Proceedings of the Seminar and AJ Swaby Address

from the

23rd Biennial Conference and Seminar of the Association of Societies for Growing Australian Plants

Wildflower Society of WA (Inc)
Perth
October 2005

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[2] Edition One was available at the Seminar in October 2005. This edition includes expanded text on two presentations, a paragraph and figure omitted from the first edition and a list of Conference Participants.

This Second Edition of the Proceedings is dedicated to Eileen Croxford who sadly passed away in January 2006, aged 92. Eileen was an original member of the Wildflower Society and ASGAP and founder of the Albany Branch of the Wildflower Society. Eileen attended the 2005 Seminar and Conference receiving an Australian Plants Award.

Cover photos: Perth City Bushland - Talbot Road Reserve and Blue Leschenaultia (*Lechenaultia biloba*). A bushland area in the Foothills area of the Swan Coastal Plain.
Photograph: Bronwen Keighery

WILDFLOWERS OF WA: LANDSCAPES, COMMUNITIES & PLANTS

Monday October 3rd 2005

AJ SWABY PUBLIC LECTURE

Monday Evening October 3rd 2005

WILDFLOWER BIODIVERSITY IN THE CITY OF PERTH

Wednesday 5th October 2005

SEMINAR PAPERS

PEOPLE KNOWING, GROWING AND PROTECTING WILDFLOWERS

Wednesday 5th October 2005

SEMINAR PAPERS

WILDFLOWER DISCOVERY IN THE WILD, LABORATORY AND GARDEN

Friday October 7th 2005

SEMINAR PAPERS

365 MILLION YEARS OF PLANT EVOLUTION IN WESTERN AUSTRALIA

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INTRODUCTION

The fossil record of the early period in the history of vascular plants in Western Australia is very poor. But from late Palaeozoic times (about 290 million years ago) to the present day, the fossil plant record, although intermittent, is relatively abundant, and provides us with an insight into the early diversification of the Western Australian flora. The changing pattern of the fossil floras in Western Australia is a legacy of both their evolutionary history and of the changing environments in which they grew. As the Earth's climate warmed from the 'icehouse' conditions of Late Carboniferous and Early Permian times, 290 million years ago, to the hot 'greenhouse' world of Cretaceous times, 130 to 65 million years ago, Gondwana progressively split apart. After Australia separated from Antarctica, about 35 million years ago, and began to move north, the Earth gradually began to cool into another icehouse phase. The cooling of Australia was, in part, offset by the continent's northern journey into warmer, equatorial waters. These long-term climatic changes had profound effects on the nature of the state's vegetation. Much of the unravelling of the story of Western Australia's changing vegetation history can be gleaned from the changing nature of the fossil plants. However, the story is very incomplete, because relatively few fossil deposits are known and few floras have been formally described. Despite this it is still possible to provide a broad overview of the changing nature of Western Australian floras over the last 365 million years.

EARLY FLORAS

The oldest fossil plants known from Western Australia come from the 365 million-year-old (Late Devonian) Knobby Sandstone, in the Canning Basin. Here a single species of the lycopod *Leptophloeum australe* occurs. Lycopods (clubmosses) at this time were tree-sized, with an unbranched trunk that forked many times into a spreading crown far above the ground. The larger branches and trunks had a very characteristic pattern of diamond-shaped scars left by detachment of the leaves. Western Australia's fossil plant record during the following Carboniferous Period is very poor. Stems of the lycopod *Protolepidodendron* have been found in the Canning Basin (McLoughlin and McNamara 2001). Late Carboniferous strata in the Kennedy Range contain impressions of another lepidodendroid called *Lycopodiopsis*. However, the much colder conditions at the end of the Carboniferous Period saw the end of the lycopod forests that had been so dominant during the preceding 70 million years.

PERMIAN FLORAS

As the ice sheets that had covered much of Australia began to shrink in Early Permian times, between 290 and 270 million years ago, huge forests formed across Gondwana, dominated by the deciduous gymnosperm *Glossopteris.* Fossil deposits of Permian age found in the coal-bearing rocks of the Collie Basin, and the northern Perth Basin, are dominated by a number of species of spatula-shaped, net-veined leaves of *Glossopteris* and the closely related *Gangamopteris* (Rigby 1966). These plants mainly colonised vast lowland swamps after the retreat of the Early Permian ice-sheets. Glossopterid plants were woody trees up to 30 m high. The other main type of leaf found at Collie is the conifer-like *Noeggerathiopsis*. Whereas glossopterids were the dominant plants in the extensive low-diversity swamp forests of Gondwana, *Noeggerathiopsis* may have preferred better-drained habitats as its leaves are most commonly found in alluvial fan deposits and along the margins of sedimentary basins.

Unlike Collie, ferns are fairly common in the Irwin River Coal Measures but are still of low diversity. Sphenophytes are more common (McLoughlin 1992). Their delicate, slender-stemmed nature suggests that they were either of scrambling habit, living, perhaps, in the understorey of the glossopterid woodlands, or low, samphire-like herbs in more exposed delta flats. Small lycophytes such as *Cyclodendron* are preserved alongside the sphenophytes and were also understorey or herbfield plants of moist sites.

TRIASSIC AND JURASSIC FLORAS

Triassic and Jurassic floras are not common in Western Australia. In the Canning Basin some Triassic units have yielded conifers, seed-ferns, ginkgoaleans, cycadophytes (zamias) and equisetaleans (horsetails) (Retallack 1995). Jurassic fossil wood is known from the Mount Lesueur area near Jurien Bay, and a few deposits with Jurassic plant impressions are known from the Mingenew district in the Perth Basin. These floras consist mainly of araucariacean or cheirolepidacean conifers, cycad-like bennettitaleans and other seed ferns.

CRETACEOUS FLORAS

Plant fossils of Cretaceous age are known to occur within the Perth, Carnarvon, Canning and Officer Basins. In the Perth Basin Early Cretaceous plant fossils occur at Gingin and Bullsbrook. The Cretaceous rocks of the Carnarvon Basin were mostly deposited in marine environments. An exception is a recently discovered rich Early Cretaceous deposit near Kalbarri. The flora shows many similarities to the Broome Sandstone flora. Within these floras lycophytes were relatively common. Ferns are represented by *Hausmannia*, a broad-leafed fern, an ancient representative of the fern family Dipteridaceae. Other ferns include osmundaceans and the *Gleichenia*-like *Microphyllopteris* (McLoughlin 1996).

A common element of these floras are seed-ferns (pteridosperms), an extinct group of plants with foliage similar to true ferns, but differing in that they reproduced by seeds instead of spores. Amongst them are the Bennettitales, which had cycad-like fronds, but whose precise affinities are uncertain. Recent studies suggest that they may be a sister-group to the flowering plants. Leaves of bennettitaleans are some of the most common plant fossils found in Western Australian Early Cretaceous rocks.

Araucarian conifers were more widespread in the past and three forms occur in the Western Australian Cretaceous deposits. Seed scales are particularly common in the Kalbarri deposit. The Podocarpaceae are abundant in the fossil record and in the Cretaceous of Western Australia are represented by *Elatocladus ginginensis*. Although the fossil pollen record shows that flowering plants first appeared in many parts of the world during the Early Cretaceous, no angiosperm macrofossils of this age have been found in Western Australia.

CENOZOIC FLORAS

Relatively rich early Cenozoic floras about 40 million years old occur in Western Australia and indicate the presence of cool-temperate rainforests in the south-western part of the State. As the continent began to cool and dry out from about 30 million years ago, the nature of the vegetation changed.Those plants better adapted to cope with drier conditions survived, at the expense of those more adapted to wetter conditions. The most significant floras are those of the Merlinleigh and Kojonup Sandstones, and the West Dale and Tambellup Floras.

Merlinleigh Sandstone Flora

This Middle Eocene beach deposit from the Kennedy Range in the Carnarvon Basin contains the oldest known *Banksia*, an infructescence called *Banksia archaeocarpa* (McNamara and Scott 1983). This is very similar to some living forms, especially *Banksia attenuata*. A number of araucariacean cones and possible scaly twigs also occur in these sandstones.

Kojonup Sandstone Flora

Scattered intermittently along the Darling Range at Calingiri, Walebing, Northcliffe and around Kojonup, are strongly silicified sandstones about 40 million years old with abundant plant impressions. The Proteaceae is particularly well-represented, with many *Banksia*- and *Dryandra*-like leaves similar to living species. Other leaves are reminiscent of *Grevillea*. The Nothofagaceae

(Southern Beeches) are represented by a single, but abundant, species. The Casuarinaceae (Sheoaks) include forms attributable to *Gymnostoma*, a genus now restricted to the tropical western Pacific and Daintree rainforests. Several leaf types and fruits probably belong to the Myrtaceae. Other dicotyledonous angiosperm leaves are more difficult to identify. They may include representatives of the Cunoniaceae, Lauraceae, Sapindaceae, Apocynaceae (Oleanders), Sterculiaceae (Kurrajongs), Elaeocarpaceae, Euphorbiaceae (Spurges) and Leguminosae (McLoughlin and McNamara 2001). Monocotyledonous leaves are very rare, but one is similar to some modern palm species. Although the conifer family Araucariaceae no longer occurs naturally in Western Australia, the Kojonup assemblages show that they were present here in early Cenozoic times, including forms close to *Agathis* (Kauri Pines). Other common conifers include the podocarps.

West Dale Flora

The most diverse and best preserved fossil leaves occur in Eocene-Oligocene fine siltstones at West Dale, near Beverley, from where 35 different types have been described (Hill and Merrifield 1993). The flora is characterised by a broad-leaved rainforest component, including *Nothofagus tasmanica*, *Callicoma* and *Alloxylon*-like forms, *Laurophyllum striatum* and possibly *Stenocarpus*. A number of unidentified angiosperm leaves have well-developed drip tips, characteristic of rainforest leaves. The flora also contains one species of fern, four conifer species, and species of Casuarinaceae, Cunoniaceae, Nothofagaceae, Lauraceae, Myrtaceae and Proteaceae. As well as rainforest elements, there are some leaves that appear to be more adapted to drier conditions, mainly members of the Myrtaceae and Proteaceae.

Tambellup Flora

Deposits near Tambellup have yielded a flora rich in impressions of sword-shaped myrtaceous leaves. Fossils in common between Tambellup and West Dale include *Rhodomyrtus*-like forms, lauraceous leaves, *Agathis* and *Nothofagus*. The Tambellup flora may represent a slightly younger (Oligocene) assemblage deposited as the climate became drier and more seasonal.

CONCLUSION

The limited number of late Cenozoic and Quaternary floras support the idea of increasing aridity, with replacement of rainforest taxa by more drought-resistant plant communities over much of the State. It may well be that the lack of good plant fossil deposits from this interval is due to the drier conditions and lack of suitable sites for long-term preservation of plant remains. Climate fluctuations between Pleistocene glacial and interglacial periods probably affected the distribution of the different vegetation types in the State, but little work has been carried out to substantiate this (McLoughlin and McNamara 2001).

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FROM THE BEGINNING, TO LANDSCAPE, VEGETATION AND SPECIATION - OUR CONTEMPORARY FLORA

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INTRODUCTION

It is thought that our universe formed 4.6 billion yrs ago. In relation to that event, people in Australia live in a very ancient land. The oldest known fragments of the earth's original crust can be seen in WA, in the zircon crystals preserved when magma solidified into granite 4.4 billion yrs ago (Hopper 1996 p5). Indeed WA's landscape is a storehouse of evolutionary data. A few examples are outlined below.

- The earliest evidence of life on earth, dated +/-3.8 bill yrs bn was discovered only a few yrs ago at North Pole in the Pilbara, by a North American palaeontologist, in the form of single celled cyanobacteria, present in fossilized stromatolites. These are the organisms within which photosynthesis first evolved, using their chlorophyll to capture energy from the sun in order to manufacture carbohydrates (food) and, (as an incidental, so to speak) in the process; producing oxygen as a waste product. This was the turning point for our world; as over time, the product of this process was an atmosphere suitable for us to live in; and as well, it turned the sky blue. These fossils indicate that life has existed on earth (right here in early WA) for +/-5/6ths of this planet's history
- 3.28 billion years ago, our Yilgarn plateau formed. This is currently about 900 kilometres long and 700 kilometres wide, constituting much of the southern half of this State. It is of interest that it was not affected (as was south-eastern Australia) by the recent ice ages.
- 2.5 billion years ago Wave Rock was formed. All this took place before Pangea began to break up about 92 billion yrs ago, into the two super-continents of Laurasia (N) and Gondwana (S). From 1,115 - 750 million years ago glaciation eroded down the original mountainous surface of WA.
- 420 million years ago first land plants in the form of mosses evolved from marine algae. These developed rudimentary roots and with the assistance (as early on as that), of mychorrhizal fungi as symbionts, (enhancing their water-uptake and nutrient acquisition) moved onshore and lichens formed on rocks. Animals by that time had also moved from the sea to land; -cf the fish fossils at Canowndra (estimated 350->400 mill yrs of age), which show their pectoral fins developing into rudimentary upper limbs (with one upper, and two lower-arm bones). Subsequently certain mosses began to creep, becoming the ancestors of ferns. 410 m yrs ago, Australia's first vascular plants evolved.
- 330-250 years ago there was glaciation, and cycads developed. (WA still has 7 different species – 4 of the genus Cycas in the north and 3 of Macrozamia in the south –relics of that much earlier vegetation.). 200 million years ago glaciers melted, conifers appeared, then angiosperms and dinosaurs dominated the earthly scene.
- 110 million years ago Tibet fractured off from the Darling Scarp as India broke away from southwest Australia, which was still part of Gondwana. Then about 100 mill yrs ago South Western WA separated from Antarctica. At that time Australia was covered by rainforests, as there was a warm, moisture-laden airstream, blowing onto the land from the Sea. Plants belonging to the ancient Southern families of Proteaceae & Myrtaceae were by then, well established. 80 million years ago Africa separated from Gondwana – Myrtaceae dominated our flora, and eucalypts evolved.

- Between 65 & 40 million years ago Eastern Aust gradually rifted from Antarctica, this caused the establishment of a cold circum-Antarctic current, which resulted in the freezing of Antarctica and initiated the aridification of Australia. Schleromorphy developed, at least 50 million years ago. By then *Banksia*, *Agonis* and *Acacia* had evolved, also the antecedents of *Anigozanthos*; our unique Kangaroo Paws. As early as this, plants were adapting to the old, nutrient poor soils by developing underground food storage organs, tough leaves and woody fruits with concentrated nutrients in their seeds. Due to low rainfall and lack of adequate drainage in this ancient worn down landscape, salt was already beginning to accumulate in the soil. But evolution went on. Everlastings appeared, flourished and diversified, various grasses grew. There were reptiles and frogs, and Australia was slowly drifting N. Fossil floras indicate that WA heathland plants have been in existence for > 40 m yrs.
- 30 million years ago the Nullarbor Plain was formed, acting from then on as a barrier to plant migration across the continent. The Swan Coastal Plain developed. 25 million yrs ago the climate changed, to become even dryer, from thence Australia's drought-resistant species, because of their adaptation to aridity, began to dominate.

LANDSCAPE

Landscape results from the physiognomy of the land together with the vegetation that clothes it; the current appearance of which relates to its history of evolution modified by successions of prevailing conditions. The original matrix of this continent has existed, almost since the beginning of our universe; riding aboard it's stable tectonic plate, without submergence or disruption.

VEGETATION

Vegetation presents the outward expression of the matrix it grows upon, affected by the reigning climate. It provides us as humans with the aesthetic experience of visual introduction to our environment, logically leading us, because of the nature of humans, to provender, relaxation and 'play potential'. The functional role of plants is to hold the soil together, to replenish the air with oxygen, to take out noxious gases and to feed the inhabitants of the earth. They are our ultimate source of energy. In diversity there is strength, resilience and our security. Vegetation is the most variable, exciting, challenging and frustrating element of our relationship with the land.

WA, separated by vast oceans from other continents and by long existing deserts from the rest of Australia, has continued to exist as a stable, ancient microcosm with inherited, extant pre-historic species of fungi, plants and animals helping to sustain one another in interwoven relationships; co-evolving to suit new conditions as they have occurred over a longer period of time than has happened to any other place in the world. The vegetation just pursuing its own evolutionary trends and distinctive ecological adaptations, within the intricate diversity of microhabitats created by WA's old, worn down landforms, and adapting to subsist in its ever increasingly nutrient-depleted soils. Plants mostly still living in mycorrhizal associations with specific fungi which provide for them otherwise scarce (or locked up) nutrients; in exchange for energy-containing manufactured food; both partners benefiting from the cooperative association. The summation of these factors has resulted in the diversity of plant communities and flora that exist in WA today.

How the landscape presents: i.e. what its appearance is to us; depends upon space, light, earth-form, water and vegetation. -The amount of natural vegetation existing in any one place relates primarily to water availability, topography and soil.

Observed plant life to the uninitiated can, to begin with, present a complex, bewildering and almost inexplicable presentation of life forms, apparently strewn across the landscape (in Australia, because of our long and complex evolution, this is accentuated). In general parlance our surrounds are regarded as "grey disorderly bush" or "dull monotonous scrub". Sought after scenic beauty is to a large degree dependent on massed seasonal flowering of ephemerals (chiefly Everlastings) or produced by the forms of trees (mostly eucalypts) against various landform backgrounds. This latter is regarded as representing the character of Australia.

Plants cover the face of most of Australia, even its deserts (unlike many another arid area in similar latitudes). The reason is, that Australia has clever plants, adapted in intricate ways to all sorts of adversities (& thereto a saga of anatomical & biochemical secrets, only beginning to be unravelled by our scientists).

VEGETATION COMMUNITIES

These range from tall forests in high rainfall areas, dominated by *Eucalyptus* trees to almost 100 metres tin height, with diverse under-stories; through to a great variety of low arid shrub lands, also with diverse under-story plants and seasonal displays (including large areas of *Spinifex*, which acts like a shrub). A few features of these communities are highlighted below.

- *Eucalyptus* forests and woodlands, especially Marri (*Eucalyptus calophylla*) in association with other 'Gums', originally covered a large area of this state. Von Mueller records vast Marri forests with trees, 10' in diameter. (These forests were mapped by Malcolm Frazer in1882) but they have been successively cleared for farmland and other purposes.
- And then there's the Quongan; an amazingly bio-diverse shrub-land, richer in plant species than rainforest, with in places more than 1sp/m2.
- Desert vegetation covers 2/3 of this state, much of this is *Spinifex* Grassland, with a wide diversity of scattered, small woody shrubs; sporadic larger shrubs and small trees, which are dominated by acacias, in particular Mulga; with residual, taller (often phreatophytic) eucalypts along drainage lines, and a great and often flamboyant display of ephemerals in season. These are escapists, making the most of rain opportunities then hibernating as seeds through the dry.
- There is also dry mallee country and even dwarf eucalypt forests and woodlands in the less than 300mm rainfall zone (desert), each with rich shrub under-stories.
- To me perhaps the most distinctive feature about WA's vegetation is this preponderance and diversity of woody shrub under-story plants, which is in great contrast to much of the rest of the world. For eg. go to a Northern Hemisphere forest. What are you likely to see? A monoculture over-story of, for instance pines, firs or larches with mosses and a few other herbaceous plants beneath. Most Eucalypts (our dominant trees) are designed with pendent isobilateral leaves that allow dappled sunlight to penetrate their canopy. This shelters and protects the plants that grow beneath them. In addition, it has recently been elucidated that a number of our phreatophytic trees actually act as hydro-lifting irrigators; obtaining water from the deep-down water-table, and distributing it through superficial feeder root systems, thus watering the under-story!

FLORA

Our vegetation is made up of an array of associated plant species. *Eucalyptus* and *Acacia* are the most widespread genera in our flora, as well as having the greatest no of constituent species and, in addition, often being the dominant entities.

In order to get any sort of a handle on the composition, functioning and diversity of our vegetation communities, their species make-up needs to be identified and understood. Taxonomy is a tool we cannot do without. Unless a thing has an accepted name you can't pigeonhole information about it.

A few features of WA's flora are highlighted below.

- WA has one of the world's richest temperate floras, this particularly applies to the area of the SW of the state between Shark Bay and Israelite Bay. Of the 8,000 spp so far recorded for this area, as many as 6,000 ie.75% are endemic, i.e. they grow nowhere else in the world; and about 70 new spp p/a are still being discovered. That amounts to >1/wk.
- WA has never had a state flora but an initial step towards this was taken by W.S.W.A in partnership with the Botanic Garden and King's Park and the Herbarium of WA, when they published The Western Australian Flora Catalogue, in January 2002, which lists and describes

the whole of the identified flora of the state, as known at that time, amounting to almost 12,000 taxa. The diversity that has evolved is awesome.

- Wildflowers are acknowledged by the Tourist Bureau as the No1 attractor of visitors to this state. This unique flora provides people from all around the world with much interest and pleasure, and those involved in its scientific elucidation, with many challenges.
- The classification of the landscape, vegetation, and flora of this state has been tackled. That is most necessary and ongoing, but it is still only the tip of the iceberg.
- We need to ID, then get to know, as well as to unravel 'how to grow'.
- Horticultural application to this treasure-house, will no doubt lead to the future international eminence of genera as sought after for gardens and for floristry, as Roses, Chrysanthemums and Carnations.
- We have not yet developed **an urban, designed landscape character** to give our habitations a Western Australian identity, nor have more that a few tapped the **spiritual significance of this land.**
- -Some have become aware that the country was special: eg. **Governor Wells** touring the colony from the Murchison to Albany in the 1870's remarked "the whole country may be described as one vast forest, with flowering plants in infinite variety and exquisite beauty."
- -It's intriguing to me that DH Lawrence even as a transient visitor recognised (if uneasily) the dream quality of the land, which he likened to a 4th dimension, whereas most white people living here haven't make the connection and are still dissociated from its spirit. DH **Lawrence and** M.L **Skinner** (in the *Boy in the Bush)* in 1924 wrote:
  "It was spring in WA, a wonder of frail unearthly beauty...beautiful uncanny flowers.... **Sombre** the bush was itself, but out of the **heavy dullness** came sharp scarlet, flame spark flowers and flowers as **lambast** as gold at sunset, as won as white flowers -and flowers of a strange darkish blue, like the vault of heaven just after sundown.... here and there a perfect wattle with its pale gold flowers like little balls of sun-dust."
- -Likewise **Irene Cunningham** (in *Land of Flowers*) observes of the land,
  "there were birds, insects, trees, mammals, invertebrates, frogs, reptiles, fungi, shrubs, vegetables, herbs, water even an occasional human, but most of all there was a flower garden. Hundreds of annuals, perennials, blossoming shrubs and trees thrived in a glorious unscripted accord. Pictures and words so no justice to them. Their reality is not captured or reproduced. An everlasting *Helipterum manglesii* in nature is a pink of such ripeness, **the breath stops**. And yet there is no excess. In nature everlastings tremble and toss as if they have feelings, uneven in shape and size, they cross ;in a disorderly joyous celebration. The scent is so unique and subtle, erotic and sublime, it might be like breathing in 'the idea', the imagination - the vision God had when he said "Let there be flowers."
  The Kangaroo Paw gives rise to a similar description: the most amazing of flowers, brightest red and brightest green, velvety as fur, soft green curling claws for stamens, just the right shape for tiny honeyeaters to sip nectar; brushing their heads with pollen to carry to the next flower.

WA WAS A GIFT TO WHITE MAN

WA was a gift to white man which he had no idea what to do with, magnificent climate, plentiful rainfall and productive soil; capable of supporting a large population. These characteristics were due to the forest then existing over the land, that engendered the climate and rain, kept the salt down and provided habitat that nitrogenised the soil. Flowing rivers that drained away the water from salt country and flowed the year round with fresh water. Land that produced bounteous food. But sad to say, so called "worthless *Banksia* scrub" was cleared and burned – converted to single crop farms that needed massive quantities of superphosphate before the land would grow foreign annual cereal crops, then needed to be drowned in insecticide and weedkillers to eliminate the explosion of insects and weeds resulting from monoculture practises – leaving no diversity to sustain natural predators.

A few features of this gift are highlighted below.

- Horticulturaly WA has a tremendous variety of outstanding assets to offer. All the Aboriginal food plants. Including at least 120 different root vegetables, adapted to the environment, nutritionally healthy and not needing to be produced as monocultures.

- WA's garden of adapted species presents a land of plenty and it is interesting to note, from a health point of view; that at the time of settlement the average life expectancy of an Englishman was 50 years whilst that of a Noongar was 70 years. Bishop Salvado & George Grey and Edward Curr in Australian Race (1880) reported that more Noongars than English lived to the age of 90.
- Botanist James Drummond reported in the Inquirer 24 August 1842,
  "From one or other of the roots, natives can at any place and time procure a meal of nutritious food with very little trouble."
  Few people today know about the diversity of this provender or the plant communities within which they exist.
- Australia's past is alive in the present and nowhere better represented than in WA. The oldest soils, the earliest plants and the people who first saw, worshiped, knew and used them. – "Balka" – *Xanthorrhoea*; "Djiriji"- *Macrozamia* and "Moodja" - *Nuytsia*. 12,000 different taxa we know, but Aboriginal people subdivided them further, according to varietal uses and other idiosyncrasities. Biodiversity -earth's various combinations, necessary for survival (theirs and ours), which has only recently been discovered by western scientists, was an essential part of Aboriginal knowledge and law; learned from birth.
- Noongars depended on plants for food, medicines, tools and personal affects, including adornment for ceremonial occasions. Land depended on plants to keep it stable and alive. Water depended on plants to keep it fresh. (Early European reports make it clear that the Noongar law protected the plants and the water, upon which all living creatures depend. The laws were recited around the fires at night and reiterated by daily actions).
- Just in the Perth area indigenous products included over 100 different vegetables (more nutritious and higher in protein than wheat), leguminous, nitrogenising Wattles for gum and their seeds for flour; "zamias", who's cycad arrowroot keeps for 10 yrs, unlike wheat flour; *Xanthorrhoe*a, with stems as delicious as artichokes, high in minerals and full of natural sugars; bardies – better than bacon, and kangaroos with tender low-fat protein. Noongars had a daily choice of numerous fowl, and various sized eggs. If white man had been persuaded to grow the indigenous food plants, that evolved to sustain, rather than deplete the soil and fresh water; Western Australia would still be a paradise (Cunningham - Land of Flowers)
- -Australian Aborigines cultivated and promulgated knowledge of the flora long before Europeans gained any such experience. Harvesting geophytes with skill so as to, in situ, promote and multiply growth for the following seasons. Carrying and scattering seeds of favoured plants, be it for culinary use or for ceremonial body decoration. It has been recorded in encyclopaedias that the Romans and the Greeks were the originators of this tradition 2-3,000 years ago but cultural records of such Aboriginal traditions go back 10 times this span!

CONCLUDING THOUGHTS

This land tells the story of its ancient lineage but we as newcomers have been slow to pick up these various vibrations and indicators - or even to learn from its original inhabitants about this wealth. It also tells the story of our occupation.

- -Our rural landscapes are wind eroded, weed infested monocultures, almost devoid of original vegetation and Australian character.
- -Our urban landscapes are currently a conglomeration of people's stories, a kind of collection of nostalgic, often poorly designed and not designed physical diaries or cultural profile of urban Australia; mostly emulating other formats and other places – copying stereotype designs and using other plants, water and fertiliser regimes.
- -We need to get to know and understand the horticultural potential of our own plants and to generate an **Australian Genre in Landscape Design**.

There is a way to the future, which can be taught by the past. It is just waiting to be tapped and interpreted, just by judicious selection from what nature has provided - with lower water and nutrient requirements, plants that are already adapted to the very sites that are being developed.

This approach has unrealised potential. Urban Landscape Design could and should be the transcendent expression in symbol and imagery of **where we want to live**, as well as the means of **creating character and giving that place individual identity.**

There is a vast international visual landscape language, similar in power to the abstractive emotion transmitted by music. **To transform and uplift our urban environment, we need to tune in, to understand the potential of our inheritance and learn to practise the poetics of the Art of our Indigenous Landscape.**

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SANDPLAIN COUNTRY OF SOUTHWESTERN AUSTRALIA

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INTRODUCTION

Vast areas of deep sands occur in the coastal areas of southwestern Australia. They stretch south from Kalbarri and west from Esperance. Sandplain patches occur up to 300 km inland. The sandplains are characteristic of the Mediterranean region with its long hot summer droughts and mild wet winters. The landforms are undulating dunes rising little more than 5 m above the flat swales, sometimes interspersed with prominent uplands of laterite, quartzite, metaschists or granite. The soils are nutrient-impoverished from millions of years of leaching without landscape rejuvenation. The vegetation is exceptionally species-rich low heath to scrub/mallee-heath, up to 2 m tall, in the so-called northern and southern sandplain country. This vegetation-type has been given the aboriginal term kwongan, though it has not been widely adopted, with heathlands or, more popularly, 'wildflower country', generally used. The scrub-heath rises to woodland (4 m) with a heathy understorey in the Perth Coastal Plain with higher winter rainfall than the northern and southern sections. Freshwater lakes are dotted through the area and it is traversed by a few rivers, such as the Moore and Kalgan, that only flow in winter-spring. Much of the area has been cleared for farming, despite the poor soils, and lesser extent housing people and infrastructure support. Dryland salinity is not a problem here.

FLORA

This is the heart of the high species diversity of southwestern Australia: although the sandplains cover only 10% of its area they account for over 4,000 (50%) of its plant species. The SouthWest in turn covers 5% of Australia yet accounts for 30% of its species. The major plant families in Australia reach their peak representation in the sandplain country. These include the woody Myrtaceae, especially *Melaleuca*, Proteaceae, especially *Grevillea*, *Banksia* and *Hakea*, the legumes, especially *Daviesia* and *Acacia*, and Ericaceae, especially *Leucopogon*. Mallee eucalypts are widespread especially in the southern sandplains. The grass-like Cyperaceae and Restionaceae are prominent though true grasses, Poaceae, are not. Creeping undershrubs, such as *Dampiera* (Goodeniaceae), are also conspicuous. Small herbs, such as *Stylidium*, and geophytes, such as the carnivorous droseras, are nowhere better represented. Annuals, essentially Asteraceae, are difficult to find except after fire. Most notable is the grass, *Austrostipa compressa*, that may form a sward in the first year after fire and is virtually absent by the next. Herbaceous weeds, especially from South Africa and the Mediterranean, have spread throughout the metropolitan and farming areas, though reserves and unassigned lands remain weed free.

While species richness is exceptional at the broad scale, it is also exceptional at the fine scale. Despite the fact that 95% of the species in a stand of vegetation are evergreen perennials, our work shows that every square metre of the interdunal low heaths typically contains 14 adult evergreen plants and these belong to 11 species (highest values were 37 plants and 21 species), so that an area of just 30 x 30 square metres contains 13,000 plants and 105 species (Table 1). Of course in taller vegetation the numbers reduce accordingly. Thus the high density of plants can be attributed to their small size but also their low projective cover (few leaves (or none) and these leaves are small or vertically oriented) such that their crowns readily overlap and plants can grow under each other.

Table 1. Plant diversity of four sandplain communities showing exceptionally high packing of plants and species per unit area. (B. Lamont, N. Enright, B. Miller, unpublished data from an ongoing major project on the sandplain flora supported by the Australian Research Council, CALM and Iluka Resources)

Sandplain community	Plants in any 1 m^2	Species in any 1 m^2	Plants in 30×30 m^2	Species in 30×30 m^2
Dune crest	7	6	6000	86
Sand over limestone	7	5	7000	56
Interdunal lowland	14	11	13000	105
Laterite upland	15	10	13000	115

Patch effects, where some species grow preferentially in association with others, is more likely in scrub-heath, where larger species, like *Eucalyptus todtiana*, favour the presence of smaller species, like *Lomandra hastilis*. Where all these species come from in the first place is a question whose answer requires a lot of insight into the factors promoting the evolution of this flora (Lamont et al. 1984, Hopper and Gioia 2004).

FIRE

The sandplain country is highly flammable in the dry season. Evidence from grasstrees (*Xanthorrhoea*) indicates that fires have been decreasing in frequency over the last 150 years, from every 4-5 years to 10-20 years at present (Lamont et al. 2004). All species have some features that enable them to survive recurrent fire. Of particular interest are the resprouters that comprise 60-90% of local floras. These may resprout from dormant buds on the stem (epicormic) but more notably from the swollen rootstock (lignotuber) or creeping underground stems (rhizomes). The exception are the grasstrees, *Xanthorrhoea* and *Kingia*, whose terminal bud is insulated from fire heat by the mantle of leaves wrapped around the apex: these just keep growing, at an accelerated rate, after fire (Lamont et al. 2004). With their slow generation times, 300-500 years or more, and low seed production, it is surprising that speciation of resprouters has kept pace with nonsprouters (new generation every time there is a fire, high seed output) in the sandplain country. I have recently suggested that a clue may lie in the greater likelihood of mutations occurring in old plants that not only causes the low seed set in the first place, but may sometimes lead to genetically distinct offspring (Lamont and Wiens 2003).

Another special feature of this flora is the fact that the most prominent species store their seeds on the plant rather than release them at maturity, called serotiny. The seeds are retained in woody fruits, such as *Xylomelum*, or cones, such as *Allocasuarina*. The heat of fire melts the resin holding the fruits closed or kills the stems supporting the fruits or cones so that they dry and open. Seeds are released soon after and are blown about til they lodge in depressions or against obstacles. Seeds that remain exposed die from summer heat or are consumed by birds. Of conservation concern is the recent invasion of galahs to parts of the sandplain country – flocks move systematically over the ground and scrounge for seeds: now few seedlings from serotinous species establish after fire so that the character of the vegetation will change favouring resprouters and species with soil-stored seeds. Since it is often easy to identify annual growth increments on the stems of these plants, it is possible to determine the age of seeds as well. This enables a picture of seed accumulation to be built up. Coupled with data on seedling establishment and survival over time it is possible to predict the outcomes of fire at various intervals.

Our work shows that populations of fire-killed banksias will decline if intense fires occur at intervals less than 10 years, or there are no fires within the life expectancy of the plants, perhaps 40 years (fires occur so frequently here that we have not been able to locate stands as old as this to confirm). Of course, as fires become more frequent so they become patchier. This means that some plants will escape burning and release their increased load of seeds in a subsequent fire so that the species does not become locally extinct. This would be helped if the seeds could reach areas where short-interval fire had eliminated the species. We examined this recently on *Banksia hookeriana*, probably the most intensely studied wildflower species in Australia. Seeds blew up to 35 m away from their parents. We then examined the genetic make-up of 20 isolated but adjacent populations and found that the plants in 7% of cases had arisen from seeds belonging to parents up to 2-3 km away (He et al. 2003). Coupled with patchiness and long-distance dispersal such as this we now have an explanation as to how species have survived fires as short as 2-3 year intervals during Aboriginal management of the landscape (Ward et al. 2001). But how can the seeds disperse so far after a single fire? Two ways have occurred to us: willy-willies and cockatoos. Certainly carnaby's cockatoo can carry pinecones for a km or more, and we are studying the possible role of wind vortices at present.

GROWTH

Seedlings survive the first summer drought by possessing narrow, drought-resistant leaves, or large cotyledons (embryonic leaves) packed with mineral nutrients that promote rapid elongation of the taproot that may reach 2 m by the start of summer thus maintaining contact with soil water. In contrast the shoots may only be 15 cm tall. It is not til the next wet season that laterals develop and the seedling starts to use soil nutrients, a remarkable adaptation to nutrient-impoverished, drought-prone soils. Tiny herbaceous plants, like the geophyte *Drosera erythrorhiza* and annuals, grow first then flower and die down by the end of winter. Vegetative growth of woody adults however starts after flowering has finished. Both are dependent on access to soil water. Thus, small shrubs flower and grow in winter-early spring, medium shrubs in spring-early summer, and tall shrubs-trees through summer-autumn. *Xanthorrhoea* is unusual in that it never stops growing (Lamont et al. 2004).

Roots grow in the wet season. Root growth in the surface humus layer is early and prolific. The Proteaceae and some legumes develop hairy root clusters (proteoid roots) that adhere to the decomposing litter, a major source of nutrients in these old soils (Lamont 2003). Much is now known about how these surface roots enhance uptake of phosphates and other poorly soluble nutrients from soil particles. As a result an estimated 80% of the root system is in the upper 10 cm of soil. Many other species, notably in the Myrtaceae, legumes and *Hibbertia*, have fungal threads attached to their rootlets (mycorrhizas) that promote nutrient uptake, especially phosphates again. Legumes convert gaseous nitrogen in the soil via their bacterial-inhabited root nodules. It is the deep roots, tap and sinkers that arise from the laterals, that maintain water uptake through summer while the surface root system is dormant.

FLOWERS

Spring (September-November) flowering of the sandplain country is what the ecotourists flock to see. While it is true that flowering does peak in spring, displays of flowers can be observed throughout the year. Had tourists come to Perth in July 2005 for example they would have witnessed wonderful displays of winter wildflowers, especially in recently burned areas, and only had to contend with 68 mm of rain. I am told that the main reason the tourist season stops in November is the advent of flies, surely a national disgrace? This means they miss seeing the remarkable root parasitic tree, *Nuytsia floribunda*, in flower. *Nuytsia* is one of many species here whose flowering is promoted by fire. One of the most notable is *Xanthorrhoea* that flowers in spring, independent of when burnt and whose 1-3 m long spikes elongate at up to 10 cm per day before they reach maturity (Lamont et al. 2004). The kangaroo paws (*Anigozanthos*, *Macropidia*) and other Haemodoraceae too flower best the year after fire.

Visitors comment on the abundance of blue flowers in the flora – dampieras, *Lechenaultia biloba*, *Trachymene caerulea*, *Hakea lehmanniana*... These certainly attract insect pollinators that see well in the uv range, but many small-flowered species with other colours (white, pink, yellow, orange, red, green) are also visited by insects. Many species with large red flowers or inflorescences are bird-pollinated, but all the previous colours are equally attractive provided enough nectar is produced to satisfy honeyeaters. In our work on *Hakea* we are showing that a distance of 13 mm between the stigma and nectary distinguishes bird from insect-pollinated species. Also all large red flowers (bird) are high in cyanide while flowers of other colours may or may not contain cyanide. This relationship does not hold for insect-pollinated species. As it turns out, the large red flowers are most accessible to birds generally (*H. francisiana, H. orthorrhyncha*) and I wonder if the high cyanide serves to deter non-pollinating birds (emus, cockatoos) from eating the palatable flowers?

Another outstanding feature of this flora is the abundance of species (eg *Calytrix*, *Verticordia*) whose flowers change from white/cream/yellow to orange/red as they age (Weiss and Lamont 1997). In some species, only part of the flower changes colour (anthers, pollen presenter, base of petals) while in others the whole flower deepens in colour. By retaining spent flowers the attractiveness of the plant is maintained while, once close enough to visit, the pollinators visit only the rewarding flowers. We have shown that if you switch the nectar rewards from the cream to red flowers in *Banksia ilicifolia* honeyeaters quickly learn to switch their preferred colours too. The system applies to both insect and bird-pollinated species. Of course this phenomenon does not hold for mammal-pollinated species as these forage at night. It is in the southwestern sandplains that the only strictly nectar-feeding marsupial has evolved: the honey possum (*Tarsipes rostratus*). Note that this would not have been possible but for the presence of suitable nectar-bearing species in flower throughout the year. The many prostrate (eg 6 species of *Banksia*) and spreading shrubs with dull robust flowers that produce copious nectar on woody stems are ideally suited for pollination by small mammals.

LEAVES

The leaves of most species are exceptionally small – leptophylls, less than 2.5 x 2.5 mm in area. Only banksias and eucalypts (the larger species with a strong root system) are mesophylls. This is coupled with extremely tough leaves (sclerophyllous) often spiny. In fact there can be little doubt that this is the world's harshest Mediterranean-type flora to walk through! This has been attributed to the nutrient-impoverished soils where there is plenty of carbon for cell wall thickening (light does not limit growth) but little protein/ DNA for cell production. However, the northern sandplains have tougher leaves than the southern suggesting that aridity also has a role (Lamont et al. 2002). The thick cuticles and vertical leaf orientation can be viewed as devices to both restrict leaching of precious nutrients as well as water loss via transpiration. It is difficult to view sunken stomates as other than ways to limit water loss. It is noteworthy that the most widespread hakea in the sandplains, *H. trifurcata*, starts the growing season with broad leaves when water and nutrients are readily available. These are replaced by needle leaves that lose far less water per unit leaf weight as the season progresses (Groom et al. 1994).

The leaves of all but the geophytes are remarkably long-lived, with 2-3 years typical. The record is 13 years for *Banksia prostrata*. This is consistent with the large construction costs in producing these leaves and the scarcity of nutrients for new growth. Indeed, most of the nutrients, especially phosphates and nitrogen, are pulled out of the leaves before they die to be recycled for new growth. Many plants actually retain their dead leaves. This increases the combustibility of the plants and might well ensure that what nutrients do remain are released around the plant at the start of postfire growth. The high combustibility of the fine foliage ensures that there is sufficient heat to release serotinous seeds – many banksias and dryandras retain their dead flowers and bracts as well and these serve the same purpose. These canopy-stored seeds are vulnerable to cockatoos because of their high protein content and the woody fruits serve to protect them. Some fruits are thin-walled but camouflaged or hidden from cockatoos. The fruits of *Hakea stenocarpa* look like stems; the leaves of *H. conchifolia* wrap around the fruits. The broad leaves of *H. trifurcata* have an uncanny likeness to its fruits – the leaves appear solid as they wrap back on themselves while the fruits stay green at maturity. Our work with cockatoos at Perth Zoo showed that they quickly removed the fruits when broad leaves were absent but removed the broad leaves when present in preference to the fruits until they learned that the 'fruits' were devoid of edible contents and gave up. Many species have spiny leaves that appear to stop cockatoos and emus from feeding on the nutritious flowers and fruits. They are ineffective at stopping kangaroos as usually thought as they are soft and exposed when young and readily eaten at that stage.

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LATERITES AND BREAKAWAYS

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Laterites form a variety of landscapes form flat plains to steep ridges (breakaways). The plants and plant communities associated with a variety of lateritic landscapes will be the focus of this talk.

SOUTH-WEST WETLANDS – FLORA AND PLANT COMMUNITIES

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Wetlands in the SW of Western Australia are highly variable, displaying a range of morphology, patterns of inundation and water quality. Wetlands can include rivers, estuaries, tidal flats, and lakes, waterlogged soils and even granite rock pools that only hold water for a very short time.

This presentation describes the flora and plant communities of three broad suites of wetlands within the SW, but largely excludes the high rainfall Warren and southern Jarrah Forest Bioregions. Wetland types include freshwater basin wetlands, seasonal clay-based wetlands and naturally saline playas and pans. These are all lentic (non-flowing) waterbodies yet represent a diverse range of wetland habitats.

Freshwater basin wetlands are semi-permanent or seasonal throughout most of the SW. The plant communities of these wetlands vary largely in response to water permanence. Within the high rainfall zone, basins support sedge and rush communities often dominated by *Baumea articulata.* As rainfall declines and inundation is more short-lived basins are vegetated by trees including *Casuarina obesa*, *Melaleuca strobophylla* and *Eucalyptus occidentalis*. The plant communities of these wooded swamps are highly threatened from dryland salinity.

Seasonal clay-based wetlands are typically shallow and contain water for a few months or less. In high rainfall areas they may be part of broad waterlogged and partially inundated flats. Alternatively throughout the SW they may occur as discreet shallow basins. The presence of heavy soils and their shallow nature has meant that these wetlands have been extensively cleared or lost through grazing. Claypans within higher rainfall areas, the Swan Coastal Plain and adjacent plateau are distinct from those of the drier inland. Annual herbs and geophytes dominate the flora in these wetlands, with important genera including *Stylidium*, *Schoenus* and *Drosera.*

The inland of the SW is dominated by an extensive system of paleo-rivers that contain numerous naturally saline wetlands. Braided channels often interconnect these playas and pans, which vary in size from a few hundred square meters to many square kilometers. Chenopod shrublands, principally dominated by *Halosarcia* spp. occupy the margins of these wetlands, giving way to *Melaleuca* and *Acacia* shrublands and *Eucalyptus* Woodlands at higher elevations. These wetlands represent the world centre of diversity for the subfamily Salicornioideae (Chenopodiaceae) and also have a unique annual flora that exploits seasonally 'fresh' habitats at their margins. A group of taxa associated with gypsum deposits are also restricted to these wetland systems.

THE BUSSELTON IRONSTONES

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The Ironstone landform is characterised by skeletal soils over massive ironstone sheet rock. It is believed these predominantly rock landforms have formed in areas of iron rich groundwater seepage, such as bogs. Examples of Ironstone landforms are known to exist in Eneabba, Gingin, Busselton, Scott River and Albany. Each ironstone community is characterized by a different suite of plant taxa.

The Busselton Ironstone is one of the most significant examples of this community. It is restricted to the eastern side of the Swan Coastal Plain at the base of the Whicher scarp, where it is characterised by dense shrubs over Restionaceae sedge species. The community is inundated over the winter months, very dry over summer and has a layer of annual herbs over spring. The Abba plains upon which the ironstones are located have been extensively cleared for agriculture. This has resulted in the Busselton ironstones being 97% cleared of their original extent.

The Busselton Ironstone vegetation community has been recognised as a Critically Endangered Ecological Community, 'Shrublands on southern ironstones'. The community is known from eleven remnants of which up to 20 species can be classed as endemic or predominantly restricted to the ironstone community. Of these 20 species, 16 are ranked as Threatened under the Wildlife Conservation Act.

This presentation will highlight the ironstone vegetation community, the significant species found within it, and the conservation efforts needed to manage such a community.

POSTERS

GROWING AUSTRALIAN PLANTS IN A PUBLIC GREENHOUSE IN SWEDEN

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INTRODUCTION

The Edvard Anderson conservatory in the Bergius Botanic Garden in Stockholm is a large winter garden, open all seasons. Plants from the European Mediterranean area are shown to the public, as well as plants from other areas with a Mediterranean climate, viz. South Africa, California and Australia.

The Conservatory is owned by the Royal Swedish Academy of Sciences, and financed by a donation by the late Mr Edvard Anderson. The opening took place in June 1995.

CLIMATE

The climate of this winter garden is Mediterranean in principle. However, in a glasshouse open to the public, additional facts have to be considered.

It is not desirable to have the hot and very dry summer period characteristic of a Mediterranean climate, as the vegetation will dry out. The visitors expect to see flowering plants all the year round. If the winters are too cool and wet, you are sure to have fungus diseases spreading. It is therefore necessary to keep the climate as dry as possible during that period. The temperature outside may drop as low as -25 °C. That causes a lot of unwanted condensation of water on the inside of the glazing if the humidity is high. Also, the visitors do not like to be cold while they watch the flowers or have a cup of tea or coffee in the glasshouse. But the plants produce more buds and you get a more impressive flowering when the temperature is held low. In order not to get the growth etiolated, it would be best to have that low temperature during daytime. To reach a compromise we keep the temperature at +15 °C during opening hours, and +10 °C the rest of the time.

LIGHT

Plants that naturally grow in full sunshine, here in latitude 59° north, have to adapt to 20 hours of daylight in the summer and as few as 6 hours during the winter months.

The lack of light is a main problem. Though we do have many hours of light in the summer, still the intensity is not enough.

During the winter, the sun hardly rises above the top of the trees, and in midwinter there are only a few hours of daylight.

The artificial light supplied amounts to 5.000 lux at ground level, to be compared to a sunny Mediterranean day of 100.000 lux. The lamps are 400 W, daylight, metal halides.

To add more lighting, is not practicably possible. That many electric fittings shade a considerable percentage of the greenhouse area instead of letting the natural light in, so the cost of installations and electricity will not pay.

SOILS

Beds and soil mixture

The Australian beds are raised, slightly sloped and 1,5 meter deep. The soil consists of 3 parts clay soil, 1 part cow manure, 1 part peat, 1 part sand and 1 part baked clay pebbles. 1 kg dolomite/m^3 was added. The pH value is about 6. Before brought in, the soil was sterilized at +80 °C for 20 minutes.

These ground beds were made 10 years ago, and have not been redone since.

Potting mixture

To get a good drainage, 1 part of commercial soil (90% peat, 5% sand, 5% clay) with a pH of 5,5 – 6,5, is mixed with 1 part of coarse sand and gravel and 1 part of baked clay pebbles in different sizes. This makes a soil mixture that is poor in nutrients. The mixture is watered and then sterilized in a microwave oven for about 10 minutes to get rid of unwanted fungi and pests in the soil.

Propagation mixture

For a sowing medium, the same potting mixture is used, but without the gravel. Cuttings root well in the small peat pots, called Jiffy 7.

PROPAGATION

To secure the specimen of plants in the exhibition, it is necessary to have a backup of new plants in the nursery. Cuttings are taken in spring and autumn. They are dipped in rooting powder before they are put in the striking medium. Seeds are collected continuously as they ripe. They are stored in a refrigerator. Before sowing, the seeds are treated with hot water, rubbed with emery paper or soaked in smoky water, to improve germination. To try new species, we acquire seeds from the international seed exchange between botanical gardens.

WATERING AND FEEDING

Pot plants

All watering is done by hand. Pot plants are watered individually when dry and starting to wilt. Some need to be watered every day and some once a week, depending on the weather and the size of the pot. The pot plants are generally fed only twice a year with a liquid fertilizer at low concentration. Plants of the Protea family are only fed when they are repotted. A special protea fertilizer is then added to the potting mixture.

Ground beds

The ground beds are watered once a week during the summer and once every second week during the winter. In summer watering is done with sprinklers, during dry and sunny spells, otherwise with a hose. During the wintertime, watering is always done with a hose. Once a year the beds are watered with a liquid fertilizer, Wallco, N 51 - P 10 – K 43 at a concentration of 0,2%.

PESTS

The Australian plants are mostly very healthy. We have a few attacks from the ink spot disease on Mangles Kangaroo Paw *(Anigozanthos manglesii).* Sometimes young plants of different *Banksia* species suddenly die, due to fungus infection.

The pesticides used in Britain against fungi, are not allowed in Sweden. Snails, aphids and whiteflies sometimes occur, but are generally easy to control. To fight the pests, we use a large amount of beneficial insects.

Biological pest control

The following insects are used in the glasshouse:

Pest	Predator/s
Aphids	Parasitic wasp *(Aphelinus abdominalis)*, Parasitic wasp *(Aphidius colemani)*, Parasitic wasp, *(Aphidius ervi)*, Gall-midge *(Aphidoletes aphidimyza)*, Lace wing *(Chrysoperla carnea)*
Leaf-miner flies	Parasitic wasp *(Dacnusa sibirica)*, Parasitic wasp *(Diglyphus isaea)*
Mealy bugs	Australian ladybird, *(Cryptolaemus montrouzieri)*, Parasitic wasp *(Leptomastix dactylopii)*
Scales	Parasitic wasp *(Coccophagus lycimnia)*, Parasitic wasp *(Microterys flavus)*
Sciarid flies:	Predatory mite *(Hypoaspis miles)*, Nematode *(Steinernema feltiae)*
Spider mites:	Predatory mite *(Phytoseiulus persimilis)*

Thrips:	Predatory mite *(Amblyseius cucumeris)*, Predatory thrips *(Franklinothrips vespiformis)*, Predatory bug *(Orius laevigatus)*
White flies:	Parasitic wasp *(Encarsia formosa)*, Parasitic wasp *(Eretmocerus eremicus)*, Predatory bug *(Macrolophus caliginosus)*
Vine Weevil:	Nematode *(Steinernema feltiae)*

CONCLUSION

The Edvard Anderson conservatory is a great success, with about 60.000 visitors yearly. In here flowering specimen of Australian plants can be seen all the year round. The flowering period starts in December, our darkest month of the year, with the spectacular Pincushion Hakea *(Hakea laurina)*. The main flowering is in our late winter and early spring when the sparkling snow outside makes a fantastic contrast to the colourful flora inside.

APPENDIX: AUSTRALIAN PLANTS IN THE CONSERVATORY

Acacia baileyana
Acacia cultriformis
Acacia dealbata
Acacia farnesiana
Acacia flagelliformis
Acacia hakeoides
Acacia longifolia
Acacia retinoides
Acacia willdenowiana
Anigozanthos flavidus
Anigozanthos humilis
Anigozanthos hybrida
Anigozanthos manglesii
Anigozanthos viridis
Astartea fascicularis
Athertonia diversifolia
Austrostipa elegantissima
Banksia ashbyi
Banksia blechnifolia
Banksia brownii
Banksia coccinea
Banksia elderiana
Banksia ericifolia
Banksia marginata
Banksia occidentalis
Banksia petiolaris
Banksia praemorsa
Banksia sceptrum
Banksia spinulosa
Beaufortia sparsa
Beaufortia squarrosa
Boronia heterophylla
Callistemon citrinus
Callistemon hybrida
Callistemon viminalis
Calocephalus citreus
Calothamnus quadrifidus
Calothamnus validus
Calothamnus villosus
Calytrix acutifolia
Cassia artemisioides
Chorizema cordatum
Clematis aristata
Conostylis candicans
Correa backhousiana
Correa decumbens
Correa pulchella
Dampiera diversifolia
Darwinia oxylepis
Dodonaea viscosa
Eriostemon myoporoides
Eucalyptus ficifolia
Eucalyptus lehmannii
Eucalyptus macrocarpa
Eucalyptus piperita
Eucalyptus pulchella
Eucalyptus stoatei
Eucalyptus torquata
Gastrolobium bilobum
Grevillea curviloba
Grevillea hookeriana
Grevillea juniperina
Grevillea rosmarinifolia
Hakea invaginata
Hakea laurina
Hakea suaveolens
Helichrysum spec.
Hibbertia obtusifolia
Hovea acanthoclada
Hovea pungens
Kennedia macrophylla
Kunzea baxteri
Leptospermum continentale
Leptospermum flavescens
Leptospermum horizontalis
Leptospermum scoparium
Leptospermum squarrosum
Macrozamia riedlei
Melaleuca acuminata
Melaleuca bracteata
Melaleuca cuticularis
Melaleuca decussata
Melaleuca fulgens
Melaleuca gibbosa
Melaleuca hypericifolia
Melaleuca lateritia
Melaleuca linariifolia
Melaleuca nematophylla
Melaleuca thymifolia
Mirbelia dilatata
Patersonia occidentalis
Pelargonium australe
Phebalium squamulosum
Pimelea ferruginea
Prostanthera denticulata
Prostanthera ovalifolia
Prostanthera rotundifolia
Prostanthera sp.
Prostanthera sp.
Ptilotus exaltatus
Ptilotus macrocephalus
Rhodanthe anthemoides
Rhodanthe manglesii
Ricinocarpus tuberculatus
Scaevola auriculata
Sollya heterophylla
Stylidium adnatum
Thryptomene saxicola
Thysanotus multiflorus
Triodia pungens
Westringia fruticosa
Westringia longifolia
Xanthorrhoea pressii

PROPAGATION FOR REVEGETATION OF MINE-SITES, REFINERY RESIDUES AND PLANT CONSERVATION

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To enable complete restoration of a self-sustaining Jarrah Forest ecosystem on bauxite mine-sites it has been necessary to develop a detailed knowledge of the biology and propagation of the pre-mining flora. Alcoa World Alumina Australia operates two bauxite mines in the Northern Jarrah Forest. Bauxite is sent to three alumina refineries on the Swan Coastal Plain. Botanical diversity of the rehabilitated mines is a key measure of successful mining. Most plant species re-establish on the rehabilitated mines from seed contained in fresh topsoil. For other species, locally collected seed is broadcast to supplement the soil seed store. Marrinup Nursery manages the collection, storage, pre-treatment and mixing of this seed. For plants with low seed production seed is grown at the nursery for hand-planting. These seeds may require pre-treatment to encourage germination (eg smoke, gibberrellic acid). The jarrah forest understorey also includes several 'recalcitrant' species that produce very few viable seeds. In nature they usually reproduce and spread vegetatively. For these species clonal propagation and planting is necessary. Many of the 'recalcitrant' species have never been grown for the horticultural trade. This poster outlines propagation methods and successful results with several plant species.

FRIENDS OF GRASSLANDS

David Eddy, Margaret Ning, Naarilla Hirsch, and Geoff Robertson
Friends of Grasslands

INTRODUCTION

Friends of Grasslands (FOG) is a volunteer community group formed in 1994 in response to a growing recognition that native grasslands across temperate southern Australia had been dramatically reduced in area and condition. Many other natural ecosystems had received substantial recognition and conservation effort over previous decades but native grasslands had received very little.

FOG's formation resulted from a meeting of ACT Government environment/conservation staff and some concerned community members. In its first few years FOG had a strong focus on raising awareness and appreciation of this natural ecosystem across the ACT community, and conservation effort toward identifying and conserving remnant areas in the ACT. As FOG's membership grew and broadened and as grassland conservation in the region progressed, FOG's horizons and interest also expanded - initially to nearby NSW and then beyond, to all of temperate grassy Australia.

Knowledge and interest in native grassy vegetation in the region also broadened beyond grassland, into grassy ecosystems generally. Grassy ecosystems include grassy woodlands and grassy forests as well as grasslands. All of these natural grassy ecosystems have undergone dramatic change across much of southern Australia since European settlement. In recognition of the similarities and relationships between these grassy ecosystems, FOG has broadened its interests and activities to include all temperate grassy ecosystems.

WHY CONSERVE GRASSLANDS?

Before European settlement, native grasslands and grassy woodlands occupied large expanses of south-eastern Australia. These areas were rapidly settled because they required little or no clearing. During 200 years of development, conservation of these low profile ecosystems was largely overlooked. Across southern Australia today, only a fraction of these original grassy ecosystems remain in close to original condition. These scattered remnants harbour many hundreds of species of native plants and animals - the majority of these are now quite uncommon across much of the landscape. Without retention and sympathetic management of these ecosystems now, and in the long term, these ecosystems and many plant and animal species may be lost forever.

OUR OBJECTIVES

FOG sees these natural grassy ecosystems as a crucial part of biological diversity and landscape health, and is working to reverse their decline. Our objectives are to:

- increase community understanding of grassy ecosystems and their conservation needs,
- encourage and help other organisations addressing the decline of grassy ecosystems,
- promote the protection of grassy ecosystems through public policy, planning and legislation, and
- assist in practical grassland management.

OUR ACTIVITIES

- field trips to grassy ecosystem remnants,
- plant and animal surveys,
- weed control and other management,
- seed collection and plant propagation,
- publishing a regular newsletter,
- slide shows, workshops and conferences,
- providing information about grassy ecosystems,
- giving management advice,
- helping Parkcare and Landcare groups and others,
- lobbying governments, agencies and others,
- commenting on management plans, and
- membership of recovery teams and working groups.

Membership of FOG is open to any individual or organisation with an interest in our native grassy ecosystems, their ecology, conservation management and sustainable us

WHAT IS A GRASSLAND ?

David Eddy, Margaret Ning, Naarilla Hirsch, and Geoff Robertson
Friends of Grasslands

Natural grasslands are vegetation communities dominated by grasses and other herbs, and have little or no tree or shrub cover. Natural grasslands are those that were naturally treeless and were a prominent feature of temperate Australia before European settlement. Since European settlement they have been dramatically reduced in area and condition. Natural temperate grasslands of the Southern Tablelands of NSW and ACT are now listed as a threatened ecological community. About 500 species of native grasses and other herbs, as well as many fungi, mosses and lichens, are found in these grasslands. They also support a rich diversity of small fauna including birds, reptiles, mammals, spiders, insects, frogs, worms and others.

Grassy woodlands are also natural ecosystems with a grass dominant ground layer, but they have a scattered or open tree cover. On the Southern Tablelands we have two broad groups of grassy woodlands including Yellow Box/Red Gum and Snow Gum grassy woodlands. Grassy woodlands dominated by other tree species, such as White Box, are found across other parts of south-eastern Australia. Yellow Box/Red Gum and White Box grassy woodlands have also experienced dramatic decline in area and condition and are also listed as threatened ecological communities.

Grassy woodlands also support a rich diversity of plants and animals. Most native plant species found in grasslands are also found in the groundlayer of grassy woodlands. In some places the scattered trees in grassy woodland areas have been cleared leaving treeless grassy areas still dominated by a diversity of native grasses and other herbs. These have often been called secondary grasslands but are regarded as part of the grassy woodland community. Where the trees are closer together and begin to form a canopy, the community is called a forest. Many of these dry forests also had a grassy groundlayer and are called grassy forests. The natural vegetation of the Southern Tablelands was predominantly a mosaic of grasslands, grassy woodlands and grassy forests intergrading across the landscape.

Diversity in Grassland

Natural ecosystems are much more complex and diverse than they appear. They usually include hundreds or even thousands of species, many of which are very small (even microscopic), and each species has an influence on its environment and on many other species. For instance, an area of several hectares of native grassland in good condition can contain 200 or more native grasses and other herbs; a scattering of trees or shrubs; non-vascular plants such as mosses, lichens and liverworts; mammals, birds, reptiles, spiders, ants beetles, moths, flies, worms; and hundreds of species of fungi and bacteria in the soil. Even with close observation, the variety of species we can find above the ground is dwarfed by the number of soil organisms below ground.

Biodiversity is simply an abbreviation of the term of biological diversity. Biodiversity can be considered at three quite distinct scales. The largest scale considers the diversity or variety of natural ecosystems or ecological communities; such as grassland, forest, wetland and even marine ecosystems. The scale most people think of is the species level. This level is about the diversity or variety of individual species and includes a huge array of very different types of organisms including animals, plants, fungi, and microorganisms. The third and perhaps the least recognised scale, is the genetic diversity with each and every individual species. This genetic diversity within a species produces results such as people with different skin, hair and eye colour; sheep with varying wool characteristics; and Mauve Burr-daisies with either mauve or white flowers. This genetic diversity is hugely important, both to individual species and whole ecosystems, in providing both resilience under external change and the ability to adapt to change.

This poster provides a very brief introduction to the sorts of diversity of size, form, texture and colour we can readily find among the larger, less cryptic above-ground species.

TAKING COLOUR ACCURATE PHOTOGRAPHS OF AUSTRALIAN NATIVE FLOWERS

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INTRODUCTION

The focus of this project was to develop a technique to create colour accurate photographs of Australian native flowers. The basic approach is to take two pictures, one after another, where the first picture contains the flower and the second picture contains a photographic reference target such as a Macbeth Colour checker. White balancing and colour corrections were calculated from the photographic target and then applied to the flower image. The technique was developed to work with either film or digital cameras. The result is a digital picture of a flower with good, though not perfect, colour accuracy. The technique was used to take colour accurate photographs of Australian native flowers under a variety of illumination conditions.

BACKGROUND

Australia has an extraordinary array of flowering plants, exhibiting a wide range of vivid colours. Unfortunately, many pictures of these plants exhibit poor rendition of the flower colour. The colour within a photographic print depends heavily on the illumination at the scene (sunny day, cloudy day, morning, evening, flash, etc.), the colour accuracy of the film, and the colour accuracy of the printing. Because of the combination of these factors, it is usual for photographs to exhibit large colour shifts from the original flower, both in hue and saturation.

There are a number of reasons for the inaccuracy in colour photographs of flowers, but the main problem experienced by most amateur photographers is the lack of end to end colour control. Particularly problematic are photographic prints obtained from negatives and prints obtained from digital cameras set with automatic colour balancing. In the former case, the colour rendition is at the mercy of the developing process and the judgement of the technician making the print who performs colour balancing at print time. Digital cameras set to the automatic white balance setting are almost guaranteed to present problems when taking close-up pictures of flowers since the automatic white balance setting usually assume that the scene either has areas of white or grey or has a wide range of colours – an assumption that fails for flower closeups. The next significant problem is that film and digital cameras are generally designed to provide aesthetically pleasing colours, not accurate colours. Most people find pictures with saturated colours more pleasing, and film manufacturers and digital camera manufacturers have responded by greatly increasing saturation for their consumer products. Almost any Australian flower with highly saturated red colours will turn into a red blob within the photograph. Since many flowers have regions of high saturation (Eckert and Carter, 2000), this can be a common problem found in many flower photographs. A final, but lesser problem is known as "anomalous colour" (Kodak Technical Bulletin, 1999), where the presence of infra-red energy or ultra violet wavelengths, invisible to humans causes red or blue shifts in pictures.

Berns (2001) presents an interesting review of the challenges associated with obtaining accurate colour photographs of artwork for archival purposes. To some extent these problems are insurmountable and he notes that accurate colour rendition for art works is only obtained by using a highly specialised scanner with seven spectral elements (rather than the three present in film and digital camera), allowing for virtually perfect reproduction. Such an approach is infeasible in the field – or within the budget of most flower enthusiasts. However, a well defined workflow that maintains colour control can provide colour accuracy produces very good results – certainly far better and more reproducible than is normally achieved.

TECHNIQUE

The following steps describe the process involved in creating colour accurate photographs:

Step 1: Use diffuse illumination.

As a general rule, flower photographs look more pleasing when taken in diffuse illumination rather than direct sunlight. This can be done by taking photographs either on a cloudy day or by taking a photograph of the flower under a diffusion tent (Blacklock et al, 1987). A diffuser or diffusion tent is simply a translucent shield placed between the direct sun and the object being photographed. Examples of a translucent shield might be a translucent thin plastic sheet or a large piece of white satin. Commercial diffusers are available, but they are also simple to make (see Blacklock, 1987).

Step 2: Use slide film designed for colour accuracy or use a digital camera and shoot the picture with manual white balance. Avoid the use of film negatives and digital cameras set to automatic white balance.

Slide films that provide reasonably good colour rendition are Fuji Astia and Kodak Ektachrome 100 EPN. Both of these are specialty transparency films designed with colour accuracy in mind. Film cannot compensate for illuminant so the most common problem with slide film will be white balancing. Most consumer digital cameras have the option to manually set the white balance. Alternatively, one of the pre-set white balances could be used. Avoid negative film and automatic white balancing options at all costs. Either of these will produce an uncontrolled workflow and there is little opportunity to reliably compensate later. This represents a necessary, but not sufficient step, to produce reliable colour accuracy.

Step 4: Take a calibration photograph and the photograph with just the flower.
Take two photographs under the same exposure and same illumination. One photograph should contain a colour target (a mini Gretag Macbeth Colour target was used in this project). The other photograph contains only the flower to be colour corrected.

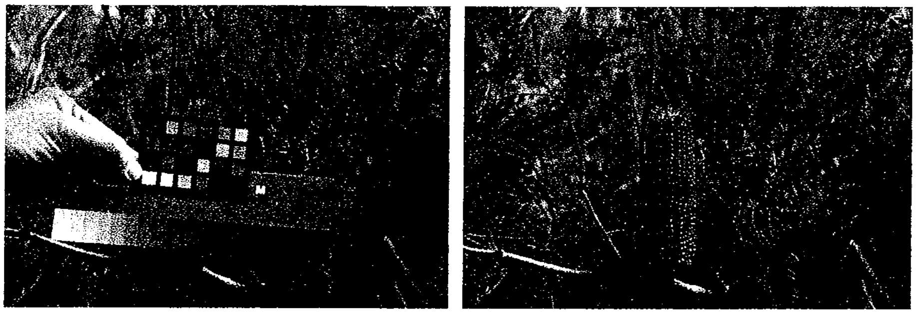

Figure 1. Example of flower with target and final, colour corrected picture. Both pictures have already been colour corrected.

Step 5: Scan in the slide using a colour profiled scanner or apply a digital camera colour profile to the digital camera image
Scan in the slides using a colour profiled scanner (Profile Prism or Profile Mechanic are good examples). Scanning in this manner ensures that the variability between scanners is compensated. Alternatively, a colour profile can be applied to the digital image using the same software. This is the most complex step from the amateur photographer. Skipping this step can still result in reasonable colour from digital cameras, but not slide scanners.

Step 6: White balance the image across several of the grey patches in the target
The combination of the profiling in Step (5) and the white balancing in Step (6) result in accurate colour compensation. The software used to white balance the image was "Picture Window Pro", which allows white balancing to be applied at several different grey scale levels rather than a single grey scale level.

Validation
While the resulting images look accurately colour corrected, it is important to validate the technique and test the accuracy of the colour compensation. In order to do this, pictures were taken of an IT8.7 and Macbeth Colour checker chart in the same photograph, as illustrate in Figure 2.

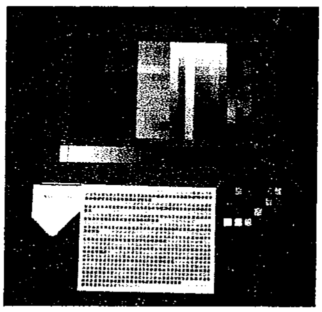

Figure 2. Example of a validation photograph, in which a Macbeth colour checker and IT8.7 chart were both included in the photograph.

The photograph was colour corrected using the technique described above. Colour measurements were then obtained from the IT8.7 chart and measured the closeness between the ideal colour and the colour in the photograph using various colour difference metrics (dE* and CIE94). Average errors were as follows: dE = 6, de94 = 3, dE2000 = 3.

These figure of merits are quite close to what can theoretically be achieved using standard colour compensation techniques (Berns, 2001), indicating that the technique represents a valid approach to achieving colour accurate photographs.

Other approaches?

The technique described in this paper is somewhat painstaking, particularly the colour profiling stage, and requires a several minute manipulation for each scanned image to achieve colour accuracy. A simpler technique was evaluated by taking digital pictures with a Nikon D70 and converting them to JPEGs using RawShooters Essentials 1.1.1. RawShooter Essentials allow white balancing in the Raw conversion process. The colour accuracy of the converted image was compared to the ideal colours using the figure of merits specified above. The approach turned out to be extremely accurate. However, tests on later version of the software (1.1.2 and onward) indicate that the colour accuracy of the conversion has decreased (eg, the software now increases the saturation of colours). As a result, this approach no longer is viable.

CONCLUSIONS

In general, the accuracy after colour management was found to be similar to that described by Berns (2001) for digitised film followed by colour management. Since the photographs in this study are all taken in uncontrolled illumination conditions and in varying types of illumination, then the fact that the colour accuracy is similar to laboratory based situations is encouraging and suggests that the goal of reasonable colour accuracy has been achieved.

ACKNOWLEDGEMENTS

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ISOPOGON AND *PETROPHILE*

David Lightfoot and Susan Corcoran

ISOPOGON

The name of the genus derives from the Greek *isos* - equal and *pogon* - a beard. This is thought to refer to the hairs surrounding the fruit.

Isopogon is an endemic genus. There are 35 currently recognised species with 27 of these found in the south west of the country. The eastern varieties span the coast from southern Queensland into South Australia and the eastern Bass Strait islands.

Isopogons are mainly small to medium sized shrubs with a number being prostrate or near so. They are characterised by semi globular or ovoid inflorescences, packed with small flowers, which range in colour from cream to yellow in the east, with pink, and mauve added in the west. The flower heads are usually terminal and showy but in some species are axillary. The shape has lead to the common names of drumsticks and coneflowers. The foliage is extremely variable and contributes to the horticultural desirability of some taxa.

The fruiting cone is held for some time before breaking up with loss of the external bracts. It is the loss of these scales and the disintegration of the fruiting cone that distinguishes *Isopogon* from *Petrophile* (where the scales are retained). In general Isopogons grow close to the coast and when they do appear inland they are not found in arid areas. They are found in heath and dry sclerophyll woodlands, generally on very well drained nutrient poor, sandy soil.

PETROPHILE

The name of the genus derives from the Greek *petra* - a rock and *phileo* - to love (*philos*, beloved). The first species described were discovered in the Sydney region in the sandstone country and were therefore thought to be 'Rock Loving'.

Like *Isopogon, Petrophile* is an endemic genus. At the moment, there are 53 recognised species with 47 of them originating in the south west of Western Australia. One species is confined to Kangaroo Island, off South Australia, and 5 species are found in New South Wales and south eastern Queensland. Most of the western species are found growing in deep sand, and in full sun within the sand plain heaths. Although some are found in gravely soils, it is almost universally extremely well drained. The eastern species live more up to their generic name and are found predominantly in sandstone country, in dry sclerophyll forest or heath. Again they grow in lots of sun, often occurring where other vegetation is thin.

The western species are found in temperate and semi arid climatic zones. They can be found reasonably close to the coast throughout the South Western botanical zone. The eastern species are found close to the Great Dividing Range and down to the coast.

The species within the genus vary greatly in their form. They are all woody; varying in size from low, almost ground hugging plants, to 3 m high medium shrubs.

Petrophiles can be stunning in flower, especially in areas where the plants are grouped together. The flowers are packed into usually cone shaped heads (although some are ovoid). The inflorescences are generally born terminally or less commonly at the leaf axils. Species with terminal flower heads often display them prominently above the foliage, and would be candidates for use as cut flower. The majority of species have flower colours in the range from cream to yellow. The eastern species are cream, and a couple of western species have grey/pink to pink flowers.

Each individual flower has a small bract that becomes woody after the flower has finished. They remain after the fruit has matured. As noted above, this feature distinguishes *Petrophile* from *Isopogon*, as the fruiting cones stay complete on the shrub, and gives rise to the common name of Conesticks.

CULTIVATION REQUIREMENTS

The eastern species of both *Isopogon* and *Petrophile* appear to be the hardiest, especially where there is any humidity. The western species are very susceptible to root rot fungal attack from

Phytophthora cinnamomi. The wet summers of the east coast promotes the growth of this fungus and is part of the reason for the cultivation difficulty of western species.

In virtually all cases the plants do best in summer dry areas in extremely well drained and slightly acidic soils. In order to maximise flowering excellent sun exposure is preferable. It has been said that most species will tolerate mild frosts especially once they are established.

Supplementary fertilizers are rarely needed, except for iron and trace elements if the plants show yellowing or signs of mineral deficiencies. As with other Proteaceae, these plants are very sensitive to phosphorus toxicity and therefore specialist native plant fertilizers are the only ones that should be used.

An acid pH and an underlying layer of limestone has been said to be advantageous.
Supplementary watering is not required, once established and should be avoided during the warmest periods (in order to reduce the chances of root rot fungus).

PROPAGATION

Both *Isopogon* and *Petrophile* can be grown from seed that germinates well if fresh, although germination times may be variable from the same batch and so seed trays should be kept for some time before being discarded. Germination in some species is improved by smoke treatment, but experimental work is lacking in many taxa. Care must be taken with the new seedlings to avoid damping off. Therefore for best results sterile pots and mediums should be used, with an extremely well drained potting mix. Over watering needs to be avoided.

With *Petrophile*, seed cones over a year old have mature fruit. Once the seed cone is removed from the plant it should be kept in a warm dry place. After a few days the scales will begin to open and the nuts can be removed fairly easily with a pair of tweezers.

One thing I have noticed when collecting seed from *Isopogon* and *Petrophile* is that, in general, the seed set in Petrophile inflorescences is far greater than that in *Isopogon.* (I have yet to determine the rate of viable seed though.)

More often than not each *Isopogon* head contains only a few, if any, seed. The mature head will break apart in your hand revealing its components. The scales are the remnants of the protective outer layer. Within these will be lots of non-viable fruit, which is characteristically a hairy dot.

The seed is contained in a drop shaped fruit of 1-3mm again surrounded by hair. It will have left an indentation on the axis of the fruiting head. There may only be a few but once you have found one, then sorting the seed from the chaff becomes easy.

Propagation can be carried out from cuttings taken from semi-firm new growth, and treated in the regular way with the warning that the hairy leaved species should not be misted too much for fear of fungal disease. Very new growth should be removed. Rooting hormone and under-tray heating will improve results.

Grafting work is only just being explored with *Isopogon* - with commercially available grafted plants starting to be seen in specialist native nurseries. I have heard of some success with grafting of *Petrophiles*, but haven't seen them for sale. *Isopogon anethifolius* is used as a rootstock for both *Isopogon* and *Petrophile* scions.

PLANT COMMUNITIES AND PLANTS OF SOUTHWEST MOUNTAINS

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INTRODUCTION

Mountains of southwest Western Australia, while low in altitude by international standards, have very high conservation value (Barrett and Gillen 1997; Watson and Barrett 2004). They include some of the highest peaks for several thousand kilometers to the north and reach a maximum altitude of 1080m in the Stirling Range in southern WA. These mountains are effectively biological islands in a landscape of otherwise low relief that formed an archipelago in the Eocene seas 40-43 million years ago. Southwest mountains are home to numerous rare and geographically restricted species and occupy several of the hotspots of species richness identified by Hopper and Gioia (2004). Over 1,500 plant species have been recorded from the Stirling Range National Park alone (Keighery 1993). The Stirling Range and Ravensthorpe Range are particularly noteworthy for their high number of endemic species (Hopper and Gioia 2004).

Mountain plant communities experience a Mediterranean climate however orographic effects are influential and the peaks of the Stirling Range as well as south coastal mountains may experience extended periods of drizzle even in summer. In the Stirling Range, occasional snowfalls occur in winter. Rainfall runoff from rocky outcrops also contributes significantly to soil moisture regimes. The geology of mountains in southern WA consists largely of metamorphic rocks and granites of Proterozoic age dated between 1300 and 1700 m.y. ago. North of the Stirling Range, the granite inselbergs of the Yilgarn Craton date back to 3,000 million years ago.

This paper provides a brief overview of the flora, plant communities and threats to mountains in southern WA focusing on the quartzite mountains of Stirling Range and the Fitzgerald River National Park (metamorphosed Proterozoic sediments), the granite inselbergs of the Porongurup Range, Mt Manypeaks, Peak Charles and Mt Lindesay; the Russell Range in Cape Arid National Park (quartzite, gneiss and schist) and the hills of the Ravensthorpe Range (Archean greenstone overlain by Proterozoic meta-sediments) (Fig .1).

VEGETATION AND FLORISTICS

Mountain plant communities are typically comprised of mallee-heath on mountain slopes to thicket and heath on higher mountain summits. These communities are rich in members of the Proteaceae, Myrtaceae, Papilionaceae and Epacridaceae. Deeper gullies, particularly on southern aspects support taller woodland communities. On skeletal soils on rocky outcrops, dwarf scrub occupies soil filled crevices while herbaceous species grow in the shade of boulders and caves. Other micro-habitats include the ephemeral herb-field flora of granite outcrops as described by Hopper *et al.* (1997)

The mountain flora of southern Western Australia is characterised by a high number of narrow range endemic species and nationally threatened species (Table 1). More than 80 species are restricted to the Stirling Range alone (Keighery 1993). The families Proteaceae, Epacridaceae, Myrtaceae and Papilionaceae are rich in endemics, in particular the genera *Darwinia, Dryandra, Daviesia* and *Gastrolobium.* Several unique and threatened plant communities have also been identified within these mountain systems including thicket, mallee-thicket and wetland communities in the Stirling Range, mallee-heath communities in the Barren Ranges (Fitzgerald River National Park) and Russell Ranges (Cape Arid National Park) and the Mount Lindesay granite complex (Keighery 1983, Barrett 1996).

Table 1: Number of endemic plant species, threatened flora and threatened ecological plant communities (TECs) for each mountain area (from Keighery 1983, Barrett 1996, Keighery, Barrett unpublished data).

Area	Endemic	Threatened Flora	TECs
Stirling Range	85	27	3
Quartzite Ranges of the Fitzgerald River National Park	32	9	1
Porongurup Range	7	2	-
Mt Lindesay Granite Complex	9	0	1
Mt Manypeaks	3	2	-
Peak Charles	3	1	-
Russell Range	17	0	1
Ravensthorpe Range -Bandalup Hill	28	8	1

High levels of speciation of mountain flora may be attributed to geographical isolation and fluctuating climatic conditions in the past. In the case of the genus *Darwinia* (Stirling Range mountain bells), it has been suggested that landscape dissection, combined with climatic and microclimatic factors, provided geographical isolation and thus facilitated taxonomic divergence (Hopkins *et al.* 1993). The mountains act as refugia, providing a more mesic environment compared with that of the surrounding lowlands. There is some striking over-lap of endemic species between mountain areas. For example, Hedgehog Heath (*Andersonia echinocephala*) and *Daviesia obovata* are largely restricted to the Stirling Range but small outlying populations occur in the central Barren Range over 100 km to east. Similarly, Mt Manypeaks also supports several outlying populations of Stirling Range flora. This suggests a flora that was perhaps more widespread in wetter conditions in the distant past. The extinction of lowland populations may be related to the onset of dry conditions in the Holocene with mountain populations persisting due to a more favorable moisture balance. However, some species may never been widespread, either due to being recently derived or through being unable to spread as a result of conservative breeding or dispersal systems (Hopkins *et al.* 1993).

THREATS TO MOUNTAIN ECOSYSTEMS

Mountain environments are generally fragile, both biologically and physically, due to their steepness, extreme weather conditions and the instability of their soils (Moore and Black 1993). Land use changes in their hinterland may isolate them as ecological islands in the sky (Costin 1983). Montane communities, occurring at climatic limits, are also highly susceptible to impacts resulting from climate change (Bridgewater 1996). The mountains of southern Western Australia have their own particular suite of threats foremost of which are Phytophthora Dieback, inappropriate fire regimes, grazing, resource extraction, climate change and recreational impacts. However, many of these threats interact with each other such as fire with weed invasion and grazing, while climate change may lead to more frequent and intense fire regimes.

Phytophthora Dieback, Recreation and Mining

The introduced root rot pathogen *Phytophthora cinnamomi* has had a devastating impact on the plant communities of the Stirling Range where climate, soils, topography and rainfall provide conditions ideal for the survival, sporulation and dispersal of the pathogen (Wills 1993; Wills and Keighery 1994, Barrett and Gillen 1996, Grant and Barrett 2003). Some two-thirds of the National Park has been infested by the pathogen (Grant and Barrett 2003) resulting in death of susceptible species, significant changes in plant community composition and structure as well as indirect ecological effects. It is estimated that over a third of the Park's flora is susceptible to the disease (Shearer *et al.* 2004). It is apparent that the pathogen has been spread to many of the peaks through the movement of infested soil, presumably on the footwear of hikers. Infestations high in the landscape have led to rapid down-slope spread of the disease along broad fronts. With many naturally rare plant species, Phytophthora Dieback threatens many species with extinction. Ten species are listed as critically endangered in the Stirling Range as a direct result of *Phytophthora.*

Prominent among the 27 threatened flora in the park are members of the families Proteaceae, Papilionaceae and Epacridaceae, typically highly susceptible to *Phytophthora.* As a result of Phytophthora Dieback infestation, the Eastern Stirling Range Montane Heath and Thicket community was proposed as a Threatened Ecological Community (TEC) in 1996 and subsequently listed nationally as critically endangered. Seven plant species are endemic to this community and 11 species are threatened. These include the critically endangered Mountain Dryandra (*Dryandra montana*) currently known from only 45 mature plants. More recently, the Montane Mallee Thicket and Heath community which occupies the slopes and summits of the lower mountains of Stirling Ranges was listed as a TEC in recognition of the scale of infestation in this community. Loss of bird pollinated endemics such as Heath-leaved Lambertia (*Lambertia ericifolia*) and the large flowered mountain peas results in a reduced food source for honey-eaters, this in turn has a flow on effect with reduced pollination of food species.

Other mountain areas threatened by Phytophthora Dieback include the Mt Lindesay Granite Complex and Mt Manypeaks. Fortunately the Barren and Eyre Ranges of the Fitzgerald River still remain healthy although they contain many susceptible species and communities. As rainfall declines northeast of Albany to less than 600 mm pa, the risk of disease spread and establishment declines. However, in moisture gaining sites with susceptible plant communities the potential for the disease to establish is always present, particularly in conjunction with soil disturbing activities such as road works or mining. Proposed mining activities in the Ravensthorpe Range and nearby Bandalup Hill pose such a threat (in addition to direct impacts) without stringent measures to prevent the introduction and spread of the pathogen.

Until recently management options for controlling dieback have been largely limited to hygiene procedures that limit the spread of the disease such as boot cleaning stations on walking trails. In high conservation healthy areas, permanent closure of roads and trails has been necessary. However, faced with this biological disaster, researchers at WA's Department of Conservation of Land Management (CALM) developed techniques for the application of the fungicide phosphite, used successfully in horticulture, to native plant species and communities in WA (Hardy *et al.* 2001). Since 1997, aerial phosphite applications have been conducted by CALM to spray selected threatened species and communities. Phosphite boosts plant defense mechanisms, thereby increasing the resistance of susceptible species to the pathogen. This slows species decline and buys time to proceed with other conservation measures such as collection of seed for *ex situ* conservation.

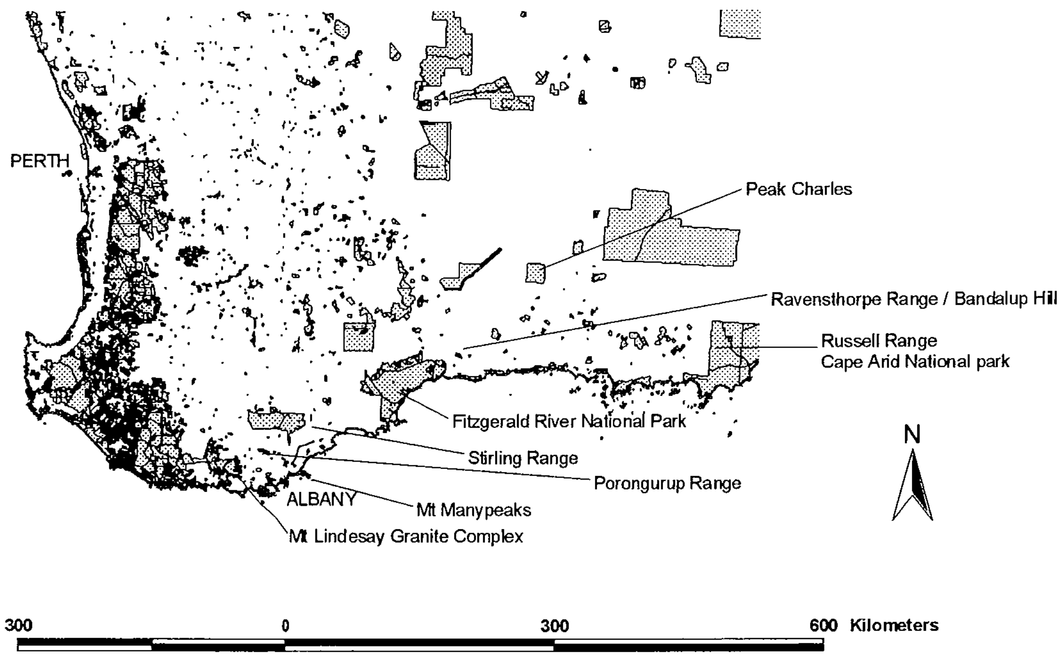
Inappropriate fire, weeds, grazing

While fire is a natural phenomenon in mountain ecosystems, fire management is now complicated by the remnant nature of many of these mountain areas, the slower rates of post-fire recovery at high elevations and the presence of Phytophthora Dieback. Slower growth and long juvenile periods (time to first flowering) are particularly apparent on higher exposed eastern peaks of the Stirling Range. Particularly long juvenile periods of nine to ten years have need recorded for several species endemic to the Montane Thicket TEC including Mountain Dryandra, Small-flowered Snottygobble (*Persoonia micranthera*) and Giant Andersonia (*Andersonia axilliflora*). The long time required to set seed and establish seed banks renders these re-seeder species particularly vulnerable to extinction by too frequent fire. Consequently, fires in quick succession in 1991 and 2000 led to a dramatic decline in numbers of species with canopy stored seed banks such as Mountain Dryandra and Feather-leaved Banksia (*Banksia brownii*). Fire may also lead to excessive grazing in the early post-fire years. Rabbit populations are common even in more remote mountain areas such as Peak Charles as well as the Porongurup Range, Mt Manypeaks and the Stirling Range. Grazing of critical endangered flora such as Small-flowered Snottygobble and Stirling Range beard-heath (*Leucopogon gnaphalioides*) adversely impacts on plant health and reproduction. However, it is possible that native herbivores such as Quokka (*Setonix brachyurus*), also contribute to grazing impacts in the Stirling Range. Fire may also lead to invasion by weed species. The Porongurup Range while noteworthy for its granite endemics also supports significant infestations of Dolichos Pea (*Dipogon lignosus*), Blackberry (*Rubus* sp.,) Forget-me-not (*Myosotis sylvatica*) and many more introduced species.

CONCLUSION

Mountain areas of southern WA have a very significant conservation value with numerous rare and endemic species. These mountain ecosystems are however fragile and subject to a range of threatening processes. Further research into Phytophthora Dieback is required to fully understand the epidemiology of the disease and to explore other methods of containing this 'biological bulldozer'. Fire management must aim to protect fire sensitive species and communities while at the same time preventing broad-scale intense and or too frequent wildfire. Management of these processes is presents an ongoing challenge land managers to ensure the preservation of these unique mountain ecosystems.

Fig. 1 Mountains of southern Western Australia



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SANDSTONE FLORA OF THE KIMBERLEY REGION

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The Kimberley Region of Western Australia has a tropical flora typical of northern Australia, including savanna woodland over *Sorghum* and *Triodia* grasslands with pockets of monsoon forest, and a range of sandstone habitats. Climate in the region is highly seasonal, with nearly all rain falling in a five month period between December and April. Botanists visiting the Kimberley typically visit during the 'dry' season, and then often only visit the more accessible areas. Wet season surveys of the more remote areas are few and far between, so wet-flowering species are often poorly represented in herbarium collections. Approximately 2,800 taxa are recognised for the Kimberley region, with about 365 endemic taxa known so far. Many endemic taxa are restricted to sandstone areas, especially in the north-western high rainfall zone.

We present an overview of the rare and endemic flora seen during our years living in the area and wet-season surveys conducted in the north-west Kimberley, often with the aid of a helicopter, over the last 15 years. Examples of new species discovered include the recently described *Grevillea cravenii* and *G. maheriae*, which together have their closest relative in southern Australia. Recently, we have rediscovered *Auranticarpa resinosa*, not seen since the type was collected by Allan Cunningham in 1820, as well as *Acacia vincentii*, not collected since 1905. Other new species include a new *Hibiscus* with spectacular large yellow flowers, *Calytrix gomphrenoides*, restricted to skeletal sand on rock pavements, *Planchonia rupestris*, a new species endemic to sandstone ranges, and the tiny new *Hypoxis cavernicola*, a geophyte which grows only under small rock overhangs. Recently we have focussed specifically on sandstone pavement habitats, which contain many species growing nowhere else. These species often have unusually adaptations to help survive the long drought between floods of the wet season. Species of the resurrection grass genus *Micraira* for example have long recognised as being highly diverse in Kakadu sandstone in the Northern Territory, but is only now realised to have many species in the Kimberley as well.

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).

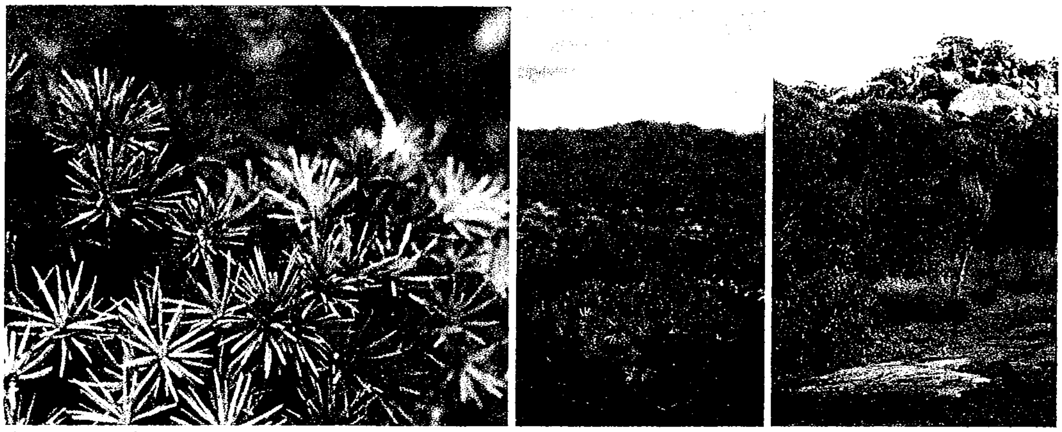

Figure 2. Left – *Borya constricta* at various stages of rehydration after rain. Centre – *Borya sphaerocephala*, Sullivan Rock WA. Right – classic zonation of plants on granite with lichens on bare rock, moss and *Borya* on shallow soil, the monotypic grass *Spartochloa scirpoidea* forming tussocks, *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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AJ SWABY PUBLIC LECTURE

BUSHFOODS - NEW DIRECTIONS IN RESEARCH ON WA BUSHFOOD PLANTS

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CONTEXT

Declining rainfall, salinity and population loss are some of the major issues facing communities within the drier areas of southern Western Australia (350-600mm) and these areas desperately need a range of ecologically sustainable industries. The native flora offers opportunity in this regard, with many species having the potential to become economically viable oil, food, timber, flower or extractive industries. Significant R+D into profitable revegetation options using native species is ongoing in the South Coast region of WA, focussing in recent years on sandalwood, broombush, *Platysace* tubers and *Acacia* seeds for human consumption, fodder crops, alternative timbers, various extractives including myrtaceous oils and native plant floriculture. All of these options and or the systems developed have made varying degrees of progress towards becoming economic reality. This address provides an overview of our research into the development of new vegetable crops from the flora.

The Australian native edible plant industry, commonly referred to as the "bushfoods" industry, is rapidly expanding (Ahmed and Johnson, 2000). In 1997 the industry value was estimated to be worth $12 million, which was based on 14 commercially significant crops; *Acacia spp.* (Wattle), *Acronychia acidula* (Lemon Aspen), *Backhousia citriodora* (Lemon Myrtle), *Eremocitrus glauca* (Desert Lime) and *Microcitrus spp.* (Native Lime), *Hibiscus heterophyllus* and *Hibiscus sabdariffa* (Rosella), *Kunzea pomifera* (Muntries), *Podocarpus elatus* (Illawarra Plum), *Prostanthera spp.* (Native Mint), *Santalum acuminatum* (Quandong), *Solanum centrale* (Bush Tomato), *Syzygium leuhmannii* (Riberry), *Tasmannia spp.* (Native Pepper), *Terminalia ferdinandiana* (=*T. latipes* subsp. *psilocarpa*) (Kakadu Plum) and *Tetragonia tetragonioides* (Warrigal Greens) (Graham and Hart, 1997). These species are grown for their edible fruits, leaves or seeds. Most of these species are not currently used by the bushfoods industry (and more importantly the wider food industry) as staple foods and most are used as flavourings, spices or additives. Interestingly, there are no Australian native species commercially grown for their edible below ground fleshy storage organs (though development work has started on Boab roots). To date there hasn't been a systematic assessment of the Western Australian flora (particularly species from the mega diverse south-west) for potential vegetable crops. In contrast, the area's rich diversity has been explored (with great success) for new species with floriculture or forestry application.

PROJECT SYNOPSIS

The flora of southern Western Australia is of international significance and contains an extraordinary number of species that form fleshy underground storage organs. Over 85% of 153 tuberous species recorded in Western Australia occur in the south west of the state (Pate and Dixon 1982). The total number of tuber forming taxa is currently estimated at 400-450 (Keighery 2003 pers. comm.) and this diversity provides an unparalleled resource to survey for potential new vegetable crops.

The fleshy underground storage organs produced by some species were routinely consumed by indigenous people prior to European settlement and a number of early settlers consumed and documented encounters they had with vegetable products observed to have been consumed by aboriginals of southern Western Australia. The horticultural potential of one tuberous species (*Platysace cirrosa*) was noted by Europeans as far back as 1835 when G.F. Moore (in Kenneally 1977) recorded in his diary that he had

> *"discovered a bulbous root like a dark potato, ..., which I mean to cultivate and which may be very useful if it succeeds".*

Unfortunately this species had been ignored by researchers since 1835. In the Jerramungup area a European pioneer, Ethel Hassell 1878-1886, (Hassell 1975) experimented with *Platysace deflexa* and *Haemodorum* spp. and thought the former to be a pleasant food, particularly when roasted. Given this diversity and history of utilisation, a project that aimed to develop new vegetable products from the flora appeared to have merit.

The first objective of this study was to select a small group of promising species (target group) from the larger group of tuberous native plants. Although there are many species that produce underground fleshy storage organs, a lot of them have undesirable properties and or do not have a clear (unambiguous) history of local consumption. An unambiguous history of consumption was a prerequisite for selection into the target group. Species known to be inedible, unpalatable or toxic or known to contain anti nutritional factors were excluded from this study. Plant and product characteristics of the remaining species/genera were further assessed. Field observation and available information were used to make an assessment of remaining species in regard to their vegetative vigour, reproductive vigour and likely ease of propagation. Attributes such as size, colour, flavour, texture and abundance of the potential product were also assessed. This approach suggested that a target group of *Platysace deflexa*, *Ipomoea calobra* and *Haemodorum spicatum* were worthy contenders for further study. A particular selection of *Dioscorea hastifolia* may also be included in the target group following further field assessments and preliminary product appraisal.

Platysace deflexa (plat-ee-SAY-see *DE-flex-a)* is a member of the Apiaceae, a family that contains many horticulturally important food plants (eg carrots, parsley, parsnip, dill and coriander). *Ipomoea calobra (i-po-ME-a CAL-o-bra)* is a relative of the horticulturally important sweet potato (*Ipomoea batanas*) both are members of the Convolvulaceae (Morning Glory family). *Haemodorum spicatum* (heem-o-DOR-um) is a member of the Haemodoraceae a family more widely known for spectacular flowers (eg Kangaroo Paws and Catspaw) than food plants.

For each target species, research into propagation and agronomy has been concomitant with product development. The following summarises progress to date:

Platysace deflexa

- Appears to have considerable horticultural potential.
- It is now known that each plant produces numerous relatively large yellow tubers, approximately 1kg per plant after 18 months, and mother plants appear to rapidly recover and sucker following tuber harvest.
- The tuber product appeals to the market.
- Tubers are nutritionally similar to carrots
- Most people surveyed enjoy taste and texture of the product when consumed raw or cooked
- Mass field propagation is the main obstacle.
- Few pests and diseases

Ipomoea calobra

- Easily propagated via seed or layering.
- Plant and product are similar in many respects to *Ipomoea batanas* and the white root tuber of *Ipomoea calobra* is pleasant to eat when cooked.
- Carrot sized product produced in 4 months
- Currently growing this species under hot house conditions, the aim being to produce enough product for more detailed product appraisal.
- The nutritional benefit of the tubers is currently being investigated

Haemodorum spicatum

- Easily propagated from seed under field conditions
- Indigenous people used the bulb as a vegetable however, market assessment suggests that it is more likely to be used as a hot spice (cf black pepper)
- No data on yield available but the crop rotation is likely to be a least two years
- Potential market (spice) identified
- Nutritional analysis is underway
- Possible food safety issues related to the accumulation of organic acids are being investigated

The findings outlined above are encouraging and over the next two years we hope to have made significant progress towards the delivering new horticultural crops that produce quality food in a sustainable manner.

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PERTH'S PLANTS AND PLANT COMMUNITIES: WITH A FOCUS ON BUSHLAND OF THE SWAN COASTAL PLAIN

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BUSHLAND

Bushland with its assemblage of unique Western Australian flora and fauna has inherent value. A sense of identity with local bushland is a fundamental part of establishing a true national identity. This sense of locality is very relevant in our turbulent world where local values are less evident.

> "*Bushland is land on which there is vegetation which is either a remainder of the natural vegetation of the land, or, if altered, is still representative of the structure and floristics of the natural vegetation.*" (Adapted from the Government of New South Wales, State Environmental Planning Policy No 19 - Bushland in Urban Areas by Keighery and Gray 1992)

The definition of bushland is based on the presence of natural plant communities. They must contain elements of both the overstorey and understorey species of the original plant community.

Urban bushland areas in WA are continually threatened by a variety of disturbance factors that affect the self-maintenance of the bushland. Such factors are: partial clearing; fragmentation (usually for more than 50 years); selective removal of species by dieback, timber cutting, wildflower picking; repetitive burning; animal impact (horses, foxes, rabbits, cats, dogs); soil movement (removal and dumping); changes in water regimes (flooding and drainage); rubbish dumping; fertilizer drift, and along waterways nutrient influx; mining (gravel, limestone, sand etc); grazing of stock, overgrazing by native fauna; proliferation of tracks and use as service corridors. Weed invasion is often the result of such disturbances and in itself becomes a disturbance.

PERTH'S BUSHLAND FLORA

Over seventy percent of the state's population lives in the Perth Metropolitan Area and adjacent cities such as Mandurah. This area is conspicuously divided into two distinct landscape units: the ancient Archaean Block to the east expressed as the Darling Plateau, and to the west the Phanerozoic sedimentary deposits of the Perth Basin expressed as the Swan Coastal Plain. Such is the contrast between the flat Plain and the Darling Plateau that the Plateau is always referred to as 'The Hills' by the people of Perth. These two distinctive areas are part of two national biogeographic regions - The Swan Coastal Plain and Jarrah Forest.

BUSHLAND OF THE DARLING SCARP AND PLATEAU

The Darling Plateau forms a backdrop to the city of Perth. This ancient series of rolling hills and deep valleys is sharply defined from the Swan Coastal Plain by the Darling Scarp and forms a distinctive landscape of particular beauty. It has long been acknowledged that a chain of parks be established on the Plateau *'from Toodyay in the north to Serpentine in the south'* (Stephenson as quoted in Oldham, 1969) to retain the character of this landscape and conserve the natural ecosystems. After more than 30 years this need has been recognised in the formation of the Darling Range Regional Park encompassing natural areas of the Scarp and Plateau.

BUSHLAND OF THE SWAN COASTAL PLAIN

Compared with the Plateau the Swan Coastal Plain is of very recent origin, the soils of the Plain having been laid down in the Pleistocene and Holocene periods. The entire Plain is characterised by low relief.

With over 2000 native plants recorded on the Swan Coastal Plain a high level of species and plant community diversity is characteristic of the Plain. The patterning of plant species distribution and of the communities in which they grow is to a great extent determined by the soils of the Plain.

McArthur and Bettanay (1960) divided the Plain from east to west into a series of geomorphic elements each with a characteristic suite of soils, generally bearing the same name. From east to west these are: the colluvial and alluvial soils of the Foothills (Ridge Hill Shelf); alluvial soils of the Pinjarra Plain and river valleys; and the aeolian soils of the Bassendean, Spearwood and Quindalup Dunes.

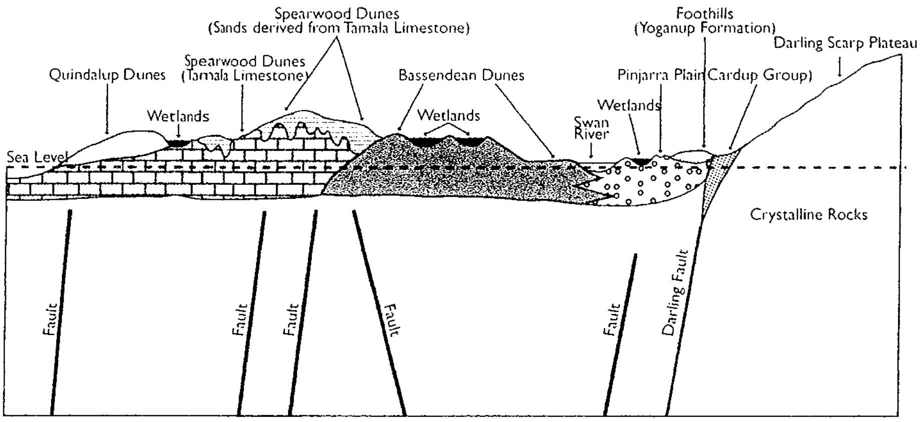

Figure 1: A stylised transect of the Swan Coastal Plain. Adapted with permission from Fact Sheet 15. The Geology of Perth. Department of Minerals and Energy, Western Australia

The more recent general soil maps of most of the Swan Coastal Plain by Churchward and McArthur (1980) are used widely in vegetation mapping. Heddle *et al.* (1980) mapped the vegetation and distinguished 29 vegetation complexes on the Plain related to the five major landform units described and illustrated above. It was not possible to map the individual plant communities as the scale of the mapping was too small.

The plant communities can be described according to the dominant species in the more common plant communities:

Open forests and woodlands dominated by a wide variety of trees, either individually or in various combinations.
The major tree species are:
- **Eucalypts** - *Eucalyptus calophylla*[1], *E. wandoo, E. marginata., E. todtiana, E. rudis, E. decipiens, E. lanepoolei, E. haematoxylin* and *E. gomphocephala*
- **Sheoaks** - *Allocasuarina fraseriana* and *Casuarina obesa*
- **Banksias** - *Banksia attenuata, B. menziesii. B. prionotes, B. ilicifolia, B. grandis* and *B. littoralis*
- **Melaleucas** - *Melaleuca preissiana, M. rhaphiophylla and M. lanceolata*
- **Cypresses** - *Callitris preissii.*

Heathlands and shrublands
The dominant shrub species of these communities are too numerous to attempt to list probably numbering close to 200 species. Examples are from the following genera: *Jacksonia, Viminaria, Daviesia, Leucopogon, Regelia, Banksia, Dryandra, Grevillea, Hakea, Petrophile, Stirlingia, Gompholobium, Calytrix, Verticordia, Pericalymma, Melaleuca, Hibbertia, Halosarcia, Sarcocornia, Xanthorrhoea, Kingia* and *Acacia.*

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[1] At times also known as *Corymbia calophylla.* The Wildflower Society has not accepted this name change.

Herblands
Again the dominant herb species are too numerous to list. Examples are from the following genera: *Borya*, *Phlebocarya*, *Lomandra*, *Dasypogon*, *Conostylis*, *Patersonia*, *Drosera* and *Stylidium*

Sedgelands
Similarly the dominant sedge species are too numerous to list. Examples are from the following genera: *Baumea, Gahnia, Evandra, Schoenus, Mesomelaena, Alexgeorgea, Leptocarpus, Cyathochaeta*, *Meeboldina*, *Dielsia*, *Restio* and *Juncus*

Grasslands
Grasslands are not a very significant component of the flora of the Plain. Their greatest area of representation is on the Quindalup Dunes. Important genera are: *Spinifex*, *Austrostipa*, *Austrodanthonia* and *Poa*.

A very diverse suite of plant communities have formed on the Plain in response to

- the type of the soils (colluvium, alluvium and sands), the interleaving of soils and the underlying rocks (Tamala Limestone, Muchea Limestone and ironstone); and
- the availability of water, both surface water in areas of perched water-tables, underground water and drainage lines.

While many communities are dominated by trees, the diverse shrub, herb and sedge strata which occur within most communities, also occur as distinct communities. Details of the floristics and vegetation of each plant community is required to document the degree of variation in vegetation. Such studies on the Plain are relatively recent (Gibson *et al.* 1994, DEP 1996 and other areas based studies) but are critical in making decisions about the conservation value of bushland on the Swan Coastal Plain. As many as 66 regional floristic groupings have been identified by recent floristic studies (Gibson *et al.* 1994, DEP 1996). Together with the survey of flora in the Metropolitan Region (Kelly *et al*, 1992 and yearly updates after Atkins 1997, Keighery 1996 and other areas based studies) and the broad mapping of vegetation complexes these studies provide the detailed basic information necessary to make recommendations on the conservation value of bushland in a regional context. Such work formed the basis of the recommendations in *Bush Forever*.

The clearing of the alluvial soils for agriculture has been as extensive as the clearing of the Wheatbelt being around 95% cleared. A recent study found that between Gingin and Pinjarra, the woodlands and open forests are almost extinct, having been reduced by clearing to a few small isolated pockets.(Keighery and Trudgen 1992). To the west, the poor sandy soils escaped much of the early clearing, but they are now disappearing along with the landforms they cover as urbanisation overtakes agriculture as the primary land use.

Many taxa of plants on the Plain evolved recently from related taxa on the Plateau. The Plain's flora is a scientific resource, a window on the evolution of ecosystems and taxa probably not available to any other centre of population in the world. It is one of the few areas in Australia to inspire a coffee table book in the 1970's - '*Sense of Place - A response to an environment - The Swan Coastal Plain Western Australia*' by George Seddon.

REFERENCES
Listed at end of Kate Brown's paper

THE BUSH FOREVER PROJECT: STATE GOVERNMENT ACTING TO CONSERVE THE BIODIVERITY OF THE CITY OF PERTH

Gary Whisson
Department of Environment 141 St Georges Tce Perth WA 6000

Bushland has long been an integral part of Perth and, together with the river this bushland, has established a clear sense of place for the people of the capital of Western Australia. The *Bush Forever* Project defines the nature and extent of regionally significant bushland areas to be protected and the method by which these areas will be protected.

The *Bush Forever* Project has three interrelated key outcomes, being:

- Identification of the bushland areas to be protected as *Bush Forever* Sites;
- Identification and application of protection mechanisms; and
- Management of the *Bush Forever* Sites.

Nearly 52,000 hectares of regionally significant bushland and their associated wetlands, 18% of the Perth Metropolitan Region on the Swan Coastal Plain, are recognised for protection. This vast area is grouped in 287 Bush Forever Sites, which range in size from 1ha to over 9000 ha. The *Bush Forever* Sites were selected on the basis of seven defined environmental criteria to ensure, that together, they contained representation of the biodiversity of the Plain. In addition to these environmental criteria, the Site selection process recognised, and generally accounted for, existing zoning and land-use constraints.

An integral, and essential part of the Project is the parallel identification of implementation mechanisms that seek to achieve the best conservation outcomes, while recognising existing planning commitments and the limits of Government's financial resources. *Bush Forever* recognises that biodiversity conservation cannot be achieved by governments alone, with a reliance on a system of conservation reserves.

The combined efforts of State and local governments, the community and private landowners are recognised and promoted as being essential for the protection and management of Perth's valuable bushland resources.

REFERENCES

Listed at end of Kate Brown's paper

THE PERTH BIODIVERSITY PROJECT: LOCAL GOVERNMENT ACTING TO CONSERVE THEIR BIODIVERITY

Karen Clarke
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INTRODUCTION

One of the most significant challenges confronting Perth as it grows is the conservation of its unique biodiversity. This biodiversity is contained in Natural Areas that are areas of native vegetation, vegetated or open water bodies (lakes, swamps), waterways (rivers, creeks and estuaries), springs, rock outcrops, bare ground, caves and coastal dunes or cliffs (adapted from Environmental Protection Authority 2003).

Local Government has a key role in the retention, protection and management of Perth's biodiversity because it represents the level of government closest to the community, is required to make land use planning recommendations and decisions with the potential to impact on most of Perth's remaining natural areas and is directly responsible for the management of thousands of hectares of both regionally and locally significant natural areas.

Bush Forever (Government of Western Australia 2000abc) is based upon the concept that the protection of regionally significant bushland is the responsibility of State Government, and the protection of other natural areas is primarily the responsibility of Local Government (with the support of State Government). Bush Forever's focus on regionally significant bushland does not detract from the importance of conserving Locally Significant Natural Areas.

In 2001, approximately 75, 000 ha of native vegetation considered to be Local Natural Areas were mapped in the Perth Metropolitan Region (Del Marco *et al.* 2004). Local Natural Areas are natural areas that exist outside of the regionally significant Bush Forever Sites (Swan Coastal Plain), and the Department for Conservation and Land Management (CALM) Managed Estate (e.g. Nature Reserves, National Parks, Conservation Parks, and State Forest) and the Regional Parks network. Approximately 58, 000 ha of these Local Natural Areas occur on private land, with about 8, 900 ha of this zoned under the Metropolitan Region Scheme for intensive development. A key challenge for Local Governments will be to protect the more common natural areas rather than just the rare and threatened.

To assist Local Governments to strategically plan for the retention, protection and management of Perth's biodiversity, the Western Australian Local Government Association (WALGA) with funding assistance from the Natural Heritage Trust and the Department for Planning and Infrastructure, established the Perth Biodiversity Project (PBP) in 2001. The aim of the PBP is to support metropolitan Local Governments and now also the Shire of Chittering to use their functions and powers effectively to protect and manage natural areas.

To assist Local Government PBP prepared the 'Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Region' (Del Marco *et al.* 2004). The Guidelines provide Local Government with an understanding of the values of biodiversity in the Perth Metropolitan Region, and a methodology for preparing and implementing Local Biodiversity Strategies. For the purposes of these Guidelines local natural areas exclude parkland cleared areas, isolated trees in cleared settings, ovals and turf areas.

Local Biodiversity Strategies prepared in accordance with these Guidelines address the expectation that Local Governments will prepare local bushland strategies. This expectation was first created in the Urban Bushland Strategy (Government of Western Australia 1995), reinforced in Bush Forever (Government of Western Australia 2000abc), and is being formalized in the Draft Statement of

Planning Policy - Bushland Policy for the Perth Metropolitan Region (Western Australian Planning Commission, in preparation).

The Guidelines introduce a four-phase local biodiversity planning process culminating in the preparation and implementation of a Local Biodiversity Strategy. The four phases are: scoping, preparation of a Discussion Paper, preparation of a Strategy and finally implementation of the Strategy. The Strategy then guides the development of a local planning policy for biodiversity conservation; an action plan for managing biodiversity on Local Government land; a strategy to provide incentives for conservation on private land; and amendment of the local planning strategy and town planning scheme.

The local biodiversity planning process assists Local Governments to:

1. Assess and determine which Local Natural Areas meet ecological criteria for Local Significance
2. Determine the opportunities and constraints for protection of all Locally Significant Natural Areas
3. Guide application of socio-economic criteria to determine which Locally Significant Natural Areas will be protected and managed for biodiversity conservation
4. Formalize policies and processes to ensure biodiversity considerations are integrated into the assessment of development proposals and construction activities
5. Develop and provide incentives to encourage private land conservation
6. Plan for the management of local reserves and other Local Government lands to conserve biodiversity.

To achieve the first objective PBP has developed Natural Area Initial Assessment Templates to standardize the collection of information to determine Local Significance and guide initial management planning for areas that will be protected. A key component of these templates is the identification and use of suitable Reference Sites to guide the understanding of assessors as to the type and condition of Local Natural Areas that surround the large regionally significant sites such as Bush Forever Sites. To better achieve this, the Perth Region Plant Biodiversity Project (PRPBP) was subsequently developed as a partnership between PBP, the Department of Environment (DoE) and CALM.

THE PERTH REGION PLANT BIODIVERSITY PROJECT

The PRPBP aims to build on the extensive existing knowledge base of plant biodiversity information available for the Perth region to support Local Government and other stakeholders in understanding, protecting and managing Perth's unique biodiversity.

A wealth of area-specific information exists on the flora and plant communities of the Perth region, particularly the Swan Coastal Plain. The PRPBP aims to make much of this information more accessible, further interpret the information for use at a variety of levels and, in the future, use this material as the basis for training programs.

The Swan Coastal Plain and Bush Forever

Over the past decade information on the Swan Coastal Plain has been compiled through a series of programs such as System 6, the Southern Swan Coastal Plain Survey (Gibson et al. 1994), System 6 Update (DEP 1996), Perth's Bushplan (Government of Western Australia 1998abc) and Bush Forever (Government of Western Australia 2000abc). On the basis of this and other information, 287 Bush Forever Sites were selected and described in *Bush Forever*. Volume 2 of *Bush Forever* outlines each of the information sets used (Part A) and contains a description of each Site (Part B). A supporting Biological Information file for each Bush Forever Site is held at the Department of Environment (Terrestrial Ecosystems Branch). Part A of *Bush Forever* Volume 2 and the introductions to the sections in Part B provides detailed background information for understanding the Site Descriptions.

Perth Region Plant Biodiversity Project and Bush Forever Reference Sites

The PRPBP is compiling **Reference Site** and **Reference Plot** information for a selection of Bush Forever Sites. Selected sites are in public ownership, easily accessible and best represent each of the major landform and soil units, vegetation complexes, floristic community types and threatened ecological communities occurring across the Swan Coastal Plain portion of the Perth Metropolitan Region, each within a series of east-west **Reference Transects** that demonstrate the natural variation across the landscape. A selection of sites representative of original vegetation along the Swan & Canning Rivers and sites representing major wetland systems is also being included.

Accessible **Photo Reference Points** have been designated within each Reference Site with an assessment of current vegetation condition so that people can be directed to these areas to demonstrate a given plant community or floristic community type. In most cases each Photo Reference Point will be representative of a previously sampled Reference Plot for which the plot information will be made available. Reference Plots are standard size areas (10 x 10 m) for which vegetation and flora information has been consistently recorded across a natural biological region e.g. Swan Coastal Plain.

Utilizing Reference Sites that best match the characteristics of your area of interest will greatly improve your knowledge of the natural values of your own area. For example, Reference Sites can be used to determine what vegetation of a given condition rating looks like and to guide species selection for revegetation projects. They are also a key component of using the Perth Biodiversity Project (PBP) Natural Area Initial Assessment templates to determine whether a natural area meets local significance criteria and for establishing initial management priorities.

The Reference Sites are being developed to demonstrate the broad patterning of plant communities across the Swan Coastal Plain and provide an initial set of information for potential reference sites that may match the conditions of your particular area of interest. However, many other areas exist that you could use as reference sites for your own particular area. This could include other publicly accessible Bush Forever Sites, intact sections of excellent condition vegetation within your own area of interest, or intact, excellent condition Locally Significant Natural Areas near your site. The key is to select reference sites that most closely match your area of interest in terms of position in the landscape (topography, aspect), geology, soil types, hydrology and plant community types.

The PRPBP complements and supports a number of existing projects by DoE, CALM, PBP and the Department for Planning and Infrastructure (DPI). While the Bush Forever Reference Site Files will be focused on plant biodiversity information, other biodiversity and management information (for example, fauna lists, fungi lists, *Phytophthora* Dieback mapping, weed mapping, management plans) can be added in the future. For example, information is currently being sourced from the Dieback Working Group and the Perth Urban Bushland Fungi Project to add additional management and biodiversity information to the files before their release.

Further information on the PRPBP and reference sites can be obtained at http://www.councils.wa.gov.au/directory/walga/index.html/pbp. Future phases of the project will establish reference site information for Perth's hills, the metropolitan region outside of the Bush Forever study area.

REFERENCES

Listed at end of Kate Brown's paper

BUSH LINKS: LINKING BIODIVERSITY, COMMUNITY AND LOCAL GOVERNMENT

Alice Stubber
Wildflower Society of Western Australia PO Box 64 Nedlands WA 6909

Bush Links is a community-based project that integrates local government, professional bush regenerators, and active community participation, to bring about ongoing management of twelve urban bushland reserves in the cities of Wanneroo and Joondalup.

The cities are fortunate to have retained bushland reserves for parks and recreation in their suburbs. These reserves form a living landscape and support an array of plants and animals that are unique to Perth. They provide the local community with an area in which to exercise, connect with nature, or take time out from the pressures of urban living. These reserves also form important links with the CALM estate and other regionally significant areas of conservation in the metropolitan area.

Acknowledging these reserves are significant, however, is not sufficient to ensure their long-term preservation. Bushland within an urban setting endures many pressures from the population. Frequent fires reduce biodiversity and encourage flammable weeds, rubbish dumping introduces weeds and diseases and detracts from the appearance of the bushland and uncontrolled access slowly destroys the vegetation. A gradual decline in the condition of these reserves occurs without proactive management to keep these problems in check. Restoration is then costly and difficult.

This is where *Bush Links* entered the picture in 2002. Since this time twelve selected reserves (six in each of the cities) have gone from a bit of bush gradually declining, to becoming unique assets valued by the community and the City.

Professional bush regeneration teams carried out substantial work in the reserves removing weeds and rubbish to tidy up the area and assist natural regeneration to take place. A series of on-ground activities encouraged participation from community members from all age groups. Activities such as a Guided Nature Walk, Bush Care Day and Weedbuster Week allowed the community to re-discover these areas and gain a sense of satisfaction from their contribution while maintaining the quality of their local environment. Collection of data and monitoring information has assisted local government in long-term management planning for these reserves.

An extensive advertising program ensured that the *Bush Links* project is widely publicised. This included articles in the *Community News*, school newsletters and other periodicals, airtime on local radio, posters in libraries and shopping centres, flyers to local residents and promotion on the city's websites. Permanent interpretational signage was installed at each reserve to identify its designation as a conservation area.

The integrated approach that the *Bush Links* project is taking means that everyone can participate, and thus everyone will benefit. Local government has the tools to manage their reserves more effectively and the community has a greater appreciation of the unique area within their suburb. The plants and animals are ensured a safe home, and future generations will grow up appreciating Perth's natural heritage.

Bush Links has received support from the Perth Biodiversity Project a Natural Heritage Trust funded project delivered through the WA Local Government Association and the City of Wanneroo and Joondalup.

REFERENCES

Listed at end of Kate Brown's paper

PEOPLE WORKING FOR BUSHLAND PROTECTION AND MANAGEMENT

Diane and Gary Matthews
Wildflower Society of Western Australia PO Box 64 Nedlands WA 6909

INTRODUCTION:

Our personal journey began with the Wildflower Society in 1988. In the April edition that year of the Conservation Council's *Bulletin* there was the announcement:

So often biological surveys are regarded, unnecessarily, as the province of professionals. However, the Western Australian Wildflower Society is organizing a botanical survey with a difference in a part of the rich and interesting Northern Sandplains. It is offering you the opportunity to be involved. No experience or previous training necessary, just an interest in wildflowers. (You don't have to belong to the Wildflower Society).

The notice went on to advise that

The study will provide you with:

- *an insight into botanical surveys.*
- *an appreciation of the rich flora of the area.*
- *some ability to identify wildflowers*
- *(if you are interested) some knowledge of data processing.*

We found this invitation, to participate as ignorant volunteers in an important scientific study, irresistible, and as they say – the rest is history. Both Gary and I have found our association with the Society to be a life changing experience. The spontaneity and integrity of the people within the Society have been inspirational.

During this presentation we will provide a general introduction to the conservation network that has developed in Western Australia over the intervening years. Later this afternoon Ann Gunness, in her talk on the Bushland Survey Project, will expand on the incredible achievements of the Society's survey programme that started it all for us, and other speakers will also expand on innovative and extremely worthwhile projects and initiatives that have developed within and around the network.

THE NETWORK:

It is not uncommon for those who attend the Society's Annual General Meetings held each June to be overawed by the standard and level of the reports and to be equally impressed by the obvious respect given to the Society by State agencies. This is as a result of individual members representing the Society on government advisory committees; by making many submissions on State policy and development issues; by attending ministerial briefings; initiating information workshops and seminars; and generally exhausting themselves in the promotion of, and in defence of, our State flora.

Some reports presented at a Wildflower Society of WA AGM:

Save Our Bushland Campaign
Bushland Plant Survey Project
Conservation Committee
Garden Sub-Committee
Major Events
Publications
Environmental Weeds
Roadside Conservation Committee
WA Flora Industry Advisory Committee

Many within the Society have active on-ground connections within the conservation network. In this state there is a strong connection between both appreciating and growing our unique flora, and a desire to conserve our botanical heritage and the linked biodiversity. Certainly there is no divisive separation. It is a working partnership that admires the skills of individual specialists from the different spheres and enjoys the opportunity to learn and participate when, and wherever possible. We have been fortunate in the calibre of the many inspiring people who have guided this process. Each network connection has had this driving force of special people that has given us little chance of being indifferent to the wonders of our flora and the major changes that are taking place within our environment during our lifetime.

In Western Australia there are at least 370 voluntary conservation groups that work to conserve and manage our flora. To illustrate the diversity and interconnectedness of many of these, we will introduce you to some that we are involved with. Of course when we talk about impersonal 'groups' we must never lose sight of the fact that they are made up of committed individuals. Also when we refer to 'volunteers' it should be remembered that many people from within research and government agencies are also members of these voluntary organisations. This diversity of talent mirrors the many facets of our uniquely rich and diverse flora and associated fauna.

MURDOCH BRANCH – WILDFLOWER SOCIETY OF WA

The Murdoch Branch has developed a close connection with both the Murdoch University and Challenger TAFE. The majority of the present committee are drawn from teachers and students involved in horticultural units at TAFE. This college has a particular focus on ..... (enlarge on courses).

The Murdoch Branch Patron is Dr Philip Ladd from Murdoch University and we present an annual award consisting of a collection of books for the best academic performance by a student from within the University's *Plant Diversity* course. Each year we also provide an opportunity for students to attend one of our general meetings to give a presentation on their study topic. It is inspiring to listen to the confidence and enthusiasm of these young people.

This mix within the Branch of horticultural pursuits and academic interests is matched by an equal commitment to putting in the hours to both work on-site in bushland remedial work and to develop effective site management outcomes.

FRIENDS OF KEN HURST PARK:

The Friends were started some years ago by the Murdoch Branch when the Park was being considered as a possible *Bush Forever* site. If you attended this morning's sessions you will have been given information on the state government's *Bush Forever* initiative which seeks to establish and protect a representative collection of all the plant communities on the Swan Coastal Plain. Ken Hurst Park is a valuable 49 hectare remnant of the southern Banksia woodland and the Jandakot wetland system. Only 3% of this type of ecological community is protected currently in the conservation estate.

There are over 200 species of plants indigenous to the area and the site contains 1 rare flora species – *Caladenia huegelii* – and 3 priority flora species, *Daviesia physodes, Lysinema elegans* and *Gonocarpus pithyoides*. Over the intervening years the Branch members have been closely involved with both the local council and state government agencies to ensure that the Park was firstly protected from being made into a cemetery, then a wildlife park, and now a major highway extension, and a railway and electricity reserve.

Many, many tedious and stressful voluntary hours are being spent in meetings and site visits with agency representatives and contractors to achieve the best possible outcome for this very special piece of significant bushland.

However, it is the camaraderie and positive results gained from being involved in physical events such as rubbish collection days, planting sessions, and guided walks that provide tangible outcomes for those involved.

FRIENDS OF BECKLEY BUSHLAND:

Beckley Bushland contained several >300 year old Marris *Eucalyptus calophylla and* twenty-three different species of orchid were discovered on this small several hectare site.

In 2004 it was announced that Beckley Bushland was designated to be a parking area and access roadway for the new southern transit railway being constructed down the centre of the Kwinana Freeway. The local Friends group was formed and together with the assistance of the Urban Bushland Council (UBC) and members of the Murdoch Branch of the Society these local people became closely involved in the planning and appeals process.

Newspaper and television media were used to bring the issue to the wider community, Main Roads Department and the state government minister's office. A last ditch attempt to force an alternative to clearing was carried out by a team who camped onsite and who also staged sit-ins in the Marris. Sadly the final decision saw less than a hectare being retained.

Prior to the bulldozers commencing their work, it was negotiated that orchid tubers would be rescued from the site both for research at Kings Park by the Botanical Gardens and Parks Authority, and for transplanting by volunteers into the remaining remnant. As transplanting of orchids is rarely attempted it is unclear if this attempt will be successful. At least the results will add something to this research. The final outcome has left many saddened and disillusioned, but those who have committed so much effort to the study and appreciation of this bushland will continue to be involved in the management of the remaining site.

URBAN BUSHLAND COUNCIL (UBC)

The Council was formed in 1993 and as its name suggests, the affiliated member groups concentrate on raising the profile of urban bushlands and their ongoing management. Apart from support for individual groups when dealing with managing agencies, the UBC also conducts information forums.

These forums have included significant work with the Fire and Emergency Services Authority seeking to revise their standard approach to fire in urban bushland, from allowing the fire to burn out, to a more aggressive approach of control and suppression. The ability to gain access to decision-makers has been an invaluable achievement of the Council as they continue to work towards sustainable management of urban bushlands.

Publications –

- *Wetlands to Wastelands? Proceedings of a seminar about the future of bushland at Perth Airport. (18/9/2004)*
- *Burning Issues. Proceedings of a workshop on fire management in urban bushland. (8/11/2002)*
- *Building Partnerships Between Community Groups and Local Government for Our Bushland. Proceedings of a seminar. (26.8.2000)*
- *Managing our Bushland: proceedings of a conference about the protection and management of urban bushland. (1998)*
- *Burning our Bushland: proceedings of a conference about fire and urban bushland. (Aug. 1995)*

A project conducted by the UBC is the Perth Fungi Project. It has been patterned on the Wildflower Society's highly successful floral surveys, using paid leaders supported by enthusiastic volunteers. This initiative has captured the imagination of many, and has drawn others into the network. Fungi are an integral part of much of the state's flora and therefore play a vital role in the continued health of our biodiversity and yet until this study very little was known about their diversity or distribution. This project will result in a major collection of samples and data. This project will be described in more details later this afternoon.

CANNING RIVER RESIDENTS ENVIRONMENT PROTECTION ASSOCIATION (CRREPA)

Gary's and my association with CRREPA began in 1994 when the local community became concerned at plans for our local wetland/bushland and associated foreshores. The aim of the Association is to ensure that our local riverine environments are both maintained and conserved for future generations to enjoy. CRREPA is a good example of how the different interests and skills of local people can be brought together to have positive outcomes.

Water quality testing has been carried out by a consistent team for 10 years and high phosphate readings resulted in a complete revision of sewage management in the area. Other busy activities combine seed collection and propagation, planting sessions, informative walks and teaching sessions. One individual member has been responsible for making his own planting tools and growing thousands of local sedges and trees that have been planted into the reserve by teams based along the 3km stretch of foreshore.

The more obvious on-ground works are matched by the not so obvious but equally time-consuming activities, of submission writing and liaison with local and state agencies seeking better sustainable management of our river systems. For CRREPA members it has been satisfying to witness the general improvement in both local environmental attitudes and the foreshore. However, because of the pressures of an increasing population, and the need to manage access to the river, we will not be able to rest on our laurels.

ENVIRONMENTAL WEEDS ACTION NETWORK (EWAN)

Unfortunately if you have an interest in our unique wildflowers in their natural bushlands you cannot ignore the weeds.

In 1994 The Wildflower Society, in partnership with Murdoch University, Kings Park and Botanic Garden, and the Australian Association of Bush Regenerators (WA,) held a land-mark conference on *Invasive Weeds & Regenerating Ecosystems in Western Australia*. This formed the catalyst for the formation of the Environmental Weeds Action Network.

EWAN is in its 10th year of activity and is a community initiative to tackle the problems of environmental weeds in bushland. It brings together community members in both rural and urban areas, bush regenerators, local government, weed scientists and ecologists to save our indigenous wildflowers from the threat of weeds. We hold general information sessions and circulate an *InfoNotes* to members.

We have been closely involved in the development of the State Weed Strategy and the State Weed Plan. Members of EWAN are represented on the State's WA Weeds Committee that was formed in 2004 to implement the State Weed Plan.

EWAN has been grateful for support from various sources for the production of an on-going series of pamphlets entitled *Managing Weeds in Bushland*. This series has so far provided botanical and management guidelines on

Geraldton Carnation Weed (Euphorbia terracina)
Arum Lily (Zantedeschia aethiopica)
Taro (Colocasia esculenta)
Woody Weed Control (incl
Soursob, Fingerleaf & Four O'clock (Oxalis sp)
Freesias (Freesia alba x leichtlinii)
The Perennial Tussock Forming Grass Weeds

The important manual *Bushland Weeds, a practical guide to their management* published in 2001 was the culmination of a five year project funded by the Natural Heritage Trust and managed and administered by a voluntary steering committee of EWAN members. This manual has provided essential information at a critical time in the development of sustainable land management in Western Australia. The manual also highlights the dedication and skill of the community volunteers who participated in the research at the project's demonstration sites and continue to battle against the odds for our bushlands.

GROW WITH US

In the early 70's when we were setting up our first garden around our new home we obtained a copy of *A Descriptive Catalogue of West Australian Plants* edited by J.S. Beard (then Director, King's Park and Botanic Garden) and published by the Society for Growing Australian Plants. This book with its lists of tantalising species and descriptions proved to be a frustrating aid to our gardening ambitions because very few of the plants listed were available. Some nurseries stocked a limited range of Eastern States natives which many of us excitedly planted, only to discover that the majority grew into tall woody plants that gave little gardening satisfaction. While this situation has since improved with a small number of specialist nurseries now providing an increasing array of quality plants, the general gardener is still denied the delights of growing many of our 'locals' due to the large gardening centres still being mostly stocked from the Eastern States.

Again there have been outstanding individuals, this time involved in campaigning for a better deal for those wanting to have the opportunity to grow our unique and beautiful plants. The Wildflower Society's *Grow With Us* team have been promoting the delights of growing locals. A partnership was developed between the Society and the Water Corporation to conduct a series of informative workshops for the wider community interested in establishing 'water-wise' gardens. Later this afternoon you will have an opportunity to learn more on this initiative.

The Wildflower Society provides regular opportunities for members and the general public to purchase plants grown by the Society's members and for the past couple of years some members have made their gardens available for the Open Garden Scheme.

CONSERVATION COUNCIL OF WA

The Council is the peak conservation group in WA. There are no pretty pictures to illustrate the Council. It is primarily a fantastic group of people working at the coal-face of our State and Federal government systems, and who make comment on the whole range of environmental issues that affect Western Australia.

Gary and I have been involved with the Council both as employees and volunteers since 1994.
They have been inspirational people. Their positive effect on sustainable and responsible environmental policy in this State has been enormous. The Wildflower Society, the UBC, CRREPA and EWAN are all affiliates of the Council.

AUSTRALIAN ASSOCIATION OF BUSH REGENERATORS (WA) (AABR WA)

AABR seeks to raise the standard of professional land managers working on bush regeneration and maintenance in this state. The Association conducts regular information sessions and high-level industry forums. The aim of the Association is to ensure that those being employed in the bush regeneration industry are accredited at a standard that will ensure the viability and conservation of our unique bushlands. At the same time AABR endeavours to keep the industry informed of any changes and technologies that may affect it.

All the above associations are non-government organisations (NGOs). They function within the time, energy and skills constraints of their volunteer members. For NGO's it can be frustrating to find that it is assumed by those outside the network that volunteers can commit normal working hours to the issues being debated. However, over the years there have been State agencies that have grown alongside the volunteer groups and who have contributed to the development of their confidence and skills. We have been involved with the following:

ECOPLAN – URBAN NATURE Dept of Environment, Dept of Conservation & Land Management

Since the early 1990's Ecoplan, originally within the Department of Environment and now operating within the Department of Conservation and Land Management, has sought to bridge the gap between the land management volunteer community and government, and to provide support. Their excellent training series *Skills for Nature* that is supported by Greening Australia and Swan Avon Integrated Catchment Management, have been pivotal in the personal development of many within the environment conservation network. These free educational workshops have included excellent topics such as:

Promoting Your Group – Ways to be seen and heard
Fantastic Flora – Basic Plant Identification
Knowing Your Weeds
Wetland Management – Techniques for solving problems
Tools for Tackling Weeds
Stop the Biological Bulldozer – Managing Phythophthora Dieback in bushland
Plant Patterning Across the Plain
Bushland Management Skills – Brushcutting

Currently Ecoplan is evolving into a more hands-on research and training establishment. Kate Brown who co-wrote EWAN's *Bushland Weeds* manual, is now with Ecoplan under Urban Nature a new initiative set up by the present State Government. The wider network is very pleased that Kate's skills and talents have been acknowledged and that the work begun by the volunteers of EWAN will now continue and, in the current jargin, have value added. Kate will be another speaker later this afternoon.

HERBARIUM

The State Herbarium has in excess of 11,922 vascular plant taxa recorded in its information systems, and has received enormous support from volunteers. The Wildflower Society's survey project continues to see regular volunteer sessions conducted at the Herbarium where plants are identified, sorted and mounted for placement into the library. Regional herbariums have been established and are also largely supported by volunteers who are essential to the gathering of sound data on our botanical heritage.

Neville Marchant, head of the WA State Herbarium, was an early President of the Murdoch Branch of the Society and encouraged many of us in our botanical interests. Neville will expand on the function of the Herbarium later this afternoon.

A recent book by environmental historian Irene Cunningham *The Land of Flowers, an Australian environment on the Brink* makes the reader aware of the floral treasures and opportunities we have lost and encourages the development of food crops based on those still available to us. The Herbarium is a library of enormous botanical interest and significance.

BOTANIC GARDENS & PARKS AUTHORITY (formerly Kings Park Botanic Gardens Authority)

An inspirational publication has been *The Bushland Plants of Kings Park Western Australia* by Eleanor Bennett with illustrations by Patricia Dundas, published in 1988. This book became the early reference for many of us working in bush regeneration in the 90s. It provided beautiful drawings for easy identification of both indigenous and feral plants and it was therefore of enormous assistance to the developing network.

The Authority has been involved in crucial research regarding the cultivation of endangered plant species. As mentioned earlier regarding Beckley Bushland, the Authority is seen as a leader in providing information on this issue.

Considerable funds have been spent on the rehabilitation of the Kings Park Escarpment. In your travels across the Narrows Bridge if you look above Mounts Bay Road to the Park you will notice a scar on the escarpment covered by jute matting. This is the latest remedial work carried out on this difficult slope. This project has been critical in ground-proofing important land management theory and also in developing training for contractors and technical staff.

FINALLY

We all have our own starting point from where we begin to place Australia's special plants in a special place in our lives. For me it was probably growing up in the wildflower paradise of the banksias woodlands of South Perth in the 40s and 50s and being able to run wild as a child through the bush. Another influence was a copy of a publication *West Australian Wildflowers* by the West Australian Newspapers bought by my Dad for ten shillings on 13/9/1944 (the receipt is still in the book) with colour plates of water colours by Edgar Dell, colour photographs by the newspaper's photographers and descriptions by the indomitable C.A. Gardner, Government Botanist. This copy was from the fourth Edition, having first been published in 1935. As a child I spent many happy hours leafing through this wonderful book.

Now over the last seventeen years we have been very fortunate to have been associated with many amazing individuals who have created opportunities for us to be involved in the conservation of our unique environment. The Wildflower Society started it all for us. It has been a very fulfilling and rewarding experience so far.

We hope you have been able to give you a worthy sample of the People Caring for Bushland in Western Australia. We know you will find the following speakers interesting and informative. Thank you.

REFERENCES

Listed at end of Kate Brown's paper

THE WILDFLOWER SOCIETY AND CONSERVATION

Brian Moyle
Wildflower Society of Western Australia PO Box 64 Nedlands WA 6909

INTRODUCTION

Since its inception as the WA Wildflower Growers Association in 1958 the members have been concerned with the conservation of the flora. This arose from the push by the government of the day to see cleared a million acres a year on the marginal sandplain country between Albany and Esperance. It was 1964 when the Association name was changed to the WA Wildflower Society (Inc.) and more recently to the Wildflower Society of Western Australia (Inc.)

The ethos of conservation is set out in the constitution of the Society. Clause 3 (a) Objects states:

To encourage the conservation and preservation of Australian and particularly Western Australia's native plants by, among other things, supporting efforts to strengthen laws and regulations for the conservation of Australian flora, encouraging enforcement of laws and regulations and making submissions on the preservation of Australian wildflowers to government and other organisations interested in the preservation of Australian wildflowers.

[The constitution does also have clauses on cultivation, the study groups and establishment of branches.]

HISTORY

This list is not comprehensive but rather an insight to some of the issues of concern to members. Before 1959 most reserves did not have any signs saying that it was illegal to pick the wildflowers and it was through lobbying by the public, including Society members that the then Forests Department had appropriate signs erected. Significant areas of the Esperance Sandplains were also set aside for flora and fauna conservation. A Society member had a reserve set aside in Kulin and a Mr Treasure of Wubin left 40 acres with Banksias which was eventually vested with the shire.

Meetings were held with the Premier and there was legislative change which resulted in a ban on picking of wildflowers from along side roadsides. It was in 1966 the Society succeeded in stopping wood tar being dumped in the Clackline Reserve. A joint effort with the Tree Society saw a large area of Geraldton Sandplain on Burma Road made a reserve in 1967. In the same year the efforts of the Wildflower Society, WA Naturalists Club, Tree Society and The Kings Park and Swan River Preservation Society foundered the Nature Conservation Council. This later became the Conservation Council of Western Australia.

Another success was the setting aside Bald Hill near Toodyay as an A Class Reserve. Members were active seeking protection from mining in reserves as well as the bauxite mining of water catchments. In 1970 submissions were made to commonwealth parliamentary hearings looking at flora and fauna protection across Australia. It is from this time that there have been regular conservation meetings of the Society. Other issues on the agenda were woodchipping concerns and getting the woodlands near Narrogin made the Dryandra Reserve.

The Society has had a representative on the Roadside Conservation Committee since its inception in 1985. It is an advisory committee to the Minister for Environment to coordinate the conservation and management of rail and roadside vegetation. A representative is also on the WA Flora Industry Advisory Committee.

THE LAST FIFTEEN YEARS

A major concern around 1990 was a proposed coal mine and power station near Mount Lesueur. Many members were active in the successful campaign to stop the project which would have destroyed an area of international conservation significance. There have been two smaller proposals since. One of them was as recent as last year. So the battle is never really over.

In 1991 the Society adopted a set of Principles of Flora Conservation, in 1995 the Principles of Seed Collection and in 1996 a Revegetation Policy. The 1990's also saw an increase in the conservation work of the Society. This was in response to the community concern about clearing in both the urban and rural areas and inappropriate development.

Bushland Conservation Fund

In 1995 the Society established the Wildflower Society Bushland Conservation Fund. This was set up to receive donations which are tax deductible. The funds can be used for the conservation of bushland and raising public awareness of bushland. At the same time we called for a moratorium on clearing. The Fund was launched by Bert Main in February and since that time more than $60,000 has been raised. A part time coordinator James Duggie was employed for several years. Two successful seminars calling for an end to land clearing were run, several position papers compiled and government agencies and politicians lobbied. James presented a paper at the 1999 Landcare Conference in Esperance and following his presentation a motion was passed saying that the time had come for no more land clearing in Western Australia. In 2004 the clearing regulation amendments to the EPA Act were proclaimed. These have not been the big step forward which was hoped for but they are a move in the right direction.

The Society has also been actively involved in planning for an Urban Growth Boundary for Perth. It is of great concern that no statistics are kept by any state government or local government agencies on the amount of clearing that is undertaken in the Perth Metropolitan Region.

Conservation Secretary

Since 1997 the Society has employed a part time conservation secretary. This has been funded from Society memberships. We have been extremely well served by Karen Clarke, Renae Stenhouse, Sue Wooller and Jo Tregonning. Regular committee meetings have been held once a month and the minutes reported to the management committee, as well as a report in each edition of the society newsletter.

There is no shortage of concerns that come to the attention of the Society and therefore we have been somewhat selective on the issues addressed. The forest debate has been led by the WA Forest Alliance so we have concentrated on bushland. Some other issues are well handled by the Urban Bushland Council and local groups and others by branches of the Society. We are represented on the UBC by Mary Gray the current president of the council.

Flora Survey Programme

The Bushland Flora Survey Project is also part of the Wildflower Society conservation initiatives. It is not possible to conserve or manage an area unless you know what is there and its values and this is one of the reasons for the programme. Ann Gunness has covered this in her presentation on the Bushland Survey Project.

SOME CURRENT AND RECENT ISSUES

Portman Mining at Windarling and Mount Jackson

This is an area containing threatened ecological communities, the declared rare flora, *Tetratheca paynterae* other priority flora and unique landscape features. The features include iron monoliths as well as cave formations. The Society ran a major campaign through the EIA process including advertising in *The West Australian.* The EPA said mining should not proceed at Windarling but this was overruled by the WA Cabinet. There were a set of ministerial conditions put in place including a community reference group and flora and landscape management plans. The Society is represented in this process and there is a lot of useful information coming from what was still a bad decision. The issues from the proposal have also raised the bar for the EIA assessment of future proposals.

Increasing Iron Ore Mining in the Yilgarn and Mid West
Beginning in 2001 there has been a push to mine the hills and ranges of the Yilgarn and Mid West area of Western Australia. This started with the Portman Mining proposal for mining at Mount Jackson and Windarling 100 km north of Southern Cross and the Mount Gibson Iron operation at Tallering Peak in November 2003. Over that time the Chinese economy has boomed and there are now so many proposals to mine the banded ironstone ranges that hardly a hill will be left untouched in a line south from Carnarvon to Eucla. These are very small deposits compared to the massive deposits in the Pilbra but the impact on the flora, vegetation and landscape amenity will be devastating. Areas under threat include Mount Gibson, Weld Range, Jack Hills, Koolanooka Hills, Blue Hills, in the Mid West and Bungalbin Hill, Helena and Aurora Range, Die Hardy Range and the Watt Hills in the Yilgarn.

On the positive front we have been able by talking to the Minister for the Environment and the Environmental Protection Authority influence the Department of Conservation and Land Management to fund a $600,000 flora and vegetation survey of some of these areas.

Mineral Sand Mining
Whilst a lot of farmland is mined for mineral sands there is also the potential to mine areas of high conservation value including those with declared rare flora, priority flora and threatened ecological communities. Some of the proposals the Society has commented on include Wonerup, (DRF), Yarloop, (TEC) and Gwindinup (TEC, priority flora). There is also a current proposal to mine next to the Shark Bay World Heritage Area.

Clearing for Urbanisation and Agriculture
As previously mentioned no statistics are kept by a government agency on how much land is cleared for urbanisation. Perth continues to expand outwards and the growth of the Mandurah and Bunbury regions is spectacular if not to say alarming. The Society has commented on numerous development proposals and endeavoured to raise an awareness of the value of bushland and to see that some is retained in the conservation estate. It compiled significant submissions to what became the Bush Forever programme which had the aim of protecting regionally significant bushland in the Perth metropolitan area. An Urban Growth Boundary concept was also developed for Perth. Components of this were utilised by the Department of Planning and Infrastructure.

Some shires in the wheatbelt have as much as 97% of the area cleared. Clearing still happens for small projects and roads. In the regions of the state where there is still major tracts of bushland clearing has not stopped and community input is still vital to counter some of the inappropriate clearing proposals that come up from time to time. Where comments are made on any project we try to provide both balance authoritative information. With feedback from the government agency staff we have gained the impression they value input from the Wildflower Society.

CONCLUSION

It has only been possible to cover a very small amount of the work that the society and its members have done. In this presentation I have tried to avoid a long list of the projects and proposals which have had comment from the Society. A more complete record of the issues and work can be obtained by reference to the quarterly Newsletter in which there is the conservation report and each year the August edition has the annual conservation report. Over the last forty seven years the society has attempted to see that future generations will still be able to understand why Western Australia was and hopefully can still be known as The Wildflower State.

REFERENCES

Listed at end of Kate Brown's paper

WILDFLOWER SOCIETY BUSHLAND PLANT SURVEY PROJECT

Ann Gunness
Wildflower Society of Western Australia PO Box 64 Nedlands WA 6909

INTRODUCTION

The program arose from the recognition that the diversity of our bushland flora was poorly known or documented, and that an understanding of native vegetation is a first step in helping to effectively plan for the protection and regeneration of native bushland. The broader community has increasingly called for help in knowing and managing their bushland. At the same time it was recognised that volunteers could be trained in basic survey techniques. So since 1988 the Wildflower Society has been documenting flora and vegetation, by survey work involving volunteers. Two important features of the project have been the emphasis on plant communities, not just individual plant taxa, and the support of professional botanists to each group of participating volunteers.

The program consists of a series of survey weekends or single days if close to Perth. One day workshops to teach the survey techniques are also included. The greatest activity is in spring with field work being the most popular aspect of the program. The field surveys are followed up by identification workshops at the WA Herbarium. Field herbariums have been prepared by volunteers for many of the study areas, many specimens have been vouchered and reports detailing the flora and vegetation published.

THE PROCESS

Funding and Support

The program has been funded from various sources and to variable degrees over its life. The fundamental reason for funding is to provide co-ordination of the program and to have survey projects led by botanists. In addition, many botanists have contributed of their time and expertise in a voluntary capacity. The Department of Conservation and Land Management (CALM) has supported the project since 1988, The Department of Environment (formerly DEP) since 1994 and grants of various amounts have come from the Australian Heritage Commission under the National Estate Grants Program (1991-92), The National Landcare Program, Save the Bush, Natural Heritage Trust (NHT) (1995 -2002). In addition some projects have been funded by local groups (City of Melville, Goodlands –Kalannie Land Conservation District and Yenyenning Lakes Management Committee). In some years projects have proceeded without funding except for the support of the Wildflower Society.

Volunteers participate completely at their own cost and until September 1993 at their own risk. In 1993 the program registered with the CALM Community Involvement Program which provides volunteers with public liability insurance during their participation in surveys. The use of facilities at the WA Reference Herbarium and support from the Herbarium staff have also been invaluable.

Survey locations and Site selection

The first surveys took place on the Northern Sandplains between Moore River and Jurien and then between 1990 and 1996 on the Swan Coastal Plain (Gingin to Busselton) where 190 sites were surveyed. These surveys demonstrated the success of offering interested members of the public and future Wildflower Society volunteers the opportunity to both participate and receive training in vegetation and flora survey.

In 1996, under Federal Government funding the Society employed a co-ordinator and the program was able to extend survey work out into the Wheatbelt. Expressions of interest for surveys to be conducted on private or local government land (at no cost to the landholder) were invited, with responses from landowners, Landcare Groups and Local Councils. The number of applications was always far in excess of the number of surveys it was possible to undertake. For example, in 1966 five sites were selected from twenty-two applicants. The number of applications increased each year until completion of this phase of the project in 2002. Selection of survey sites was based on the following criteria:

- level of protection: fenced and ungrazed a minimum criterion
- the level of knowledge about the site: if poor in greater need of survey
- level of community participation
- the value to the community in surveying the site
- the bushland conservation value of the site in a local and regional context
- accessibility to the site: given the limited time and the involvement of volunteers, the sites need to be fairly accessible
- size of the site: preferably able to conduct a significant portion of the first field survey over a weekend period

In 2003 a survey was undertaken at Eurardy Station in the Northern Wheatbelt and in 2004-5 work has returned to the Swan Coastal Plain, Darling Scarp and Whicher Range.

Methods

The survey methods are described in *Bushland Plant Survey: A guide to Plant Community Survey for the Community*, a field guide written by Bronwen Keighery and published in 1994 by the Wildflower Society as part of the program. It was developed from established methods and adapted for use by the community. It is now a regularly sought after text for professionals and community involved in bushland survey. The field survey does not require a strong knowledge of botany and there is a task for everybody, with numbers of participants limited if necessary to ensure this holds.

The survey methods are based on the ecology of the study areas and use systematic quadrat recording in different vegetation types. Quadrats provide a consistent framework for survey, necessary in vegetation with such a high diversity of plant species (from 7 to 90 different vascular plant species have been recorded per 10m x 10m quadrat (eg. Gibson *et al.* 1994). The value of quadrats is that they

- Establish a systematic procedure for the collection of information by volunteers
- Focus attention on sampling all plant species in the area of the site, helping to avoid concentrating on common or conspicuous ones
- Provide the basis for structural and floristic descriptions of plant communities
- Establish baseline information for the plant species list
- Establish sites for monitoring change in plant communities over time.

The field surveys yield a collection of specimens for identification, including some of importance for vouchering at the WA Herbarium and for compiling of field herbaria. An identification workshop is held at the WA Reference Herbarium following each survey and the survey botanist is responsible for completion of this part of the project. A small band of dedicated volunteers meet regularly at the Herbarium to help carry out this time consuming work.

OUTCOMES

- Reports detailing flora, vegetation and conservation values have been produced for each survey. These reports also provide information to assist with management and revegetation. The surveys have also provided information to help in the identification of a conservation reserve network for the state. A list of reports is provided on the Wildflower Society website: http://members.ozemail.com.au/~wildflowers/
- Field herbaria have been compiled for many projects, particularly those in the Wheatbelt. These are presented to the landholder or community group and a photocopy is also made for retention by the Wildflower Society.
- An increase in knowledge of species distributions and new locations for species of conservation value. Most survey sites in the Wheatbelt for example had taxa of conservation significance (Declared Rare or Priority Flora or previously unrecognised taxa).
- Co-operation with the WA Herbarium including the vouchering of more than 3000 specimens and providing important material for taxonomic work.

- A richer understanding of the values of the bushland to all involved. There is always a wonderful sense of surprise when people are made aware of the wealth of plants in any piece of bushland – a recurring reaction from new volunteers, landholders and community participants. This is helped by the enthusiasm and passion of volunteers involved.
- The program has helped to develop a growing number of people in the community able to conduct their own surveys. Many volunteers now have the confidence and knowledge to be able to work with their shires or community groups to protect their local bushland and to tackle local conservation issues. In addition it has provided valuable experience and training to undergraduate and newly graduated botanists who participated as volunteers, some subsequently as survey leaders.

REASONS FOR SUCCESS

The program has been running for 18 years, some volunteers have been involved throughout its life and new enquiries continue. This in itself is an indication of its success. Based on feedback from volunteers, landholders and community participants some of the reasons for its success are as follows:

- The involvement of people who care and have a passion for bushland and who feel they are assisting in bushland conservation.
- An opportunity to learn in a "**hands on**" manner.
- The opportunity to get out amongst like minded people, to meet people, to make good friends, to be part of improved communication and a link between scientists, landholders and the community.
- Volunteers getting the opportunity to visit bushland they would otherwise not be able to get access to.
- The commitment of professional botanists sharing their knowledge and expertise with volunteers.
- Because information is collected in a scientific manner according to standard survey techniques, it provides projects with credibility and professionalism which is valued by the people requesting surveys.
- Funding support

A CASE STUDY EXAMPLE

McBurney Family: Nyamutin Farm in the Central Wheatbelt south of Pingelly

Part of the McBurney family farm contains 150 hectares of bushland high in the East Yornaning catchment. They recognised their bushland as "something special" and a natural asset. Their accountant had recommended selling it as it was a liability (incurred rates and had no agricultural value and no real estate value). They wanted some confirmation of their belief in its natural values and through the East Yornaning LCDC applied to the Wildflower Society for a survey. The bushland certainly met the selection criteria for survey.

The survey was conducted over a weekend in early October 1998, with 29 Wildflower Society volunteers, the McBurney family and members of the local community involved. Accommodation was in the machinery shed and woolshed and typical country hospitality was provided including a lamb chop barbecue on the Saturday night.

The survey confirmed the high conservation values of the bushland. Five plant communities associated with the laterite and granite soil complexes were identified along with a diverse flora of 308 native plant taxa including five priority (threatened) species, two undescribed species and several species of taxonomic interest (Gunness *et al.* 1999). A field herbarium and report were presented to the McBurney family.

Feedback from the McBurney's when asked about their impressions of the survey included comments such as 'excellent', 'very professional', and the absolute commitment by volunteers and their passion for the bush. The survey reinforced their belief that their bushland was special – even more than they had realised, and gave them a better understanding of the very good condition their bushland was in. It has convinced them that it is a special piece of bush that must be preserved and they have investigated ways of ensuring its ongoing preservation. It adjoins a Class C Crown Reserve and negotiations are currently under way with CALM to purchase the bushland.

CONCLUSION

Over its 18 year existence the Wildflower Society Bushland Plant Survey program has successfully fulfilled a set of objectives which have evolved and can be summarised as follows:

- To introduce the community to bushland plant survey techniques, in particular the recognition of native plants and plant communities
- To aid community groups and individuals (local government, schools, landcare groups, bushland friends groups, farmers and private landholders) to know and care for their bushland through support of survey programs designed to document and monitor the vegetation and flora.
- To foster co-operation, understanding and city-rural links between experienced volunteers and the broader community towards the ongoing conservation and management of bushland

This is a community based program which serves to INSPIRE, EDUCATE and REWARD.

REFERENCES

Listed at end of Kate Brown's paper

GROW WITH US

Mary Gray
Mary Gray, Convenor Garden Committee,
Wildflower Society of Western Australia PO Box 64 Nedlands WA 6909

> 'Less than 1% of plants grown in home gardens are Australian plants. Yet there is so much creative opportunity, so much beauty, and so much variety in our own flora. The shapes and colour of leaves, delicacy of flowers, the variety of plant habit, colours and textures of soil and woody trunks, and the plethora of birds and insects which visit.
>
> It is hard to understand why there is so little use of our unique flora in gardens of Perth. The potential for creating some very special gardens with Western Australian plants is endless. However it is the design and presentation of a garden which is so critically important. In the past 'native gardens' or 'Bush Gardens' have generally been so badly designed or not designed at all that they have given us a bad name. It is time we moved beyond this impasse and start growing some fabulous gardens that will give Perth the recognition of its incredible flora. *We must start with the basics of good design.'* (Wildflower Society of Western Australia (Inc) 2002)'

This is a quote from 'Grow With Us' in the section on garden design.

So what is 'Grow With Us' and how did it all start?

In August 2001 I had my native garden open to the public under the Australian Open Garden Scheme. Weatherwise, August is a risky time of the year, but luck was with us and both days were fine sunny days. Over 1000 people turned up in a steady stream to look at an inner city garden on an old-fashioned quarter acre block in Mt Lawley. They came with note books in their pockets and a thirst for information, asking questions about everything. The water crisis inspired many but there was also a great interest in WA plants. Claire Welsh was there and she announced: - "Mary we will have to do something about this".

So we formed a Garden Committee and got to work to respond to the surge in public interest in our plants. Committee members were Janet Atkins, Hazel Dempster, Lin and Jim Barrow, Sybil Speak, Mary Gray and later Elizabeth George joined us. First of all, we encouraged members - with branch support - to open more gardens under the Open Garden Scheme. Eastern Hills and Northern suburbs branches came to the party and helped Janet Atkins (Mundaring) and the Zagrevskys (north coastal) display their fabulous gardens.

Our next step was to seek guidance from Society members by holding a workshop in February 2002. What would we promote? What would we advocate against? What basic principles would we work from and what will we actually do? We needed to sing the same song and have the support and inspiration of our membership.
So from the workshop we decided on 5 goals:

- to promote WA plants and especially those most suited to growing in gardens
- to promote good garden design and the beauty of individual WA plants
- to promote gardening practices compatible with the harsh realities of our Perth environment and which are not environmentally damaging
- to reach out to people in the wider community who are keen to learn and grow some WA native plants
- to involve members and branches widely in our activities

Plants to be promoted are expected to meet four criteria

- they are attractive
- they can be grown with little added water in poor soils once established
- they are available
- they are native to WA

These 5 goals and 4 criteria for selecting plants underpin everything we do in our *'Grow With Us'* activities. The workshop gave us lots of good ideas for activities and away we went.

We identified a considerable gap in the information available for people starting out in their quest to grow a good native garden. There is plenty of information about *what* local plants to grow but little about *how* to grow them. *So in 2002 we decided to produce a resource kit "GROW WITH US" and to have it ready to launch at the Wildflower Society's Spring Fling* in September where it was launched by Marion Blackwell.

'Grow With Us' is designed to show the home gardener of Perth how to grow wildflowers in their garden. We decided what sections were needed, used existing material if we could find it, and wrote the rest ourselves. Sections include garden design, soils, plants (- how to choose them, plant lists for soil types of Perth, where to buy plants, and how to plant them); maintenance, references and further help, and of course a membership form.
The kit is in a loose-leaf folder so that gardeners can insert their own additional information. We assemble them ourselves (Sybil does!) and they have sold well.

But just producing a resource kit is not enough. Within the context of ongoing water restrictions and far too much lawn around Perth, Hazel Dempster and I managed to convince the Water Corporation to sponsor a set of 6 *'Waterwise Growing Workshops'* in 2003. The Water Corporation also generously offered to advertise the workshops in a local newspaper.

This enabled us to contract Sue Dempster to co-ordinate and run the workshops. We attracted small numbers but produced very satisfied graduates. The workshop for landscapers however attracted about

80 keen participants. Sue has continued on, targeting the landscape industry, by running her own 'Four season Seminars' and we attend with our book stall and helpers.

Rather than run our own workshops we now take our book stall along to the State Government funded **'Great Gardens'** Workshops run each autumn and spring. This contact with the gardening public has kept our book sales moving and we gain a steady stream of new Wildflower Society members. And we don't have to do any of the organising.

Our other major opportunity to interact with the gardening public is at **Garden Week** - put on by the horticultural industry for a week each autumn. Each year we have put a lot of creative effort into an eye catching display of local plants, plant sales -supplied by Northern Suburbs branch-, book sales, and we do *a lot of talking with gardeners* and give copious free advice. Each year the format and theme is quite different. The knowledge and expertise of Hazel Dempster and Janet Atkins as chief designers and supervisors of the display make it all happen. Sybil runs the book sales and many members go on the rosters each year and share their vast knowledge with the gardening public.

There are many other activities we have conducted to spread the word:

- Webmaster Jim Barrow has added a 'Growing Section' to the Society's web site.
- In 2002 Nurseryman George Lullfitz presented the Society's biennial public lecture: *A New Image for Australian Plants'.* It was a full house at Midland TAFE college.
- Since 2003 we (ie Hazel, Elizabeth and Janet) have contributed articles on growing WA plants to each edition of the *WA Gardener Magazine*
- Janet Atkins Hazel Dempster and I were involved in an initiative by the Eastern Metropolitan Regional Council to develop *'Guidelines for local government for landscaping with native plants'.* A nice draft booklet was produced but unfortunately has gone no- where.

All these activities have been very well received by the small percentage of people who want to change their gardening habits. We are however dealing with very few people. Just a drop in the ocean. During this process we have become ever more aware of the magnitude of the cultural change needed to shift a mindset still firmly entrenched in European plants, green lawns, deciduous trees, all grown with copious quantities of water and fertiliser. TV garden shows and gardening magazines continue to reinforce this attitude and promote the instant garden with mature plantings of plants alien to the harsh Perth environment.

Change will only come with comprehensive and long term education and awareness programs, backed up by payment for the real cost of water used whether reticulated or abstracted directly from the environment (groundwater, streams).

Government policy however has not helped. We have heard the Premier saying *'we are not going to have a total sprinkler ban because we dont want a brown Perth'.* Water is far too cheap here and charges are inequitable across commercial industrial and domestic sectors. The Water Corporation gives householders a $300 rebate for a backyard bore. If 3 neighbours get together and put down 1 bore between them, they each get $300, so that is $900 toward the cost. Meters are not required and the water they use is free. This has taken the pressure off scheme water but it has also been counterproductive. New bore owners over water with inpunity: daily reticulation for far too long is common practice. In new suburbs on the urban fringe, you can see acres of green lawn, a few inappropriate palm trees, agapanthus, a few TV strappy plants and not much else.
In the commercial sector, vegetable growers do not pay for water from their private bores and they are the biggest consumers.

The Nursery industry has done little to shift fashions toward local WA plants and we believe they need to change their attitude dramatically. Most nurseries sell only a few native plants, staff often don't know their WA plants, and WA native plants are usually not identified, let alone where the plant comes from.

The exceptions are the few specialist native plant nurseries, and Zanthorrea Nursery in Maida Vale is an outstanding example. Last year Jean, Alex and Jacqui Hooper received the 'Wildflower Society Award' for their contribution to the industry and the growing of the *West's Wonderful Wildflowers.*

LOOKING AHEAD

We are not happy with the Water Corporation, the Nursery industry, and government policy on water and gardens. And there are areas that we in the Wildflower Society need to work on too.

- *Starting with ourselves the Wildflower Society:* we need to focus on promoting the beauty of individual plants. Also we need to show the public more members gardens filled with WA plants.

- *The Water Corporation* needs to modernise its attitude to the plants they promote rather than using the same old 1970's mindset of unsuitable plants. An improvement to its web site, and more friendly ads would make a good start. The Water Corporation needs to uphold Environmental law and meet Ministerial limits set for groundwater abstraction rather than breaching them as they have for the last 5 years- thereby accelerating acidification and drying of wetlands on the Gnangara Mound.

- *The Government via the Department of Environment* needs to get serious about maintaining environmental values on the Mounds. The EPA recently released its stinging annual compliance reports of groundwater abstraction from the Gnangara and Jandakot Mounds.

- *The nursery industry* needs to get its head out of the sand and take up a real interest in plants again, especially our WA plants. The community is filling the gap to a degree by leading the way ahead and our plant sales are a sellout. Commercial nurseries take note.

- *All sectors* need to fill the huge gap in knowledge and understanding of growing WA plants with effective community level education. The **Great Gardens** workshops are a good start but need more focus on our own WA plants and less on 'soil amendment' and all manner of products other than plants.

- *The Government* needs to fund programs to develop amenity planting and tourism here in WA. There is funding of floraculture for export of cut flowers but not for landscaping.

- We need to stop watering so much and get away from the paranoia of a brown Perth

- *Government policy* needs to recognise the limitations of our climate, soils, wetlands and *declining* water resources and adjust water prices and policies accordingly.

ACKNOWLEDGEMENT
Grow With Us is the outcome of the co-operative and collective effort of all the members of the Garden Committee, with active support from many Society members. I wish to acknowledge the willing commitment of each of them.

MANAGING ENVIRONMENTAL WEEDS IN BUSHLANDS OF THE SWAN COASTAL PLAIN

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INTRODUCTION

The Banksia, Tuart, Marri and Jarrah woodlands, the shrublands and the species-rich heathlands and the wetlands of the Swan Coastal Plain and Darling Plateau are wonderful places. They contribute to Perth's unique natural landscapes, provide a window into the natural world, habitat for native fauna and support an extraordinarily diverse flora. They are fast disappearing though, mostly under urban development. Those bushlands that remain face a range of threats; one of the most serious is invasion by environmental weeds.

Some of the most serious environmental weeds that threaten Perth's Bushlands are South African species, principally the perennial grasses as well as bulbous and cormous species. Many of the perennial grass weeds particularly Veldgrass (*Ehrharta calycina*) spread into bushland displacing the native understorey species, increasing fuel loads, and altering the structure of the native vegetation. Many of the South African bulbous and cormous species including Freesia (*Freesia alba* x *leichtlinii*) Watsonia (*Watsonia meriana*) and Harlequin Flower (*Sparaxis bulbifera*) will move into relatively undisturbed native vegetation and form dense monocultures displacing native herbs and shrubs.

WEED MANAGEMENT

Protection of our unique bushlands from these weeds is about carefully targeted on ground actions that prevent introduction or spread of weeds, and work towards their control and sometimes their eradication while protecting complex natural systems. Friends groups and community volunteers carry out much of the bush regeneration and environmental weed management in Perth at present, and for them access to technical resources is particularly important. The bushlands of south west Western Australia support such an incredibly diverse flora and effective management is often about knowing and understanding individual bushland patches. Technical support is also important for setting up replicated trials to test various control options for serious weeds, and the impacts of those control options on native plant communities. This approach provides solid data to guide management actions, and also provides demonstrable outcomes to potential funding sources. At the same time, community volunteers involved gain an understanding of the options available, including the practicalities, costs and impacts of various physical and chemical control methods. They are then able to make informed decisions about implementation of those control options across particular bushland sites.

In 1998 the Environmental Weeds Action Network (EWAN), with funding from the Natural Heritage Trust, employed a project officer to work with community volunteers and local and state government land managers at bushland sites across Perth's Swan Coastal Plain. The underlying objective was to provide technical support to these various land managers so they could develop strategies for effective weed management in their bushlands. Much of this work is continued through the Department of Conservation and Land Management's (CALM) Urban Nature Program. The following examples are drawn from these projects.

Shenton Bushland

Work with the Friends of Shenton Bushland on management of Yellow Soldier (*Lachenalia reflexa*), a South African cormous weed, focused on determining effective management of the weed where it invades Banksia and Tuart woodlands on calcareous soils of the Swan Coastal Plain.

With a single annually renewed bulb, Yellow Soldier appears to spread prolifically by seed. Seed capsules contain around 60 seed and there are usually between 2 and 10 capsules per plant. Fire does not appear to kill bulbs as plants flower prolifically the first season following fire. (Duncan 1988).

Distribution of Yellow Soldier in Shenton Bushland does not necessarily follow disturbance with populations extending into relatively intact bushland.

Interestingly the populations are generally quite discrete suggesting that the seed is not dispersed over very long distances. Fire is possibly plays a role in spreading Yellow Soldier within the bushland, reducing competition from the native vegetation and creating bare areas where the seeds can germinate.

The work in Shenton Bushland investigated the effectiveness of hand-removal and two herbicide treatments on the control of Yellow Soldier and the impact of each treatment on co occurring the native flora. Spot spraying with Brush-off ® (metsulfuron methyl) at 0.2 g/15 L (5 g/ha) reduced the cover of Yellow Soldier by 65 % in one season and appeared to have no significant impact on native shrubs or herbs including native geophytes (Brown *et. al* 2002). In the years since the results of the study became available to the Friends of Shenton Bushland, they have secured funding to implement control of Yellow Soldier across the bushland. A map of the distribution of Yellow Soldier where it was invading the Banksia Woodland helped provide information for costing the project and indicated clear objectives to funding bodies. In the species-rich Banksia Woodland at Shenton Bushland, Yellow Soldier co-occurs with up to 25 native species in a 2 m x 2 m plot and the current policy is to allow indigenous species to recolonise control sites unassisted. In recent times the work from Shenton Bushland has been successfully picked up by other bushland mangers trying to control Yellow Soldiers in their particular patch.

Brixton Street Wetlands

Another geophyte from the Cape Region of South Africa, Harlequin Flower, is a serious invasive weed of clay-based wetlands on the Swan Coastal Plain. An interesting example of management of this invasive cormous species comes from the Brixton Street Wetlands. Lying 20 km south east of Perth at the foot of the Darling Scarp, this small 19 ha remnant on the winter-wet flats of Guilford formation clays has an exceedingly diverse flora of 307 native taxa (Keighery and Keighery 1991). Species rich herblands cover the winter-wet claypans, herb rich shrublands, the clay flats and *Eucalyptus calophylla* woodland the higher ground where the soil is well drained. With this kind of habitat almost entirely cleared on the Swan Coastal Plain the area is of outstanding conservation value. One of the major threats to the native flora and to the plant communities is invasion and competition from weeds such as Harlequin Flower. Where it invades these wetlands it forms dense monocultures, displacing much of the rich native herbaceous flora.

Initially it was thought the population invading Brixton Street Wetlands could be managed with an intensive hand-weeding program. The first year this was tested it became evident it was going to be extremely labour intensive and expensive. Effective, affordable and appropriate control in the wetlands required a combination of carefully targeted hand-weeding and herbicide application. Herbicide trials put in 1999 indicated that Harlequin Flower could be controlled effectively with metsulfuron methyl (Brush-off®) at 2.5 g/ha (0.1 g/15 L) with limited impact on co-occurring native species in the Brixton Street Wetlands (Brown and Brooks 2003).

The Harlequin Flower populations invading the wetlands were generally fairly discrete and have only ever been spot sprayed. A spray contractor with knowledge of the flora and a background in bushland work has been employed to carry out chemical control on heavier infestations in more disturbed areas and on the drier sites. Meanwhile bush regenerators have been employed in the wetlands through September/October to manually remove small isolated populations in undisturbed areas and populations growing around the edges of claypans where herbicide use is inappropriate. To be effective the project has relied on workers and volunteers having an understanding of the distribution of Harlequin Flower across the Brixton Street Wetlands. Maps of the distribution of the weed have been particularly useful allowing for the development of a carefully targeted works program that has seen workers revisiting and removing small isolated populations over a number of years.

This work has been done in partnership with the friends of Brixton Street Wetlands and partly funded by The Wildflower Society of Western Australia, Perth Branch. The populations of Harlequin Flower have become greatly reduced in the last couple of years and so management has simply involved bush regenerators covering areas where the old infestations were and carefully hand-removing remaining isolated plants.

Friends of Gingin Brook

The last example comes from work with the Friends of Gingin Brook on Taro (*Colocasia esculenta*) where it invades the fringing vegetation along the Gingin Brook. The Gingin Brook, 150 kilometres north of Perth, is fed by perennial springs arising from the hills north east of the Gingin townsite. One of the last remaining patches of fringing vegetation left along the brook, where it crosses the heavier soils at the base of the Dandaragan Plateau, is located in the townsite. For two kilometres along the brook, Flooded Gum (*Eucalyptus rudis*) and Swamp Paperbark (*Melaleuca rhaphiophylla*) form a dense canopy over an understorey of native herbs, rushes, sedges and ferns. The herbs, *Centella asiatica*, *Persicaria salicifolia* and Water Buttons (*Cotula coronopifolia*) form ground cover. Tassel Sedge (*Carex fasciculata*), Tall Sedge (*Carex appressa*) and the fern, *Cyclosorus interruptus*, tend to dominate the understorey. Where Taro invades it completely displaces the understorey and allows no regeneration of overstorey species.

The Friends of Gingin Brook tried physically removing small (up to 10 m x 10 m) outlying populations, in the summer of 1999. The work was quite labour intensive with corms weighing around five kilos and the biomass left to dispose of significant. Follow-up work was required for the next two years and involved removing small plants that was regrowth from pieces left behind. Although effective on smaller populations, physical removal was not practical for larger infestations.

Also in the summer of 1999 preliminary herbicide trials were established with assistance from the Friends. In December 2000, following assessment of those preliminary trials, all Taro (around one hectare) was cut to the base and painted with a 50 % glyphosate (Roundup®) solution. These plants were up to two to three meters high and beyond the reach of a backpack unit. Six weeks later the regrowth, less than one metre high, was carefully spot sprayed with a 2 % glyphosate (Roundup®) solution + metsulfuron methyl (Brush-off®) (0.05 g/L + Pulse® 2 mL/L). A small 750 mL hand held sprayer was used to carefully target Taro regrowth. The glyphosate provided a relatively fast knock-down of top growth so the area covered could easily be seen. This work was carried out by the Friends of Gingin Brook supervising a Green Corp Team. Project officers also provided on ground support for the work.

Along a monitoring transect established before the work begun, the understorey in fringing vegetation went from almost 100 % cover of Taro to 100 % cover of native species over a couple of years. Only six species of natives made up that cover; Tall Sedge, Tassel Sedge, Swamp Paperbark and Flooded Gum all spread by seed, often in water flow, while *Cyclosorus interruptus* and Native Knotweed (*Persicaria decipiens*) spread rapidly by vegetative means.

The Friends of Gingin Brook continue to work along the brook sharing their knowledge and experience with the growing number of property owners who want to restore their own patch of fringing vegetation.

CONCLUSION

These examples have mostly focused on protection of specific bushland patches. They demonstrate the importance of knowing and understanding particular sites and mostly they illustrate that if we really try, often we can control, manage and sometimes eradicate environmental weeds where they are threatening what remains of Perth's bushlands.

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INTRODUCTION

Fungi are neither plants nor animals but constitute the separate Kingdom Fungi. Fungi are an ancient component of Australian biodiversity. There are many times more fungi than plants in Australia, perhaps 250,000 species or more. The large majority of Australian fungi are yet to be discovered or named. Many of the fungi are unique to Australia, as they have co-evolved with our unique plants and animals. Most plants throughout Australia and the world have beneficial fungi partners – mycorrhizal fungi. World-wide, a non-mycorrhizal condition is more the exception than the rule under natural conditions. One notable group - the Proteaceae represents one of the few angiosperm families in the world predominantly lacking mycorrhiza (Brundrett, 1991). Australian mycorrhizal plants include tall trees, shrubs, herbs and orchids spanning groups such as the Epacrids, Orchidaceae, Myrtaceae, Casuarinaceae, Fabaceae, Goodeniaceae, Rhamnaceae, and Stylidiaceae.

MYCORRHIZAL FUNGI

Mycorrhizal partnerships are one of the common strategies used by Australian plants to obtain nutrients from poor soils in many vegetation types, including in forests, woodlands, and heathlands. A symbiosis between mycorrhizal fungi and plants involves transfer of sugars from plants to fungi and transfer of soil nutrients from fungi to plants. Networks of fungal hyphae radiate outwards from roots into the soil. Fungi networks can explore a far greater volume of soil than roots and act as an extension of the plant root system, resulting in improved nutrient uptake for the plants. Aside from capturing soil nutrients and delivering them to plants, mycorrhizal fungi have many other significant roles in the ecology, conservation and restoration of bushlands. These include:

- Decomposing litter and wood.
- Recycling nutrients.
- Improving plant vigour, and reducing the impact on plants of diseases.
- Linking different plants via fungal networks, e.g. nitrogen-fixing plants to others.
- Contributing to soil organic matter.
- Binding soil and developing soil structure and combating erosion.
- Providing a food source for insects, microbes, and small native mammals such as woylies.

Two broad categories of mycorrhiza are endo- and ecto- mycorrhiza. Ectomycorrhiza are the most predominant type with woody plants. The fungi form a sheath around the fine roots of plants but do not penetrate between the cells. Endomycorrhiza occur with woody and herbaceous plants. They do not have a sheath but the hyphae penetrate inside the plant root cells. Significant types of endomycorrhiza include: (a) Arbuscular mycorrhiza which occur with a wide range of woody and herbaceous plants (Brundrett and Abbott, 2002). (b) Ericoid mycorrhiza which form with Ericales including the epacrids (Dixon *et al.*, 2002). (c) Orchid associations. Many native orchids are dependent on specific fungi to help promote germination of their seeds, and to rapidly colonize soil and acquire nutrients (Batty *et al*, 2002). Orchids which do not have chlorophyll such as the underground orchid - *Rhizanthella gardneri* - rely on fungi to supply carbon via their simultaneous connection to other plants such as *Melaleuca uncinata*.

Far fewer types of fungi form endomycorrhiza than ectomycorrhiza, and endomycorrhizal fungi do not generally produce large fruit bodies. One estimate suggests that there are 5000-6000 species of mycorrhizal fungi in the world with the majority being ectomycorrhizal (Molina *et al.* 1992). Major Australian ectomycorrhizal plants include dominant genera such as *Acacia, Allocasuarina, Gastrolobium, Eucalyptus,* and *Nothofagus.* A diverse range of fungi form ectomycorrhiza. They are the most commonly seen type of mycorrhiza as they produce large fruiting structures, e.g. the mushrooms, toadstools, puffballs, coral and cup fungi, false truffles and truffles or a range of other types often grouped together under the term 'the macro fungi' or 'the larger fungi'.

The taxonomy and surveys of ectomycorrhizal fungi are usually based on their fruit bodies. The fruiting bodies appear at irregular and unpredictable intervals. Therefore biological surveys of fungi require repeated sampling times as any one time will only reveal only a fraction of the fungi present at any location. There is no comprehensive treatment of the Australian ectomycorrhizal fungi. Many fundamental discoveries about Australian fungi are yet to be made. One example is the recent discovery in a Perth urban bushland of a putatively ancient Gondwanan relic fungus *Cortinarius phalarus* associated with *Melaleuca* and *Astartea* (see the PUBF web site at www.fungiperth.org.au). Another example concerns the truffle fungi – all of which are thought to be ectomycorrhizal. There are probably more types of truffle fungi in Australia than in any other part of the world. Over 80 genera and 290 species are known so far in Australia, and there may be between about 1200-2400 species. More than 35% of Australian truffle genera and 95% of truffle species so far known in Australia are endemic (Bougher and Lebel 2001).

FUNGAL PARTNERS AND REVEGETATION

The many fungi present in natural Australian bushlands contribute to the productivity and health of those bushlands. But these fungi take a very long time, if they ever do, to re-establish unaided into badly degraded or revegetation sites in regions such as Australia's wheatbelt (Tommerup and Bougher 2000). Most native fungi are unable to colonize and thrive on the altered soil environment of former farmland. Potential implications of the absence of native fungi in such situations include loss of major soil biodiversity, decline in nutrient cycling processes undertaken by fungi, poor health of plants dependant on symbiotic mycorrhizal fungi, and ineffective re-introduction of fungus-eating animals (Bougher and Tommerup 2003). Sustainable biodiverse revegetation for the long-term may not be achievable by returning the plants alone. The myriad of other organisms that comprise the biodiversity and ecological functioning of natural vegetation must also be returned. Fungi need to be, and can be, assisted back into revegetated areas in order to enhance biodiversity conservation, and to help re-establish the natural processes that have contributed to long-term sustainability of natural vegetation in the past. Techniques for restoring native fungi into revegetation on Australian wheatbelt farms have been developed recently (see the FungiBank web site at www.fungibank.csiro.au). Just as with seeds, it is best to obtain fungi from the local area, as they are likely to be best suited to the revegetation. This also helps to maintain local gene pools.

The significance of fungal partners of plants in Australian ecosystems extends well beyond the fungus-plant partnerships. This is highlighted by Australia's highly biodiverse truffle fungi. Truffles fruit below the ground and produce an odour to attract animals such as woylies and potoroos. The animals dig them and eat them. The truffle spores pass through the gut and are deposited in dung. The dung is often buried by insects and the spores may germinate to form new mycorrhizal associations with plants. Hence there is a three-way interdependence between the truffles, the animals and the habitat plants.

The 3 F's - Flora, Fauna and Fungi and their interdependent linkages need to be considered together for effective conservation and management of the Australian biodiversity and environment. The capacity to implement the 3 F's is currently hindered by the low availability of knowledge about Australian fungi, including their names and relationships, distribution, and ecology. The fungal information base needs to be improved and made widely available for on-ground applications.

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HERBARIUM VOLUNTEER PROGRAM

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The State Herbarium has in excess of 11,500 vascular plant taxa recorded in its information systems, and has received enormous support from volunteers. Programs involving volunteers include: Regional Herbaria; Imaging program; Reference Herbarium; specimen mounting; specimen placement and public identifications. Neville Marchant, an early President of the Murdoch Branch of the Society and the Society will describe these programs.

TWENTY YEARS OF PLANT SURVEY ACROSS THE STATE

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INTRODUCTION

Western Australia is larger than most countries, extending from the tropics to the temperate and contains an area regarded as of world significance because of the diversity of it's flowering plants. Despite this, when I commenced work in 1974 as the Kings Park Research Officer even the most common and dominant species where poorly documented. For example when we did the first rare flora inventory for the State in 1979 (23) and used, as a basis a list species with less than five collections, there were several thousand, including Marri. Obviously most of these were neither rare nor endangered.

As a consequence a personal focus of my work has been on the distribution and variation of all species, both common and rare, and the communities and habitats in which they grow. A selection of publications arising from this work are numbered in sequence in the reference list. The references are listed in the text under these numbers, but a more extensive bibliography can be found on Naturebase (www.naturebase.net/science/science papers.html), by searching under the author or subject.

Over this time my professional focus has gradually evolved from working as a plant geneticist at Kings Park to a survey botanist with the Department of Conservation and Land Management (CALM). At Kings Park my survey work began with involvement in conservation through reserve planning in the Perth area ('System Six', DCE 1974) which, in itself led to a long term interest in weeds (21) and then developed and shifted through three key projects - collection of horticultural material and then a survey of the Stirling Ranges (7); the Eastern Goldfields Survey (1978-1995, 10) and the Mitchell Plateau Survey (1980).

In 1984 I began work in a dedicated survey position as Regional Survey Botanist in the Department of Fisheries and Wildlife. In 1985 this Department amalgamated with National Parks and Forestry to become CALM. This presentation largely covers these decades as CALM is 20 this year. Since the late 1980's aspects of this work has been with the Wildflower of WA's Survey program.

SURVEY 1984 - 2004

The Surveys

Since joining CALM I have participated in survey at a variety of levels.

- **Regional Survey**
  I have participated in, undertaken or lead eight regional surveys: 1984 Nullarbor (2); 1986 Kimberley Rainforests (5); 1980-2005 Swan Coastal Plain/Scott Plain (6,9,12,13,16,18); Warren Bio-region (14), Carnarvon Basin (17); Wheatbelt (22) and the Pilbara (current).
- **Subregional and Specific Area Survey** (over 300 reserves, national parks and bushland areas) Subregional; and Specific Area Survey including Cape Range (8), many national parks, nature reserves and bushland areas (1,4,7,12,15,18), including all offshore islands from Lancelin to Carnarvon (19).

The aim of these surveys has always been to gather high quality information and to make this available to fellow researchers, reserve managers, planners and the community. Thus, publication of the results in a wide variety of forms has always been the aim and has almost always been achieved.

OUTCOMES

These wide ranging surveys have led to relocation and discovery at the genus, species and community level, including:

- rediscovery of "presumed extinct" species and one genus (*Meziella*, 6);
- previously unknown species;
- new records for Western Australia in both native and naturalised species;
- many large range extensions; and
- some very significant communities.

Some of these discoveries which will be the subject of the address are summarised in Table 1.

Table 1

Communities/Species	**Record type**	**Survey**	**Reference**
Murdannia nudiflora	New record for WA	Mitchell Plateau	
Cleome kenneallyi	new species	Mitchell Plateau	
Darwinia sp. nov.	new species	Stirling Range	7
Velleia exigua	rediscovery, 1851	Stirling Range	7
Tetratheca aphylla	rediscovery, 1887	Eastern Goldfields	10
Logania nanophylla	new species	Eastern Goldfields	10
Chamelaucium paynteri	new species	Eastern Goldfields	10
Senecio euclaensis	new species	Nullarbor	2
Eriochilus dilatatus	new subspecies	Nullarbor	2
Darwinia thymoides subsp. *bella*	new subspecies	Area survey	1
Caesia viscida	new species	Cape Arid survey	
Hydatella australis	rediscovery, 1904	Cape Arid survey	
Meziella trifida	rediscovery, 1842	Scott Coastal Plain	6
Arthropodium preissii	rediscovery, 1911	Swan Coastal Plain	9
Eryngium subdecumbens	rediscovery, 1902	Swan Coastal Plain	9
Phyllangium palustre	rediscovery, 1901	Swan Coastal Plain	9
Actinotus whicheranus	new species	Scott Coastal Plain	
Blennospora doliiformis	new species	Swan Coastal Plain	9,13
Calandrinia sp. Brixton	new species	Swan Coastal Plain	18
Schoenus natans	rediscovery, 1847	Swan Coastal Plain	9
Tetraria australiense	rediscovery, 1902	Swan Coastal Plain	9
Brachyscias verrucundus	relocation, 1986 in 2000	Swan Coastal Plain	
Cymbonotus preissianus	rediscovery, 1966	Wheatbelt	20
Triglochin turrifera	New record for WA	Wheatbelt	22
Arthropodium sp Yenyenning	new species	Wheatbelt	
Rumex crystallinus	rediscovery, 1854	Carnarvon Basin	17
Southern ironstone communities	rare community	Swan Coastal Plain	9,16
Claypans	rare community	Swan Coastal Plain	9

This success in locating new and old species are several. Firstly we have surveyed many places in a rich and poorly known region, some with poor accessibility but others in the city! However, the key factor in these surveys is to record ALL species present, including the weeds and insignificant species, in a consistent and repeatable manner across the landscape or habitats of the survey area. Collections are mostly identified by the group, collated, data based, and analysed.

Concurrently with this. we have always deposited large numbers of vouchers of common, rare new and otherwise interesting collections in the WA Herbarium. In 2004 I have almost 17,000 individual collections and over 10,000 joint collections in the WA Herbarium. The taxonomic results arising from many of the surveys have been published as have the large number of weed records (21).

Most significantly the surveys have aided creation of a better system of reserves for our outstanding flora and the recognition of many rare communities, such as the southern ironstones (16), species rich claypans and even some that are extinct, such as those of the Greenough Alluvial Flats. These highly endangered communities are the subject of State and Commonwealth recovery plans.

These data have also helped show that species richness and rarity is a common feature in South Western Australia. Earlier work showed that the heathland region between Eneabba in the north and Badgingarra in the south supported 37-92 species per 500 m^2 and this was considered exceptionally rich. Regional surveys have shown that such levels are common rather than exceptional and are often exceeded in sites on the Swan Coastal Plain (9) and western Wheatbelt (22). Rarely recorded species are also a feature of quadrat, habitat and reserve scale surveys.

The rediscovery of presumed extinct species is obviously and perhaps ominously slowing, however, the rate of discovery of distinctive new taxa (both subspecies and species) shows little sign of slowing as more detailed local and regional surveys are undertaken. Currently a largely previously unknown and undocumented range of ecotypes and species complexes in many groups are being elucidated as biological survey, genetic and taxonomic studies are correlated (examples: *Hakea trifurcata*, *Samolus junceus*, *Craspedia variabilis* and *Stylidium brunonianum*). This suggests that our flora is richer than we could have imagined in 1974 and that many exiting discoveries still lie ahead.

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A CHALLENGING OPPORTUNITY: PLANTS AND PLANT COMMUNITIES OF THE PILBARA

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The Pilbara biogeographical region in north western Australia encompasses 1.8 million km^2. The region extends from mangal shores on the tidal north west coast through alluvial, colluvial and hardpan plains on inland valley floors which abut roughed and abrupt granitic, greenstone and ferruginous sedimentary ranges that include the highest peaks in Western Australia. To the east and north the region is fringed by the Little and Great Sandy Deserts while to the south the subdued ranges and hardpan plains of the Ashburton and Gascoyne dominate. This region has a characteristically arid to semi-arid climate with average summer maxima exceeding 40°C and winter minima averaging 13°C. Annual rainfall varies between 250 to 400 mm although this is highly variable with respect to season and is strongly influenced by monsoon and cyclone activity. Rainfall is mostly received in summer with spring being the driest time of the year. Soils are characteristically red, skeletal and covered by a stony mantle although deep sands and cracking clays are present.

The vegetation of the Pilbara is poorly documented with the only regional mapping being undertaken in the 1970's at a now inappropriate resolution. This mapping identified approximately 70 vegetation types across the region which is in stark contrast to contemporary mapping, which in some areas has delimited 200 types in less that 0.01% of the region. Contemporary regional scale mapping using land systems as a surrogate for vegetation types delimited approximately 100 types within the region. Conspicuous Pilbara vegetation types are woodlands and shrublands dominated by wattles and grasslands with scattered emergent eucalypts (including *Corymbia*) that are dominated by hummock grasses, although areas of dense woodland and forest exist along some of the large watercourses adjacent to permanent springs and on some of the hardpan plains.

The Pilbara flora has not been comprehensively documented despite considerable biological investigation associated with the resources industry and over 300 years of botanical collection. Nevertheless, the flora is diverse being dominated by arid (eg. *Senna*) and tropical elements (eg. *Cullen*), although a few mesic and rainforest elements persist (eg. *Thysanotus, Clerodendrum*) especially in refugial habits. The juxtaposition of arid and tropical elements, as highlighted by the phytogeographically important "*Acacia-Triodia* line with refugia supporting mesic and rainforest relicts", has significant consequence on floristic diversity and vegetation composition. Over the last 25 years the Pilbara plant list has increased by over 50% to be conservatively in the vicinity of 1300 vascular species. Dominant families, often conspicuous across the landscape, include the Mimosaceae, Papilionaceae, Poaceae, Amaranthaceae, and Caesalpiniaceae, while dominant genera include *Acacia*, *Triodia*, *Senna*, *Sida* and *Ptilotus*. Interestingly, floral elements associated with more mesic semi-arid regions further to the south are conspicuous by their near absence in the region as exemplified by the daisies.

Approximately 100 species are of conservation significance within the region although the overwhelming majority of these are poorly known and ongoing survey is required to assess their status before legislative protection can be conferred. As many of these species are in poorly known or taxonomically difficult groups, ongoing taxonomic investigation is also required to resolve such problems. One vegetation type is currently listed as a Threatened Ecological Community although ongoing investigation is required to substantiate this proposition. Three other types are under consideration for listing. While unsustainable pastoral practices, mining and land clearing for industrial development pose a substantial threat to the botanical diversity of the region, especially at a local scale, the principal landscape wide threatening processes impinging on the integrity of flora and vegetation and the ecosystem processes that sustain the botanical diversity are altered fire regimes and invasive environmental weeds. Addressing these threatening processes in an inventory deficient setting presents both an opportunity and a challenge for botanists in the Pilbara.

PLANT VARIATION IN THE WILD: PATTERNS OF GENETIC VARIATION IN THE FLORA OF SOUTHWEST AUSTRALIA

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INTRODUCTION

Variation in natural plant populations can be investigated at a broad range of levels. These include: (i) the assessment of quantitative (continuous) characters such as leaf shape, number of flowers per inflorescence, seed set, growth rate, time to flowering; (ii) discrete variation such as flower colour; (iii) chromosome variation; (iv) protein variation, in particular isozyme electrophoresis; and (v) nuclear and organelle DNA variation. In this paper the focus will be on geographical patterns of genetic variation at the population and species levels in the southwest Australian flora and in particular how molecular genetic markers have been used to improve our understanding of evolutionary and ecological processes in this rich and highly endemic flora.

Determinants of patterns of genetic variation in plants are extremely varied and often involve complex interactions between plant attributes such as to life-form, floral architecture, mode of reproduction, incompatibility system, pollination system, and ecological and environmental parameters that may influence pollination events, population size and isolation. A further level of complexity can be added when one considers the evolutionary history of the species where events such as climate change and localised extinction, contraction to refugia, range expansion and fluctuations in population size over time can also have substantial influence on the current patterns of genetic variation. In the next section a brief overview is given of our current understanding of the evolutionary history of the southwest flora, probably the most pivotal element determining patterns of genetic variation in plants in this region.

EVOLUTIONARY HISTORY OF THE SOUTHWEST FLORA

The flora of southwest Western Australia is recognized for its remarkable diversity and endemism and is one of the world's vascular flora biodiversity hotspots. The region is characterized by considerable evolutionary complexity, combining refugial species in higher rainfall areas with fragmented relictual species and suites of newly derived taxa in the more arid areas (Hopper et al., 1996). Compared with many other floras, particularly in North America and Europe, this flora has persisted for an extremely long period, probably well into the Cretaceous, without any large-scale extinction episodes associated with glaciation. In addition, widespread climatic and habitat instability have been experienced in this region since the late Tertiary leading to cyclic expansion and contraction of the mesic and arid zones (Hopper et al., 1996). Significant recent speciation is postulated to have occurred during this period particularly through the semiarid transitional rainfall zone of the southwest Botanical Province (Hopper, 1979). However, there is also increasing palaeo-botanical evidence that a relatively high proportion of the flora is more ancient (McLoughlin and McNamara, 2001). Thus it seems likely that a second consequence of the climatic instability since the late Tertiary has been the extinction of many relictual species throughout much of their range but their persistence in geographically restricted and fragmented or disjunct population remnants.

Historical events such as range fragmentation and population bottlenecks will be strong determinants of population genetic structure. Recent gene flow between population groups within fragmented or disjunct species in the southwest, either by long distance seed dispersal or pollen movement, has probably been limited or absent for a long period. A likely consequence is significant genetic differentiation between populations with any phylogenetic similarity being due to common ancestry rather than any ongoing process of genetic exchange. Thus, many taxa are likely to consist of lineages which have been historically isolated for an extended period of time and would be expected to show significant levels of intra-specific variation associated with climatic and physiographic events, and eco-geographic variation. These patterns are particularly evident in rare and geographically restricted species that make up a significant proportion of the high floristic diversity in the region.

PATTERNS OF VARIATION IN THE SOUTHWEST FLORA

Morphological and chromosome variation

Complex patterns of morphological and chromosomal variation are evident in the prolific speciation found in many genera in the southwest flora (James and Hopper, 1981; James, 1996). For example, extensive intra-specific morphological variation has been demonstrated in a number of species in *Anigozanthos* (Hopper and Campbell, 1977), *Conostylis* (Hopper, 1977) *Acacia* (Hopper and Maslin, 1978) and *Eucalyptus* (Kennington and James, 1998). Many of the species investigated are found in the transitional climatic zone and the variation observed can be attributed to climatic and physiographic events.

Fragmented and dissected population systems are also associated with the development of complex cytoevolutionary patterns in species such as *Isotoma petraea* and *Stylidium crossocephalum.* The evolution of complex hybridity *in Isotoma petraea* in southwest Australia appears to be indicative of the evolutionary dynamism of this region. This species occurs in relatively small isolated populations found on granite outcrops and other rocky areas scattered over much of arid central Australia. Throughout most of its range it is outbreeding and its chromosomes structurally homozygous forming seven bivalents at meiosis. However, in southwest Australia populations have developed a system of complex heterozygosity involving a series of reciprocal chromosome translocations that has also evolved in conjunction with inbreeding. A large body of evidence indicates that the evolution of this genetic system started at Pigeon Rock with a multiple interchange ring of six chromosomes and progressed in a south westerly direction, ultimately leading to populations with ring of 14 complex heterozygotes at Mt Stirling (James, 1965; James et al. 1990).

Stylidium crossocephalum shows extensive polymorphic and polytypic chromosome variation with karyotypic forms characterising populations or population clusters across its range from Perth to Geraldton. The dissected nature of the populations means that geographical isolation is likely to result in limited gene exchange between populations and chromosome forms. Studies on hybrids between the chromosome forms also indicate that chromosomal sterility barriers will further inhibit genetic exchange between localities with different chromosome complements (Coates and James , 1979).

In both these cases chromosomally distinct geographically isolated populations, or groups of populations, behave as independent lineages with little or no current gene exchange between them. In addition, chromosomal sterility barriers will effectively reinforce barriers to gene flow that exist due to the geographical restriction of pollinator movement between populations.

Molecular genetic variation

The high levels of morphological and chromosome variation between populations within species and between closely related species are also reflected in relatively high levels of genetic differentiation based on molecular genetic markers. This differentiation has been shown to be typical of species in a number of southwest genera and is particularly evident in rare and geographically restricted species. Relatively high levels of population differentiation based on isozyme studies, nuclear DNA and cp (chloroplast) DNA have been reported for 22 animal pollinated mainly outcrossing taxa with disjunct populations systems. These taxa cover a range genera including long-lived woody shrubs and trees, and herbaceous perennials (Coates 2000).

A typical example of this population differentiation can be found in *Lambertia orbifolia*, a large bird pollinated woody shrub known only from seven populations that have a significant disjunct distribution (Fig 1). Allozyme studies show that the genetic divergence between all populations is very high. Phylogenetic analyses based on either gene frequency data or genetic distance give identical tree topologies and indicate that the two disjunct population groups are separate evolutionary lineages. The analysis of cpDNA variation confirms this conclusion (Byrne et al., 1999). Inferences based on the proposed long term effects of Pleistocene climate change on the southwest flora suggest that the current population genetic structure in *L. orbifolia* is the result of local extinction of intervening populations, and extended isolation of the two remnants (Coates and Hamley, 1999). This is supported by studies on large endemic forest eucalypts in areas between the two population groups that show patterns of local extinction and range contraction due to climate change (Wardell-Johnson and Coates, 1996). Similar patterns have been observed in other rare and threatened species from most parts of the Southwest Botanical Province (Table 1).

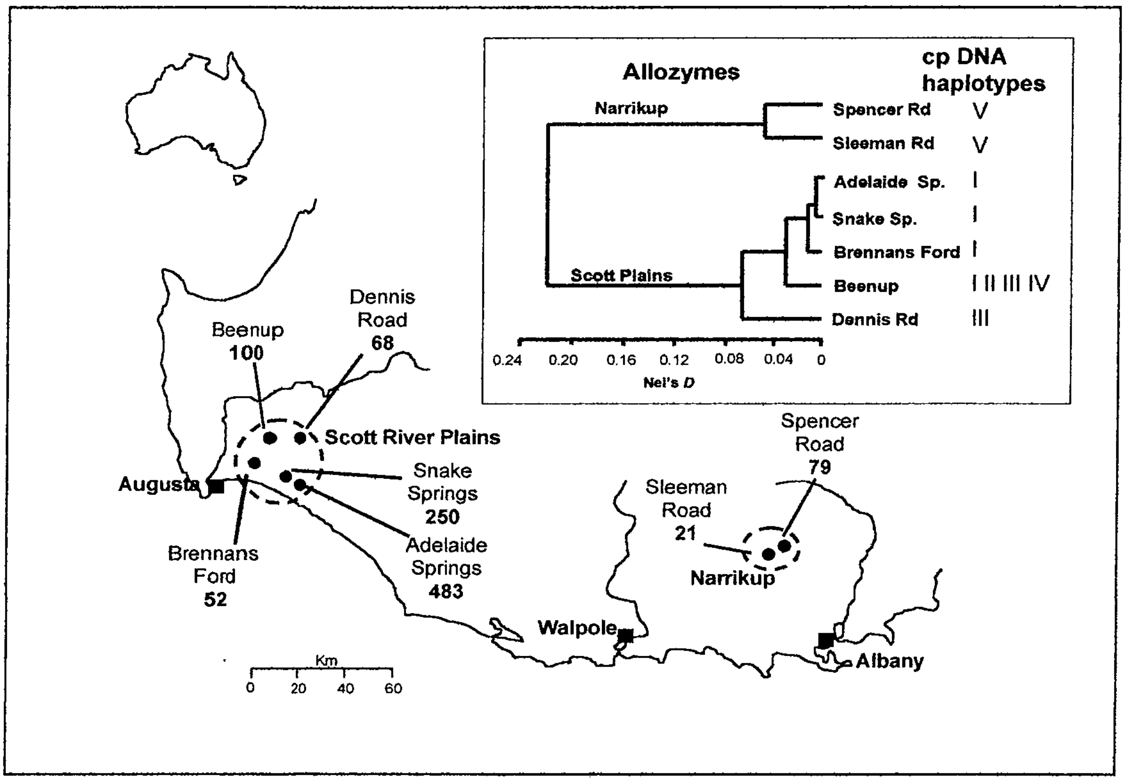

Figure 1: Phylogenetic relationships based on UPGMA of allozyme data and geographical distribution of disjunct populations (Scott River Plans and Narrikup) of *Lambertia orbifolia.* Population size (number of reproductively mature plants) is given after each population name. The analysis of cp DNA variation based on RFLPs detected eight mutations distributed over five haplotypes (I - V) with the Narrikup populations distinguished by a single haplotype characterised by six unique mutations.

Another example, clearly demonstrating the complex patterns of variation in this flora is the *Stylidium caricifolium* complex (Coates et al. 2003). Seven species are currently recognised: *S. affine, S. chiddarcoopingense, S. caricifolium, S. maritimum, S. nungarinense, S. sejunctum,* and *S. wilroyense* covering a significant proportion of the southwest region (Fig. 2). Species in the complex show remarkable variation in their geographical distributions from widespread to a range of only a few kilometres. They are found in a diversity of habitats, from coastal dune systems (*S. maritimum*), to high rainfall Eucalypt forest (*S. affine*), through to semi-arid Eucalypt woodland and shrublands (*S. sejunctum*). All species have allopatric or parapatric distributions, with *S. caricifolium* and *S. affine* the only exceptions that have relatively large zones of parapatry where hybridization has also been documented. A number of taxa are extremely closely related with *S. affine, S. caricifolium,* and *S. nungarinense* thought by some to differ only at the subspecific level and *S. maritimum* considered conspecific with *S. affine*. Another taxon, *Stylidium* sp. [Clackline], thought to be a stabilized hybrid derivative of *S. affine* and *S. caricifolium,* also is known from a geographically restricted area between the two putative parents. With the exception of *S. nungarinense* and *S. chiddarcoopingense,* species within the complex have very different chromosome complements (Fig. 2) including, in a number of cases, different chromosome numbers. The level of genetic differentiation between taxa was high indicating more ancient speciation events. At the population level differentiation was also high in most taxa supporting the notion that long term population fragmentation and disjunction are features of these species and major factors in speciation in this complex.

Species	*D* (SE)
Lambertia orbifolia	
Scott River Populations	0.042 (0.009)
Narrikup Populations	0.049
All Populations	0.142 (0.024)
Acacia anomala	
Chittering	0.030 (0.006)
Kalamunda	0.091 (0.025)
All populations	0.152 (0.020)
Between Groups	0.243 (0.016)
Stylidium coroniforme	
Wongan Populations	0.109 (0.021)
Maya Populations	0.016
All Populations	0.207 (0.041)
Between Groups	0.289 (0.040)
Stylidium nungarinenese	
Southern Populations	0.054 (0.016)
Wongan Populations	0.011 (0.004)
All Populations	0.197 (0.149)
Between Groups	0.325 (0.010)

Table 1: Measures of genetic differentiation (*D, genetic distance*) among populations of disjunct plant taxa in southwest Western Australia.

Finally recent phylogeographic studies on common species in southwest Australia indicate some commonality in geographical patterns although the findings here again are generally more complex and as with other studies reflect a much more ancient pattern of population evolution associated with climatic instability since the late Tertiary. Studies on two species based on cpDNA variation, *Santalum spicatum* (Western Australian sandalwood) (Byrne et al., 2003) and *Eucalyptus loxophleba* (Byrne and Hines, 2004) indicate two geographically distinct haplotype lineages showing a north south separation. In both species past fragmentation was considered the most likely cause of the differentiation between the lineages. The level of sequence divergence between lineages was similar in both species and suggests a mid-Pleistocene time frame for this divergence. This shared phylogeographic pattern is consistent with a hypothesis of significant climatic fluctuations during the Pleistocene and provides further evidence for the view that such climatic instability has resulted in significant historical fragmentation events in the flora of this region.

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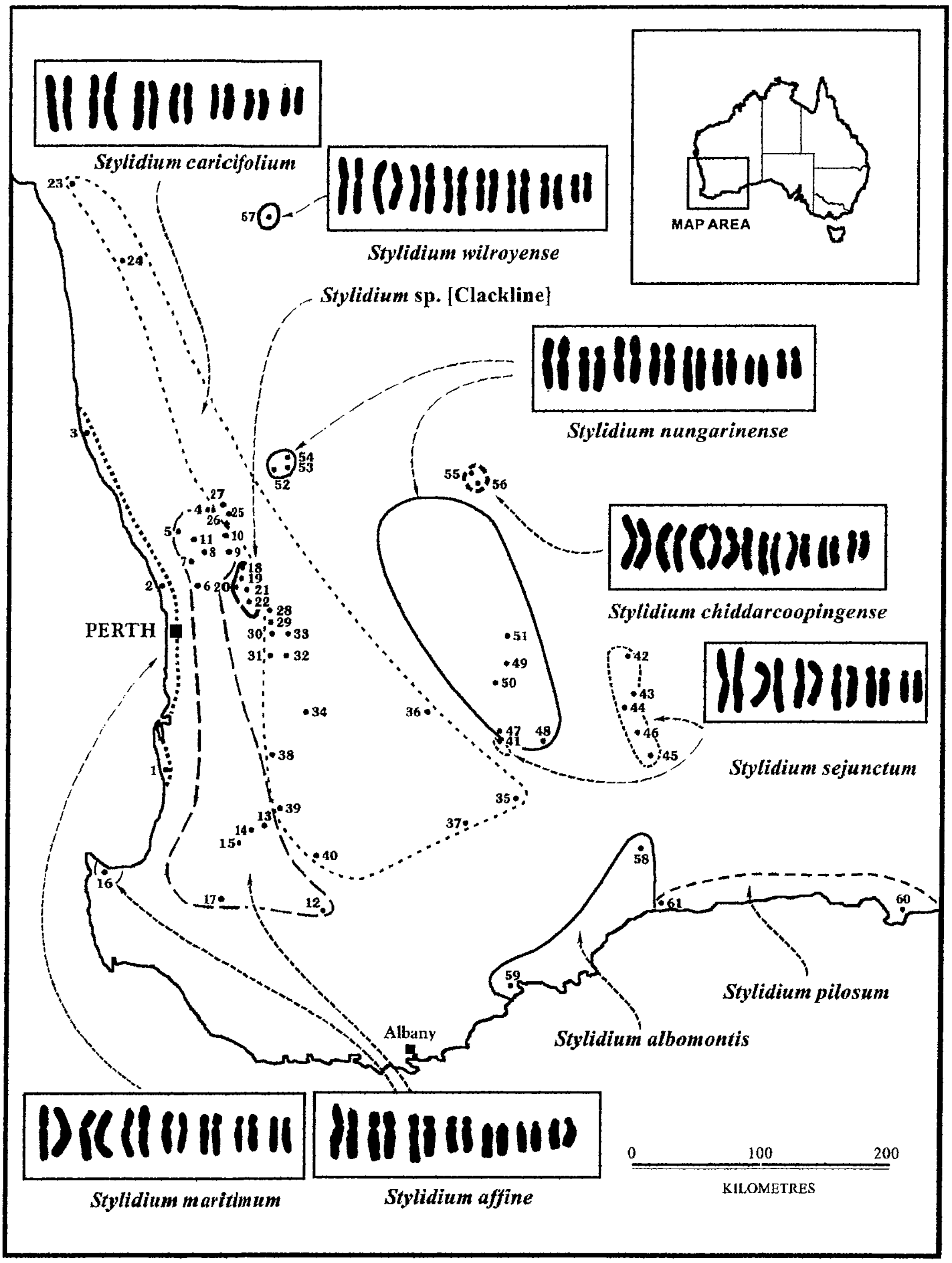

Figure 2: Distribution, karyotypes and sampled populations for taxa in the *Stylidium caricifolium* complex and two closely related taxa *S. pilosum* and *S. albomontis*. Because *S.* sp. (Clackline) is chromosomally variable and probably of hybrid origin, a representative karyotype is not given.

THE GREAT ACACIA NAME DEBATE

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On 16 July 2005 the Nomenclature Section of the XVII International Botanical Congress in Vienna voted to accept a recommendation to conserve the name *Acacia* with an Australian type (*A. penninervis*). This means that the vast majority of the Australian Wattle species will keep the scientific name *Acacia* and will not have to be called *Racosperma.*

This has been an excellent outcome, not only for Australia but also for the hundreds of people around the world who use Australian species for a wide variety of purposes. The decision means that less disruption will occur worldwide by keeping the name *Acacia* for species of the Australian group than would occur had the name been applied to groups that predominate outside Australia. In botanical legalese, it has been judged that global nomenclatural stability was best served by retypifying *Acacia* with a new type species.

This *Acacia* name issue has been much discussed and hotly debated over the past couple of years. This is not surprising because as currently defined *Acacia* is one of the largest of plant genera in the world with species represented on most continents: about 1000 in Australia, 150 in Africa, 185 in the Americas and 95 in the Asia-Pacific region. A summary of much of what has happened over the past two and a half years is presented on the website http://www.worldwidewattle.com/infogallery/nameissue/chronology.php

The decision concerning *Acacia* was an extremely difficult one for the botanical community to make and there were always going to be those who would be unhappy with whatever outcome ensued. Nevertheless, it is important to appreciate that all arguments, both for and against retypifying the genus, were properly considered by the appropriate bodies (commencing with the Committee for Spermatophyta and ending at the plenary session of the IBC) and that the decision reached was consistent with the Rules and Principles outlined in the International Code of Botanical Nomenclature. This has nevertheless, been a contentious issue.

In this talk I will:

- outline the history of events leading up to the final decision that was reached at the IBC in Vienna (see synopsis below);
- summarize the arguements both for and against the proposal to conserve Acacia with a new type (reasons why the various committees voted in favour of the proposal are enumerated below);
- discuss the nomenclatural implications for Australia and other countries following the decision to accept the conservation proposal.

Synopsis of recent relevant matters concerning the proposal to conserve *Acacia* with a new type

July 2005. On 16 July the Nomenclature Section of the XVII International Botanical Congress in Vienna, Austria, voted to accept the Spermatophyta Committee's recommendation to conserve the name *Acacia* by retypifying it with a new type as proposed by Orchard & Maslin (2003). This decision was subsequently ratified at the Plenary Session of the Congress on 23 July.

May 2005: Papers published in Taxon presenting the case in favour of conserving the name *Acacia* with a new type (Orchard & Maslin 2005) and the case opposing this action (Luckow *et al.* 2005).

Nov. 2004. Paper published by Maslin & Orchard (2004a) in response to Pedley's (2004) paper concerning *Racosperma.*

Sept.- Nov. 2004: Decision of Committee for Spermatophyta receives attention in Australian public media. An article titled 'Our wattle gets special naming rights' published by James Woodford in Sydney Morning Herald on 24 Sept. A number of ABC (Australian Broadcasting Commission) radio stations interview Bruce Maslin concerning this issue: ABC Albany, Western Australia (interview with Clare Valley), ABC Adelaide, South Australia (interview with Grant Adams - went to air on 3 Sept.), ABC Riverina, Wagga Wagga, New South Wales (interview with Anne Delaney – went to air on 4 Nov.)

Aug. 2004: Report published by the Secretary of the Committee for Spermatophyta outlining reasons why that committee recommended acceptance of Orchard & Maslin (2003) proposal to retypify *Acacia* (Brummitt 2004).

Aug. 2004: Announcement of Spermatophyta Committee's decision to recommend acceptance of the Orchard & Maslin (2003) proposal to retypify *Acacia* was posted on the Australian Botanic Gardens website at http://www.anbg.gov.au/cpbr/taxonomy/acacia-conserved-2004.html.

Aug. 2004: Paper published by Maslin & Orchard (2004) concerning the Spermatophyta Committee's decision to recommend acceptance of their proposal to retypify *Acacia.*

June 2004: Committee for Spermatophyta voted to recommend acceptance of the Orchard & Maslin (2003) proposal to retypify *Acacia.*

March 2004. Paper published by Maslin responding to issues raised by Walker & Simpson (2004) who opposed the retypification of *Acacia.*

Feb. 2004: Paper published by Pedley (2004) advancing arguments for the adoption of *Racosperma* over *Acacia* for the Australian species.

Feb. 2004: Additional documentation submitted by the Secretary of the Committee for Spermatophyta (see Dec. 2003).

Feb. 2004: Paper published by Walker & Simpson (2004) advancing an alternative view to the Orchard and Maslin proposal of May 2003.

Feb. 2004: Notice submitted by Maslin to editors of various Australian newsletters advising that it is inappropriate at present to adopt the name *Racosperma*; a similar notice also sent to the Council of Heads of Australian Herbaria.

Dec. 2003: Paper published by Pedley (2003) effecting remaining combinations of Australian Acacias into *Racosperma.*

Dec. 2003. Relevant documentation submitted by the Secretary of the Committee for Spermatophyta to Members of that Committee in order that they may assess the Orchard and Maslin (2003) proposal to conserve *Acacia* with a conserved type.

2003: Various articles published by members of Australian amateur groups, largely expressing support for the Orchard and Maslin proposal (see Burns 2003, Simmons 2003 and Williams 2003)

May 2003: Formal proposal published by Orchard and Maslin (2003) to conserve *Acacia* with a conserved type following subdivision of the genus.

March 2003: Paper published by Maslin *et al.* (2003) suggesting that it is timely to accept formal subdivision of *Acacia* into a number of segregate genera.

Summary of reasons why committees voted in favour of conserving Acacia with an Australian type (Presented at the IBC in Vienna by Dr R Brummitt, Secretary of the Committee for Spermatophyta)

1. There are 1000 species of *Acacia* in Australia which would otherwise be called *Racosperma*, which constitute by far the biggest genus on that continent, much bigger than *Eucalyptus* for example.
2. There is a multi-billion dollar agroforestry industry based on the Australian species which are now being grown an a vast scale in a number of other countries.
3. The name *Acacia* has a much higher profile among the general public in Australia, where it is their national symbol, than in any other continent including Africa, as evidenced by the numbers of people who sent the letters displayed alongside. [Around 250 letters supporting the Spermatophyta Committee's recommendation were sent to Dr Brummitt ahead of the Vienna Congress: see http://www.worldwidewattle.com/infogallery/nameissue/support.php.]
4. There is a large horticultural industry in Australia based on their native species, which are used in a very great number of different ways.
5. Many of the 1000 species in Australia are restricted endemics which have attracted local and national legislation, and nomenclatural changes will affect the large number of scientists and administrators who the Australian federal and state governments employs in connection with the genus.
6. If the proposal is not accepted, 13 times as many species in Australia will have to change their name as in Africa.
7. Outside Australia 55% of the native species are going to change their names to *Senegalia* anyway, whatever decision is made on the type of *Acacia*.
8. Because of the cultivation (and escape from cultivation) of many Australian species outside Australia, many people in those countries already think of 'Acacia' as meaning "the Australian species".
9. Retaining the name *Acacia* for fewer than half of the species outside Australia will lead to considerable confusion in Africa and elsewhere.
10. Nomenclaturists must take note of the needs of those who use the names of plants.

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CONSERVING OUR ORCHIDS

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Orchids are a very diverse flowering plant family in the wetter climatic zones of Australia, which, unfortunately, coincide with the highest levels of land clearing for agriculture and urbanisation. Most WA orchids occur in the southwest which has a Mediterranean type climate with cool, wet winters, followed by 5-8 months of summer drought when orchids aestivate as dormant tubers. This region is a terrestrial orchid biodiversity hotspot of worldwide significance with over 400 orchid species, most of which are endemic. At present 36 taxa of WA orchids are critically endangered and a further 39 are priority taxa. Orchids in the WA wheatbelt are highly threatened, with 7 species listed as *Critically Endangered* that may not survive without human intervention. Even common species are declining in many urban and rural areas due to habitat loss, weed invasion, declining rainfall and land degradation. These threats can be addressed by recovery actions utilising recent scientific advances in orchid research and conservation that are discussed in this presentation. These actions require recovery teams, which are effective collaborations between universities, government agencies and community groups.

Southwestern Australia is a centre of exceptionally high plant species richness and endemism and is one of the world's 25 biodiversity hotspots where it has been suggested that conservation activities should be focussed. The high biodiversity in this floristic region is thought to result from a long evolutionary history without major tectonic disturbance or glaciation and the low productivity of many habitats due to nutrient poor soils and drought (Hopper & Gioia 2004). These factors allow many species with similar habitat requirements to coexist. Consequently, the Southwest Australian Floristic Region is a living biological laboratory, where extremely high endemism and biodiversity provide unique opportunities to study issues relating to the conservation and management of terrestrial orchids. In particular, it is possible to compare orchids that are common or rare, have very general or highly specific habitat requirements, or have widespread or restricted distributions.

Orchids depend on mycorrhizal associations with a particular group of fungi (the *Rhizoctonia* alliance) for seed germination and survival. Our recent research has established that most WA orchids have associations with a narrow diversity of compatible fungi, but some widespread orchids associate with a wider diversity of fungi (Bonnardeaux et al. unpublished). Translocation attempts with plants and animals often fail due to a lack of understanding of ecological requirements of species. The conservation of Australian orchids depends on mycorrhizal fungi required for propagation of plants in the laboratory and to define suitable habitats for transplantation in the field. Knowledge about how orchid fungus diversity varies between and within habitats will help explain orchid recruitment patterns and why some orchids are extremely rare (Batty et al. 2002). Thus, the capacity to identify and manipulate orchid fungi is an essential cornerstone of orchid conservation.

An orchid seed-baiting technique was developed to detect mycorrhizal fungi compatible with terrestrial orchids by sowing orchids seeds over organic matter separated from soil (Brundrett et al. 2003). This technique allows the time-course of germination events to be observed and results in protocorms from which mycorrhizal fungi can be isolated or orchids propagated. Orchid seed baiting is now routinely used to identify suitable habitats for transplantation of rare orchids. These experiments have revealed that mycorrhizal fungus activity is concentrated in coarse organic matter and litter, suggesting that orchids may be vulnerable to frequent fires conducted for "fuel reduction" in their habitats.

Examples of current orchid conservation projects are summarised below. All of these projects are collaborations between the University of Western Australia, The Botanic Gardens and Parks Authority and CALM.

1. Seed of critically endangered species such as the Granite Spider Orchid, the Lonely Hammer Orchid and the Underground Orchid have been obtained and are being stored as part of an international collaboration (the Millennium Seedbank Project). A comprehensive collection of mycorrhizal fungi from WA orchids has also been obtained. These fungi are the basis for an efficient new method for propagation of terrestrial orchids, which is being used for both horticulture and conservation (Batty et al. 2002, 2005).

2. Recent rare orchid population surveys have included all known habitats of the underground orchid and other rare species. Volunteers, especially members the Friends of Kings Park and the WA Native Orchid Study and Conservation Group, made major contributions to these surveys (Preston and Brundrett 2004).

3. The new orchid seed-baiting method described above was used to locate potential new habitats for rare orchids such as the Busselton Spider Orchid (*Caladenia busselliana*) by testing soil from transects at their remaining habitats. These tests located optimum positions for transplanting orchid seedlings raised in the laboratory. Orchid seed baiting has become a powerful research tool to help us understand why orchids grow in certain locations, but not in others. These studies have increased our understanding of the recovery of orchids in post-mining landscapes and the distribution of orchids in urban bushland (Collins et al. 2005, Scade et al. 2005).

4. Another current project is investigating orchids in urban bushland remnants of varying sizes and conditions. This project is investigating the impacts of vegetation condition on the survival and pollination success rates of Perth's most iconic bushland orchid species (Newman et al. unpublished).

5. A case study focuses on conservation of the Western Underground Orchid (*Rhizanthella gardneri*). Our recent successful propagation of this orchid was a major breakthrough. This resulted from the isolation and growth of its unique mycorrhizal fungus and the establishment of a three-way partnership with broom bush plants in glasshouse pots (Mursidawati 2004). The underground orchid is parasitic on fungi (myco-heterotrophic) and consequently can only survive in soils where that fungus is present (Brundrett 2002). Current projects seek to understand the habitat requirements and nutrition of the underground orchid, with the eventual goal of increasing the size of its populations in the wild (Batty et al. 2004).

6. Due to the great appreciation that many people have for our native orchids, they are effective tools for educating people about environmental issues in Western Australia. Orchids are of particular relevance to conserving urban bushland habitats in WA. Our orchids also are a valuable ecotourism resource. Several examples of educational projects based on WA orchids are discussed, but much more work is required.

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NATIVE PLANTS AND PHOSPHATE.

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All life on Earth needs phosphate (P). To say "Native plants don't need P" is nonsense. Many are very good at managing with little, and some are good at getting it. Because P often determines rate of growth, controlling the supply is an important management tool for all ecosystem managers, whether the ecosystem is small garden or a whole forest. Ergo, better learn something about it!

You need to know just one chemical fact about P: it loves oxygen. So keen is it, that it will burst into fire in air. So keen, that it grabs more than it is entitled to and surrounds itself with four oxygen atoms. The result is the phosphate ion: "PO_4". Because it contains more oxygen than the valency of P can nicely balance, phosphate is negatively charged - actually there are three phosphate ions with different charge but the important thing from our point of view is that there is negative charge.

You need to know just one thing about phosphate: it loves iron-oxide. That is why we use it to stabilise rusty surfaces prior to painting. P is also very keen on aluminium oxides. As soon as phosphate ions are added to soil, most of them are grabbed by iron or aluminium oxide surfaces. It is just about impossible to know how much of the P is stuck on iron oxides and how much on aluminium oxides. The two oxides have similar properties and, for our purposes it doesn't matter which is the more important. Because of this strong affinity, in most soils, there is little P left in solution. Just how much depends on how much iron/aluminium oxide surface is present and on its properties. That varies widely from very little in Perth grey sands to a great deal in soils derived from basic rocks (eg basalt, basic gneiss) especially in areas of high rainfall. The amount of sorption is important for three reasons.

- One is that the amount of P you need to get good growth is much higher on soils with a lot of iron/aluminium oxides – soils with high sorption. And a lot lower on soils with little iron/aluminium oxides.
- Two is that the rate of supply is much slower on soils with high sorption – P is "rationed" to plants.
- And three is that whether P leaches into water bodies depends strongly on the soils sorption ability. In soils with high sorption, enormous amounts of excess P have to be applied before movement to water bodies is important.

P is so keen on iron/aluminium oxides that it likes to burrow in – the P slowly diffuses into the oxides. This is a very slow process. After a year of reaction, the effectiveness of P fertilizer often decreases to about a half that of fresh fertilizer – and it gets even slower. That makes it difficult to study; science is seldom funded on such long terms. Fortunately we can speed the process by using higher temperature; by using say 60° we can cram a year's reaction into a day or so. The phosphate ions that burrow into the particles take some of their negative charge with them and thus the particles become more negatively charged. Consequently they are less able to react with more P. It is this process that slowly leads to the soil becoming "saturated" with P and can, in soils with low to moderate sorption, cause leaching loss of P to water bodies.

How do plants get P from soil? The roots are bathed in soil water. Transport mechanisms on the surface of root cells actively grab P ions from the water and move them into the interior of the cell. From there they move further into the plant. This means that the concentration of P in the soil water close to the root decreases. This starts a cascade of movement. Ions diffuse in the soil solution towards the root and this, in turn, decreases the concentration near the oxide particles. Consequently ions jump from the surface of the particles into the solution. Because the surface concentration is thus decreased, ions then start to move slowly back from the interior of the particle towards the surface. All this is fairly slow. So it is a good idea to get the surface of the roots as close as possible to the surface of the soil particles and thus decrease to distance ions need to move. This is why plants have root hairs. They penetrate fine spaces and get up close and personal. At least some kinds of mycorrhizas act the same way. They can be thought of as "super" root hairs. Some may also have super uptake mechanisms that are able to take P from very low concentrations.

For a long time, that was thought to be all there was to it. However, it slowly became clear that some plants were too effective for their uptake to be explained by these simple mechanisms. They are more active. They secrete substances such as citric acid that can dissolve iron and aluminium oxides and therefore also P. If you are going to dissolve some P, it is a good idea to "wrap up" the affected bit of soil so the product of your industry doesn't get away. You develop "cluster" roots. These are sometimes referred to as proteoid roots but they are not confined to Proteaceae and indeed some of the early studies were with a species of Lupin.

This strategy is widely adopted by plants living on low-P soils and that means most plants in WA. But think about the long-term effects. Each growing season a flood of citric acid leaves the cluster roots and dissolves some of the nearby oxides. The smaller particles are dissolved most quickly. Later in the season, soil microbes attack and oxidise the citrate so the oxides precipitate again, mostly around existing oxide particles. Hence the long-term effect of annual dissolution of oxides is, paradoxically, growth of ever larger lumps of oxide in our soils. It has been argued that this is why we have so much gravel in our soils and also the massive bands of oxides you see in parts of the landscape. We had previously thought that our Proteaceae grew on our gravelly soils because they could. Now we are wondering if perhaps the soils are gravelly because Proteaceae grow there.

Despite all the understanding we now have about P requirement, it is still possible to apply too much and induce P toxicity. This is especially true when the plants are being grown in pots using a growing medium with little ability to sorb P. P toxicity takes two forms. One form was first noticed in subterranean clover. The edges of the leaves die and begin to rot. These symptoms also occur in native plants, but are not always recognised. It is more common to note that native plants turn yellow with too much P. They become chlorotic. This is caused by induced iron deficiency and can be overcome by applying iron chelate.
Is there a safe way to supply P? Yes there is: it is called sheep poo. We humans excrete P mainly in urine but sheep excrete it in faeces. Some of it is organic – linked to carbon atoms – and some is inorganic. The organic form breaks down slowly and is a good slow-release fertilizer. The inorganic form is present as a moderately soluble calcium phosphate. Provided plant roots can get up close, it is a good safe form unlikely to leach and unlikely to be toxic. As they sing in the Sound of Music, a spade full of poo makes the roots go down, in the most delightful way.

One could add something like: for a general paper on the soil chemistry discussed see:
Barrow, N J 1999 The four laws of soil chemistry: the Leeper lecture 1998. Australian Journal of Soil Research. 37: 787-829.

WONDROUS ROOTS OF WESTERN AUSTRALIAN PLANTS

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INTRODUCTION

Western Australia is a part of Gondwanaland, and some of the most ancient parts of the Earth' crust can be found here. The rocks are up to 3.6 billion years old, with some of the sediments being as old as 4.3 billion years. Other parts of the Western Australian landscape are geologically younger, and originated more recently from calcareous marine deposits. The ancient soils are amongst the most heavily leached and nutrient-impoverished in the world. The calcareous soils lock up phosphorus in calcium complexes. Therefore, phosphorus is one of the least available nutrients, at least for plants that are not adapted to the Western Australian soils. It is an essential nutrient for all living organisms, including Western Australian native plants. Micronutrients (*e.g.*, copper, manganese, zinc) are also scarcely available on ancient weathered soils; micronutrients are also essential for life.

The nutrient-impoverished soils of the southwest of Western Australia harbour one of the World's 25 hotspots of biodiversity (Myers *et al.* 2000, Hopper & Gioia 2004). The Proteaceae (*e.g.*, *Banksia*, *Grevillea*, *Hakea*) represent the top most species-rich plant family in Australia, and have a very long geological association with the continent, beginning 65 million years ago. Cyperaceae (sedges) are also an important component of the Western Australian flora. Therefore, both the Proteaceae and the Cyperaceae offer a unique opportunity to study plant adaptations to nutrient-poor soil conditions. We have grabbed that opportunity, to learn more about our highly biodiverse flora and to search for traits that would be desirable for crop plants grown in Western Australian soils.

WONDROUS ROOTS: A PLETHORA OF ROOT SPECIALISATIONS

A relatively large proportion of the species from the nutrient-poor soils in Western Australia, including almost all Proteaceae and Cyperaceae, cannot produce a symbiotic association with a mycorrhizal fungus. That is paradoxical, because mycorrhizas are widely considered an adaptation to phosphorus-impoverished soils. Moreover, it is widely accepted that all ancestors of the Proteaceae and Cyperaceae were once mycorrhizal. Therefore, during the course of millions of years of evolution, most of the species belonging to the Proteaceae and Cyperaceae must have lost their ability to be colonised by symbiotic mycorrhizal fungi. Instead, many species belonging to these plant families in Western Australia produce root clusters. In the Proteaceae we find 'proteoid' or 'cluster' roots. In Cyperaceae 'dauciform' or 'carrot-shaped' roots are common. Root clusters also occur in several other species belonging to different families that are common in Western Australia, *e.g.*, in *Viminaria juncea* (native broom), *Casuarina* (sheoak), *Jacksonia* and *Kennedia* species. Other forms of root clusters can be found in Restionaceae (rushes), another non-mycorrhizal family (Shane & Lambers 2005).

The functioning of the root clusters of Proteaceae and Cyperaceae is a major component of our current investigations in the School of Plant Biology at the University of Western Australia. Once it was believed that their adaptive significance was to enhance the roots' surface area, and hence allowed the roots to 'scavenge' for nutrients. However, the individual rootlets and root hairs of the root cluster would all be competing with each other for the same molecules in the soil, and hence do not make this a very effective scavenging structure.

We have recently discovered that these root clusters release vast amounts of organic acids, especially citric acid, during just a couple of days in their very short existence. Cluster roots live for about 3 weeks only; dauciform roots live for less than 2 weeks. Citric acid effectively mobilises phosphorus and micronutrients that are 'locked up' in the soil, pushing these vital nutrients in solution for the roots to take up. Therefore, root clusters actively 'mine' the soil

(Figure 1). This is a costly process because of the large quantities of organic acids that have to be produced and released. However, the root clusters are very successful where roots that lack this ability to 'mine' the soil, including mycorrhizal roots, would fail. Ideally, crop plants would have similar adaptations of efficient nutrient acquisition, to perform well on the soils in Western Australia, and this is the subject of our further investigations.

Many Proteaceae, including *Banksia* and *Hakea* species, are readily killed by phosphorus fertilisation; they are highly sensitive at slightly enhanced soil phosphorus levels. Even at slightly elevated levels of phosphorus in soil, many Proteaceae tend to 'hyperaccumulate' phosphorus in their leaves, building up toxic phosphorus concentrations (Shane *et al.* 2004a). Other plants rarely achieve such high concentrations in their leaves, even when heavily fertilised with phosphorus. That is because most plants have the capacity to reduce the rate at which phosphorus is taken up when the phosphorus supply in the soil exceeds the plant's demand for phosphorus. That is, they "close the doors through which phosphorus enters the roots when a big crowd of phosphorus molecules is waiting to move in". We have recently discovered that the extreme sensitivity of harsh hakea (*Hakea prostrata*, Proteaceae) is due to its severely impaired capacity to reduce its phosphorus-uptake rate at elevated phosphorus levels in the soil (Shane *et al.* 2004b). Some time, during the course of millions of years of evolution on severely phosphorus-impoverished soils, this capacity diminished. To conserve the precious biodiverse flora in Western Australia, we have to respect these millions of years of evolution, and ensure that phosphorus-sensitive plants are not exposed to elevated soil phosphorus levels.

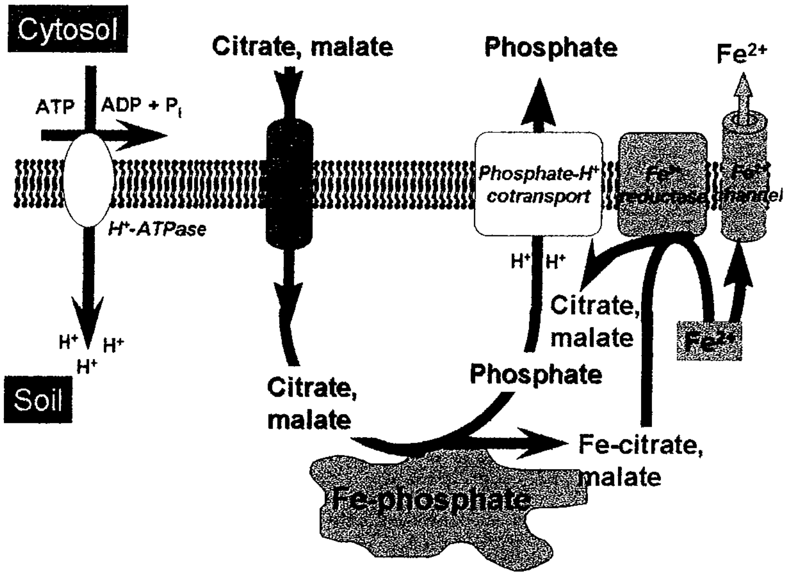

Figure 1: Root clusters release large quantities of carboxylates (citrate, malate), which are the anions of organic acids (citric acid, malic acid). When released into the soil, these carboxylates mobilise sparingly available nutrients, especially phosphate.

Having discovered the physiological cause of the phosphorus sensitivity of harsh hakea (*Hakea prostrata*, Proteaceae), we made a wider survey of related species. Interestingly, the close relative *Grevillea crithmifolia*, also belonging to the Proteaceae, do not suffer from phosphorus toxicity, even when exposed to phosphorus levels that are much higher than those that kill some *Hakea* or *Banksia* species. We found that the roots of this Grevillea, unlike those of *Hakea prostrata*, "close the doors through which phosphorus moves in" when supplied with a lot of phosphorus. These new findings offer enormous potential for breeders who are keen to develop new cultivars in the Proteaceae. It should not be too difficult to cross phosphorus insensitivity into new cultivars, which could then be grown without the risk of phosphorus poisoning in our gardens. One of my colleagues in the School of Plant Biology at UWA, Dr Guijun Yan, is working to achieve that aim.

Other "wondrous roots" that will be covered in this presentation include the specialised root structures involved in symbiotic nitrogen fixation. In Fabaceae we find root nodules, a symbiosis with rhizobial bacteria. In Casuarinaceae, rhizothamnia form a symbiosis with *Frankia*. In Zamiaceae coralloid roots are formed; these are a symbiotic association with cyanobacteria (Lambers *et al.* 1998).

Parasitic plants are more common in the Western Australian flora than in most other parts of the world. Many of these are root parasites, which connect to the roots of one or more host plants via specialised structures called haustoria. Via these specialised root structures, root parasites suck in water and dissolved nutrients that are taken up by the host plants. It is yet another strategy to cope with nutrient-impoverished soils (Lambers *et al.* 1998).

Mycorrhizas are common structures in Western Australian plants, *e.g.*, Myrtaceae, Fabaceae, Orchidaceae, as they are elsewhere in the world. Mycorrhizas are important for the acquisition of immobile nutrients, including phosphorus and some micronutrients. Yet, mycorrhizas are not nearly as common in the Western Australian flora as they are in most places in the world. Instead, these plants have "root clusters", referred to above.

Some carnivorous plants (*Utricularia* species) have specialised underground structures to catch their prey. After capture, the trapping device releases enzymes and acids to digest the prey, and the nutrients are released in a form that can be taken up by the plant. These prey-trapping devices are not roots in a strict botanical sense of the word, but they do occur underground. Western Australia is home to over 40 *Utricularia* species, many of which are endemic to the region (http://florabase.calm.wa.gov.au/).

CONCLUDING REMARKS

The many specialised structures and functions of the Western Australian flora have evolved in close association with the ancient landscape. Over millions of years, nutrients have been leached from the soil, leaving the substrate for plants severely nutrient impoverished. Today, the well adapted species that evolved in these nutrient-impoverished habitats are an important component of the rich Western Australian flora, widely recognised as one of the 25 global biodiversity hotspots (Myers *et al.* 2000).

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IDENTIFICATION OF A GERMINATION-PROMOTING AGENT IN PLANT DERIVED SMOKE

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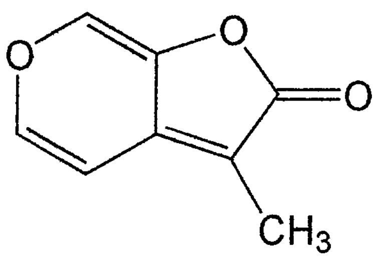
The recent discovery and synthesis of an agent in smoke that stimulates seed germination (Flematti *et al.*, 2004) provides a defining step forward in understanding seed dormancy in natural and managed ecosystems in Australia and overseas. The germination-promoting compound was isolated from cellulose-derived smoke using a number of bioassay-guided separation processes and is a previously unknown compound in the chemical and biological sciences. We have confirmed the structure of this compound by synthesis as the butenolide, 3-methyl-2*H*-furo[2,3-*c*]pyran-2-one (**1**). Testing on selected highly smoke responsive species (*Lactuca sativa* Grand Rapids, *Stylidium affine* and *Conostylis aculeata*) throughout the isolation and synthesis process indicates the chemical is the main germination-promoting agent in smoke, subsequently supported by germination in indicative Australian, South African and Californian smoke-responsive species. Concentrations as low as 1 ppb (1 μg/L) promote germination, illustrating the compound's potent nature and highlighting its significant potential for use in restoration and conservation projects. A summary of the steps involved in the isolation of this potent biologically active molecule along with future research endeavours to ensure successful translation of this technology into scientific and industry benefits will be discussed.



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GROWING WA PLANTS

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INTRODUCTION

In Western Australia our indigenous plants are grown primarily for their ability to withstand dry conditions. This has influenced the demand for them in horticulture and landscaping. Their beauty, form, colours and uniqueness have been designated to a secondary impetus. We are faced with the lack of support to promote and develop WA Plants for local home gardens and amenity landscaping and the anomaly of having an industry who continues to want to stay with exotic or mostly non WA plants species. Any funding mostly supports programmes purporting towards potential export markets. The development, selection and propagation for suitable plant selections for landscape schemes, local government parks and gardens and the expanding revegetation requirements are lagging far behind the requirements now and for the future.

INFLUENCES AFFECTING THE FUTURE USE OF WA PLANTS

- Water restrictions and the future availability of water with predicted climate change with less rainfall.
- Suitability of local species already adapted to local soil types and low water and fertiliser requirements.
- Conservation revegetation providing biodiversity replacement of local species and planting to provenance.
- Selection and breeding of WA Plants for mainstream horticulture and landscaping.
- Current trends dictated by mainstream Industry media in favour of predominantly exotic Mediterranean climate plants.
- Changes from traditional horticultural methods to allow for successful survival of WA plants in landscaping.

ADVANCES IN PROPAGATION AND PLANT BIOLOGY IN WA

Botanic Parks and Gardens

Isolation of abutenole chemical in smoke, and specific heat treatments for the germination of seed of previously difficult to grow species.
Development of Somatic Embryogenesis of creating seed for species with limited natural seed formation.
Investigating plant-breeding barriers to the development of new plant selections.
Propagation and translocation of terrestrial orchids.
Propagation and translocation of rare and endangered species.

Department of Agriculture

Tissue culture research for floriculture.
Plant breeding and maintenance programmes for floriculture. Grafting and root stock trials.

Scientific research universities: UWA, Curtin, Murdoch, Edith Cowan

Plant biology specific to WA plants.
Plant breeding and selection development of *Boronia species*

Private Companies

Revegetation – direct seeding.
Plant selection for landscaping and floriculture.
Plant Breeding.
Grafting and root stock trials.

CURRENT SUPPLIERS AND GROWERS

Traditional N&G Industry nurseries.
Specialist Australian plants nurseries.
Forestry, Landcare and Local Government nurseries.
Community Supported Nurseries: APACE, Bennet Brook.
Community Plants Sales: Eastern Hills Wildflower Society, Northern Suburbs Wildflower Society, Mandurah Wildflower Group, and Friends of Kings Park.

THE ROLE OF WILDFLOWER SOCIETY OF WESTERN AUSTRALIA

The Society continues to promote the growing of WA Plants through their 'Grow with us' programme and encouraging the entry of more Australian plant gardens into the Open Garden Scheme. The desire for members to propagate our WA plants has diminished somewhat since the early days of the Society most are generally happy to buy their plants from any available sources though renewed interest has been shown at recent propagation workshops. The Society has supported the Green Skills Southern Plants project in Albany and Denmark with well attended propagation workshops.

Eastern Hills Wildflower Society, The Northern Suburbs Wildflower Society and the Mandurah Wildflower Group have members who grow plants for their annual plant sale.

Northern Suburbs Wildflower Society has a small nursery where members do adventurous propagation to grow, develop and sell many different species use in home gardens and rescued plants from local areas to be developed, for revegetation and rehabilitation of local areas as well as for their annual plant auction. Seed trials with local difficult species have met with success by applying some or all of the undermentioned methods. All natural material is collected under license.

GROWING FROM SEED

The issues when growing our plants from seed have become more sophisticated as more knowledge is gain. Timing of seed collecting, storing and treatment of seed such as stratification, application of smoke or smoked water, treatment with heat determining before sowing is becoming more practiced.

GROWING FROM VEGETATIVE MATERIAL

Several practices have proven satisfactory
Use of etiolated material: **It has been well known for many years that plants put aside for stock plants produce better quality and easier to strike cutting material. Going a step further again these plants put under light shade will encourage new growth to stretch out or become etiolated which puts longer spaces between the leave buds. This etiolated material is ideal to use as a cutting and is found to strike quickly and produce stronger root systems therefore more successful plants. Plant material gathered from young lignotuber regrowth after fire, has similar properties.**
Hormone Gels: High success rates have been achieved with the locally produced Clonex Gel, which is a unique and powerful blend of vitamins, minerals, hormones and antimicrobial agents in a highly effective and stabilised gel base, has proven to be very successful. It seals the freshly cut tissue instantly maintaining a moist environment around it to allow the high potency hormones to be absorbed.

SELECTION OF SPECIALIZED PROPAGATING MATERIAL

Cutting Material: Plant material from most species gathered from burnt or disturbed areas has proven very successful especially with many difficult to grow from tradition methods.
Leaf Cuttings: Plant species from the Goodeniaceae and Stylidiaceae families can be grown from individual leaves. Single leaves pulled away from clump or rosette of plant and treated like a cutting form roots followed by the new plantlets.

Rosettes: The sections of clumping and rosetted plants are be divided apart to form individual plants. These plants produce a new set of roots from the base of each new clump or rosette each year appearing from about March onwards with the change of season. All old roots cut away and old or damaged leaves removed. New plants are then treated as cuttings.

Seedlings as cuttings: After a fire thousands of seedlings appear. Success by transplanting is very limited, but they make ideal cutting material and strike very quickly. Gently pull up chosen seedlings from the ground. In preparation, remove any roots to the base of the stem and treat as normal cutting. Old excess seedlings grown in containers from seed can also given new life at a later date with this method. Annuals can also be used in this way.

Division: Monocotyledon or strappy leaf plants including rushes, sedges and grasses can all be divided to from new plants and refreshen clumps. From March or the change of the season in Autumn is the most successful time to carry this out as again a whole new root system is formed from the pervious years growth. In some plants, the sections pulled away easily while others can be cut with a sharp knife. All old roots and dead and damage leaves are removed and foliage reduced for easily handling. The newly sectioned segments are then treated like normal cuttings or placed directly into tubes depending on size of division. Set divisions can then be drenched with fungicide to prevent any relocation of disease. Suckering plants are divided up to make more plants.

Rhizomes: Kangaroo Paws, Cats Paws, Ptilotus spp and any other plants with fleshy underground stems are treated as above for division.

Root cuttings: Some plants, which send out suckers from underground roots, have the potential to be grown from root cuttings. Trials on Snooty Gobble Tree or Persoonia longifolia have been carried with some limited success.

Bulbs, Orchids: These can only be salvaged from areas to be destroyed or private land with permission, They are best marked out when in flower them lifted in autumn when new growth is occurring.

PLANT RESCUE FOR INCREASED DIVERSITY IN REVEGETATION

There are many areas of bushland, which will be destroyed due to ever-increasing urban development. Such areas have not been previously considered to have any value for plant rescue, mainly because of the misconception that our local wildflowers can not be propagated or relocated successfully. Areas to be cleared can be located through town planning maps from local government, Main Roads, Department of Conservation and Land Management, and private landowners. The presence of Phytophthora cinnamonii needs to be determined.

Plant rescue offers an opportunity to gain valuable knowledge of the plant mechanics and biology of the plants involved as material is prepared for propagation.. Valuable material both above and below the ground can be rescued. Plant rescue for rehabilitation projects in nearby reserves allows some plant provenance of the areas to be retained, which would otherwise be lost.

Preparation of the rescue areas:

Find out timelines for the destruction of the bushland areas. Survey and map the site to assess the species contained. If time survey through different seasons. Determine which species can be collected and plan to do so at the best time. Locate and mark specific plant and bulbous species eg orchids for later collection at a more suitable time.

If time allows burn all or part of the area to encourage new regrowth and promote new seedlings and encourage annual species. Examine the benefits of spraying area with phosphonic acid for dieback. Smoked water can be applied to some areas to encourage germination of seedling of receptive species.

CHALLENGES FOR THE FUTURE

To retain the biodiversity of our bushland through natural and revegetation practices
To retain our precious resource for the future of horticultural plant selections
To continue to develop propagation methods for difficult to grow species.
To develop an understanding of more suitable culture practices to grow and maintain our plants successfully in our landscapes subject to predicted climate change
To be able to supply the forecast demand
To promote our wonderful Australian flora to all Australians

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