstone belts of Western Australia. In 'Geobotany 17: The Ecology of Areas with Serpentinized Rocks'. Roberts, B. and Proctor, J. (Kluwer Academic Publishers.: The Netherlands).

Coleman, R. and Jove, C. (1992). Geological origin of serpentinites. 'In The Vegetation of Ultramafic (Serpentine) Soils: Proceedings of the First International Conference on Serpentine Ecology'. (eds. A. Baker, J. Proctor and R. Reeves) (Intercept. Andover: Hampshire).

Coleman, R.G. (1977). Ophiolites. (Springer, New York)

Forster, B.A. and Baker, D.E. (1995). Characterisation of the serpentinite soils of Central Queensland, Australia. Proceedings of the Second International Conference on Serpentine Ecology. pp 1-16.

Forster, B. A. and Barton, A. L. (1995) Land systems of the Capricorn coast. (Queensland Department of Primary Industries: Rockhampton).

Lombi, E., Zhao, F. and McGrath, S.P. Cd and Zn Uptake, Accumulation and Cellular Distribution in Hyperaccumulator Plants. *Proceedings of Remade Lands*. .(Eds A. Brion and R.W. Bell) pp 6-7. (Promaco Conventions Pty Ltd: Canning Bridge, Western Australia)

McCabe, J., Rayner, D. and Melzer, A. (1998). Terrestrial flora of the serpentinite communities associated with the proposed Marlborough Nickel Project. (Central Queensland University: Rockhampton). Unpublished report.

McGrath, S.P., Sidoli C.M.D., Baker, A.J.M. and Reeves R.D. (1993) *Integrated Soil and Sediment Research: a Basis for Proper Protection* (Eds H.J.P. Eijsackers and T. Hamers) pp. 673-676. (Kluwer Academic Publishers:Dordrecht).

Melzer, A., Houston, W., Rayner, D. and Lowrey, R. (1998). Terrestrial fauna of the serpentine communities associated with the proposed Marlborough Nickel Project. (Central Queensland University: Rockhampton). Unpublished report.

Mount Chalmers P & C Association. (1978). History of Mount Chalmers. (Mount Chalmers, QLD).

Murray, C.G. (1969). The petrology of ultramafic rocks in the Rockhampton district, Queensland. Geological survey of Queensland, Publication 343.

Nature Conservation (Wildlife) Regulations. (1994) Queensland Nature Conservation Act 1992 (Reprint 2).

Proctor, J. (1999). Toxins, nutrient shortages and droughts: the serpentine challenge. *Tree*. 14, 334-335.

Proctor, J. and Woodell, R. (1975). The ecology of serpentine soils. *Advances in Ecological Research*. 9, 256-347.

Proctor , J., Johnston, W., Cottam, D. and Wilson, A. (1981). Field-capacity water extracts from serpentine soils. *Nature*. 294, 245-246.

Roberts, B. and Proctor, J. (1992). Geobotany 17: The Ecology of Areas with Serpentinized Rocks. (Kluwer Academic Publishers: The Netherlands).

Ryan, T. (2001) unpublished data (Environmental Protection Agency: Brisbane).

Satler, P.S. and Williams, R.D.(Eds) (1999). The Conservation Status of Queensland's Bioregional Ecosystems. pp. 11/44. (Environmental Protection Agency: Brisbane.)

APPENDIX A

TABLES

Table 1 Mining History of the Livingstone Shire

Area	Year	Gold mining history
Mt Wheeler	1868	Mount Wheeler's alluvial foothills were the sites of many shafts used for gold mines. These mines yielded large quantities of gold. Round shaped shafts were dug by the Chinese, and Europeans dug square or rectangular ones.
Cawarral	1863	Gold was discovered on Cawarral Station. The Annie (2km south of Mt. Wheeler) and the Helena were the most well known of the Cawarral mines, both producing gold for approximately 40 years. (Centenary Booklet Sub-Committee, 1974).
Tungamall (near Cawarral)	1870	In 1870, the flat between Tungamall and Cawarral township was mined for gold, and a good return was made (Bird, 1999).
Constitution Hill (near Cawarral)		Nearby Constitution Hill had a long tunnel cut into it in an attempt to find a reef of gold, but to no avail (Centenary Booklet Sub-Committee, 1974).
Mount Chalmers	1860	In 1860 gold was found near Mount Chalmers, and the Mount Chalmers mine was the second most important mine in central Queensland (after Mount Morgan). Today, two craters half-full of water, and two brick water tanks are all that remains (Carpenter, 1991).
Limestone Creek (Bondoola)	1800's	North-west of Mount Wheeler the Galawa mine was opened on Limestone Creek (Carpenter, 1991).
Canoona	1858	Canoona goldfield sourced the first payable gold obtained in Queensland (Bird, 1999).
Marlborough	1867	Gold was also discovered in the Marlborough region in 1867 (Carpenter, 1991).

Table 2 Vegetation structural formations and percentage within serpentine landscape

Structural formation	Percentage within landscape
Woodlands	80
Open forest	15
Grasslands	4
Riparian forests and scrubs	0.8
Heaths	0.2
Low closed forests {vine thickets}	<0.01

Table 3 Endemic serpentine plant species within the Livingstone Shire in Central Queensland

Conservation status[a]	Species	Family
	Brachychiton bidwillii vel. Aff. (Batianoff + 9812233)	Sterculiaceae
V	*Bursaria reevesii*	Pittosporaceae
P	*Callistemon* sp. (Marlborough Ck. G.N.Batianoff + MC9108006)	Myrtaceae
V	*Capparis thozetiana*	Capparaceae
	Chamaesyce sp. (First Sugarloaf P.I Forster PIF3393)	
V	*Corymbia xanthope*	Myrtaceae
V	*Cycas ophiolitica*	Cycadaceae
	Eucalyptus fibrosa subsp. (Glen Geddes M.I. Brooker 10230)	Myrtaceae
V	*Hakea trineura*	Proteaceae
	Hibiscus sp. (Glen Geddes P.I Forster PIF 9409)	Malvaceae
P	*Lissanthe* sp. (Marlborough J. McCabe AQ659027)	Epacridaceae
P	*Macrozamia* sp. (Marlborough P.I. Forster + PIF 12269A)	Zamiaceae
V	*Neoroepera buxifolia*	Euphorbiaceae
P	*Olearia* sp. (Glenavon P.I. Forster + P.I.F-15039)	Asteraceae
V	*Pimelea leptospermoides*	Thymelaeaceae
V	*Pultenaea setulosa*	Fabaceae
P	*Scleria tryonii*	Cyperaceae
R	*Stackhousia tryonii*	Stackhousiaceae
	Possible endemics	
	Hibbertia sp. (Mt Slopeaway G.N Batianoff 911039 GNB)	Dilleniaceae
	Indigofera sp (G.N Batianoff + MS9105126)	Fabaceae
	Stenocarpus sp. (G.N Batianoff + 911015)	Proteaceae

[a] under the *Queensland Government Nature Conservation Act, 1992* (V – Vulnerable, R – Rare, P – Pending classification)

Table 4 Non-endemic plants of conservation significance from the Livingstone Shire serpentinite

Conservation status[a]	Species	Family
R	*Cerbera dumicola*	Apocynaceae
P	*Parsonsia larcomensis*	Apocynaceae
P	*Scleria tryonii*	Cyperaceae
P	*Capparis humistrata*	Capparaceae
V	*Marsdenia brevifolia*	Asclepidaceae
V	*Quassia bidwillii*	Simaroubaceae
V	*Leucopogon cuspidatus*	Epacridaceae

[a] under the *Queensland Government Nature Conservation Act, 1992* (V – Vulnerable, R – Rare, P – Pending classification)

APPENDIX B

UNPUBLISHED UPDATED REGIONAL ECOSYSTEM CLASSIFICATIONS

‘Regional ecosystem 11.3.38 (was 11.11.7x1 **Author:**Tim Ryan)

Supplementary description:
Forster and Barton (1995) Kunwarara & Tungamall (in part)
Brigalow Belt uveg: 230

Description: *Eucalyptus fibrosa* subsp. Glen Geddies (M.I. Brooker 10230) *& Eucalyptus tereticornis ± Melaleuca viridiflora* and *Corymbia tessellaris* tall woodland with a grassy ground layer, on alluvial plains and broad drainage lines derived from serpentinite. Occasional patches of *Melaleuca bracteata* can occur.

Provinces: 12, 14

Protected areas: No representation.

Special ecological values: Habitat for rare and threatened plant species: *Stackhousia tryonii, Pimelea leptospermoides, Bursaria reevesii, Capparis thozetiana* and *Hakea trineura*

Comments: Logging of *E. fibrosa* for posts and heavy grazing. Occurs only in the Marlborough Plains province and the north of the Mount Morgan Ranges province on alluvial plains and drainage lines from serpentinite hills.

Estimated extent: naturally restricted type

Conservation status: Not of concern (still to be confirmed)

Regional ecosystem 11.11.21 (was 11.11.7x2 **Author:**Tim Ryan)

Supplementary description:
Forster and Barton (1995) Marlborough
Brigalow Belt uveg: 229

Description: Semi-deciduous vine thicket on Serpentinite hills and mountains. Common species include: *Gyrocarpus americanus, Brachychiton rupestris, Austromyrtus bidwillii, Backhousia spp., Grevillea helmsiae & Acacia fasciculifera.*

Provinces: 12

Protected areas: No representation.

Special ecological values:

Comments: Occurs only in the Marlborough Plains province and the north of the Mount Morgan Ranges province on hills and mountains of serpentinite. Clearing for nickel mining.

Estimated extent: naturally restricted type

Conservation status: Of concern (still to be confirmed)

APPENDIX C

PLATES

Plate 1 ***Pimelea leptospermoides*** **(Vulnerable)**

Plate 2 ***Stackhousia tryonii*** **(Rare)**

Plate 3 **Giant *Callistemon* sp, of Marlborough Creek**