

Australian Plants

September 2011
Vol 26 No 208

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All photos in this issue by Jim Barrow unless otherwise indicated. Front cover: *Hakea victoria*. Back cover: *Lechenaultia biloba*.

Australian Plants articles

Australian Plants is published quarterly to promote knowledge of Australian native plants. Contributions and offers to produce an issue are welcome. Please contact:

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Australian Plants No. 208 Issue of Volume 26 which comprises issues 206 - 213. Published quarterly and available nationally in 3000 copies by the Australian Plants Society NSW Ltd

© Australian Plants Society NSW Ltd 2011 ABN 87 002 680 408 ISSN 0005-0008

Printed by Elect Printing, Fyshwick, ACT Print post approved PP226253/00017

Introduction: Wildflowers of the South West

John Aitken, Joint Editor, *Australian Plants*

Congratulations to Dr Jim Barrow who wrote all the articles in this wonderful issue and is also responsible for the layout. It represents hours of effort on his part and I am confident that those who read Jim's articles and marvel at his photos will share his passion for Western Australia's south west . Jim was, in a "former life", a Chief Research Scientist in CSIRO. Since (partially) retiring, he has been active in the Wildflower of Western Australia. He initiated their website and managed it for a dozen years. He is a past president of the Society and a previous editor of the Society's newsletter.

Preface, Jim Barrow

As an admittedly biased Western Australian I want to see many articles about our plants in this journal. But someone has to write them. If there have been few in the past the fault, dear Brutus, is not with the editors but with ourselves. If we want to read articles about Western Australian plants then the onus to write them is surely on us Western Australians.

I hope that this issue will also be of interest to "t'other-siders". It starts by describing our environment. In many respects it is a tough one for plants. The summers are hot and virtually rainless; the soils are acutely deficient in many nutrients but especially in phosphorus. Many plants have developed the strategy of secreting citric acid from their roots in order to solubilise phosphate. Ironically the long-term effect of this strategy is to tie up the remaining phosphate ever more tightly. As a result, virtually the only plants that can survive in such soils are those that adopt this strategy.

Plants deal with the problems the environment poses in several different ways. This is one of the sources of their fascination for us and probably the key to their diversity. They also distribute themselves in complex yet subtle ways across the landscape. If you appreciate this, you will better enjoy your next visit to Western Australia; surely you have already been at least once?

Many millions of years ago, it seems that our plants began competing vigorously for pollinators. The "pollination wars" began. Many complex, spectacular, tricky and even bizarre ways of achieving pollination were developed. We enjoy this spectacular display; I hope you will enjoy reading about it.

The environment

In order to appreciate our plants, you need to know a little about the environment . This section will tell you what we mean when we say "the South West", a little about its climate, and how the climate and geology have interacted to produce the current landscape and soils: the factors that determine which plants grow where.

The South West

Western Australia is a big place; about 2.5 million square km. In this article we are mainly concerned with just the South West corner. How do we define the "South West"?

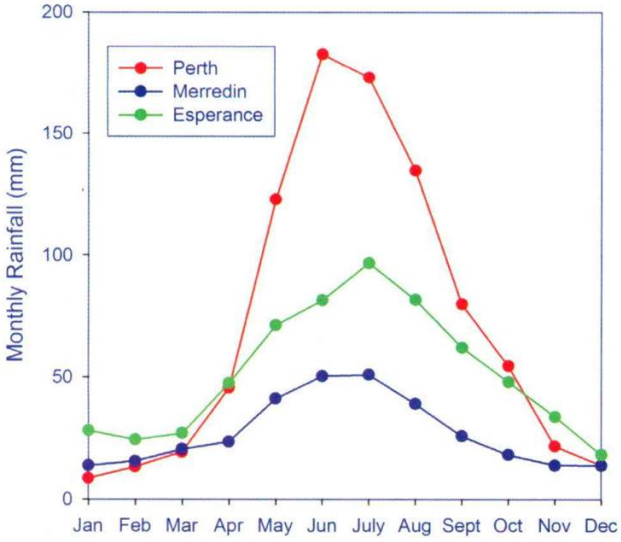
It's a bit like Alice Through the Looking Glass. "When I use a word," Humpty Dumpty said, in rather a scornful tone, "it means just what I choose it to mean - neither more nor less." So the South West means different things to different people. Here we use it to mean the part that receives sufficient rainfall in most years to provide a winter-spring period in which rainfall exceeds evaporation and so there is sufficient moisture for growth. That includes the area suitable for farming, but goes a little further because the "outer" edge often has interesting plants.

Rainfall

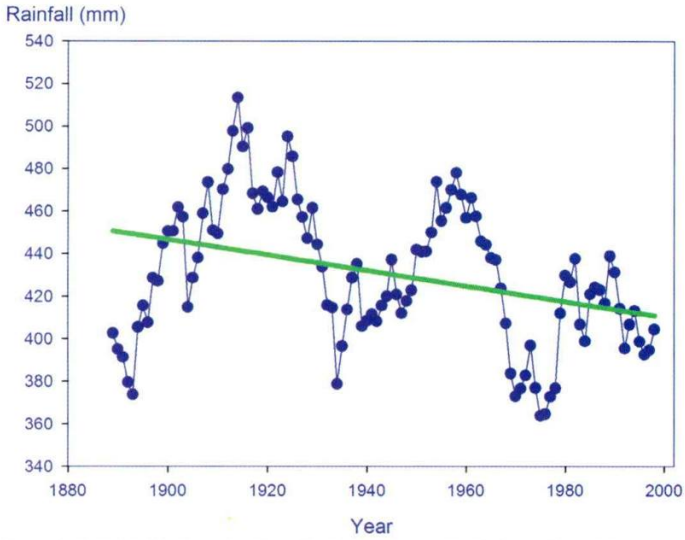
I grew up in Victoria. After moving to Western Australia, it took me a long time to realise that a fine summer's day would remain a fine summer's day. There was no need to take a pullover and a raincoat with me. Indeed, we could expect that summer would consist of little else but fine summer's days. For example, in the three summer months for 2009-2010, the total rainfall in Perth was 0.2 mm. So the summers are hot and dry; the winters used to be cool and very wet.

Indeed they are still fairly wet. The graph on the opposite page shows the marked winter peak for Perth rainfall. At this latitude you can go more than 300 km inland before the rainfall drops to about 260 mm very roughly the limit for cropping. Further north the area with enough rainfall for cropping gets narrower, petering out near Kalbarri. As you go south, the arable area sweeps around the coast until east of Esperance because the low pressure systems that bring our winter rain impinge on this coast. At Esperance, the winter peak is less marked because of this effect.

As the graph opposite shows, there has been a downward trend for the



Monthly rainfall at three locations in WA. Records as follows. Perth 1876-1992, annual total 868 mm; Merredin 1903-2009 annual total 326 mm ; Esperance 1969-2009, annual total 623 mm. Recent years have been drier. For example, for the years 1993-2008, Perth has averaged 753 mm.



Annual rainfall in Northam, the West Australian town with the longest rainfall recording. The graphs have been smoothed by plotting the 10 year looking-forward moving average. The green line shows the overall trend.

rainfall. This has not been smooth: the 1950s and 1960s were rather wet and this was the period when much land clearing occurred in Western Australia and also the period when many of the Metropolitan reservoirs were planned and built. The drying trend has been tough on Western Australian farmers and also on our plants. Let us hope that you choose a wet year when you plan your trip. We could certainly do with one.

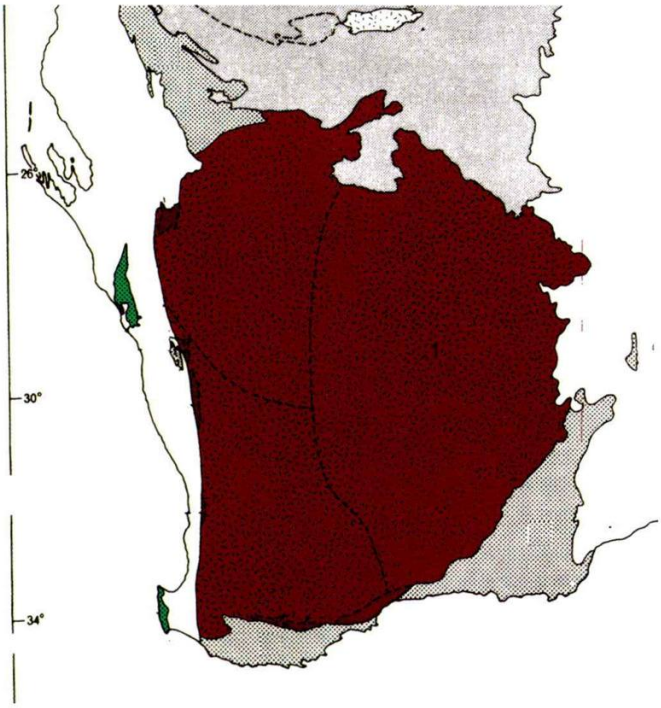
The landscape and its base; the geology

To many people, the Western Australian landscape is mostly flat and boring. True, much of it is indeed flat, but once you have learned to "read" it, never boring. But why is it so flat? And why do we have at least a couple of mountains such as the Porongurups and the quite impressive Stirlings? And why is the landscape dotted with "rocks" and "breakaways", both important locations for the flower seeker? To answer these questions we need to look at the geological history.

The geology

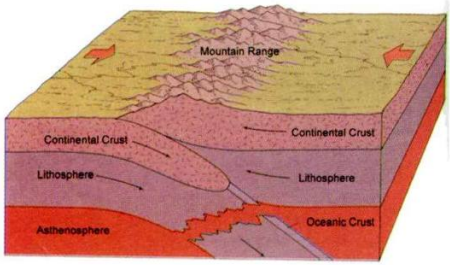
The geology of the south west is mostly very simple: it is almost all granite. One of the oldest granite masses of the world. When the earth was young, the relatively small proportion of its mass that contained a high proportion of silicon slowly floated to the surface to form a "scum". That scum, which we call granite, is the basis of our continents. It was subjected to some pretty strong forces in the early days, roiling and churning, and these movements brought up some of the underlying more-basic rocks, the source of the mineral wealth of the goldfields. But it has been very quiet for the last couple of billion years and though it skittered about, as continents do, nothing very dramatic happened to the surface: no glaciers at least during the last 200 million years or so, and only a tiny amount of vulcanism. Only a few bits mostly around the edges were sometimes under the sea, and therefore able to accumulate sediments. Just two dramatic events occurred. One was the formation of Gondwana, about a billion years ago. The other was its break-up. This occurred in stages with the last stage about 60 million years ago.

When Rodinia and later, Gondwana were formed, prior continents came crashing together. When that happens, something has to give. One of the continents rides over the other. The tremendous forces involved cause the crystals in the granite rocks to reform in parallel lines, normal to the thrust. The rock is then a "Gneiss" (pronounced



Simplified geology of the SW. The reddish area is the ancient granitic shield. The green area the "seam" formed when Gondwana was formed.

"nice", not "niece"). What is more, the basic rocks under the granite get injected and the rock becomes more basic. It is a "Basic Gneiss". Why does this matter? Because soil and landscape formed on this kind of rock is rather more fertile. It grows tall forest - Karri trees. They occur on the Porongurup Range, in the Pemberton-Manjimup area, and on



When two continental plates collide, one is lifted above the other. Some of the more-basic material of the lithosphere is lifted and mixed with continental crust. Source: http://pubs.usgs.gov/gip/dynamic/understanding.html

the "chin" of the south west between the capes. These soils have been found to be excellent for wine production.

Breaking up is also dramatic. As Australia started to move away from Antarctica, the trailing edge dropped a bit and fell below the sea. Sediments accumulated – including beds of sponge spicules near



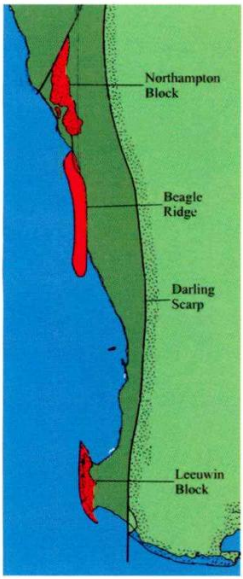
The rounded outline of the Porongurups contrasts with the rugged Stirlings. Photo: Lin Barrow



A touring group admiring the Stirling Range. Photo: Lin Barrow

what is now Fitzgerald River. The break-up wasn't all that smooth and included a period when the continent pivoted near the southwest. This squeezed some of the sediments up to form the rugged Stirling Range. So the Porongurups and the Stirlings, within easy viewing distance of each other, have quite a different history, different rocks, different soils, and very different plants.

When greater India sailed off from the west coast, the split was at first long and straight, as most such splits were. So for many thousands of years, there was a narrow, linear sea off the coast. It must have looked like the Red Sea today. Today's evidence for that split is the Darling Scarp – easily the most prominent feature of the landscape of the southwest. It is about 1000 km long and more or less straight and with a sort of fork at the top to form the Dandaragan Plateau and a cross-fault at the bottom to form the Whicher Range.



Echoes of Gondwana. the remnants of the join shown in red, and of the subsequent split by the Darling Scarp

When you travel eastwards from Perth, you climb about 300 m up to the top of the Darling scarp. Most of the wheatbelt is fairly close to this altitude. The next steep climb as you proceed eastwards, is the slope of the Mount Lofty Range as you leave Adelaide! We live in a flat continent..

When Gondwana split along the Darling fault, the edges of the split crumbled and the depression so formed was filled with sediments up to 10 km deep. Perth sits on this edge. It is underlain by 6 to 7 km of sediments giving rise to the Coastal Plain.

The basalt

When continents split, there is often a large outpouring of basic lava — basalt. A modern example is the large area of outpourings caused by the African Rift Valley and the resulting fertile soils of Kenya and Uganda. Our split did generate two basalt flows, 123 and 130 million years ago, in the early Cretaceous. However, almost all of it is covered by later deposits. There is one exposure on the beach at Bunbury, another at Black Point near Augusta and a little-known one at Whalers Beach near Albany. The absence of all but a trace of basalt is another reason for the poverty of our soils.



Exposed basalt columns a the beach near Bunbury. Photo Lin Barrow

The sediments

As noted earlier, most of the sedimentary deposits occur around the edge of the granite massive. This means that they are close to the coasts and therefore receive more rain than further inland; they often have steeper relief and are more scenic; and finding accommodation in coastal towns is easier for the tourist. Many of them are therefore well visited.

Starting from the "top" (that is the north) we have the Kalbarri National Park which is nearly 200 000 ha. Most of it is Tumblagooda sandstone which is at least 1000 meters thick. It was laid down about 400-500 million years ago mostly during Ordovician and Silurian times when sands from the Yilgarn block were washed onto a broad rift valley which opened between Australia and what is now Southern Tibet (would you believe) as Gondwana began to break up. About 2 million years ago the river meandered gently across a coastal plain. There was then a fairly rapid uplift and the river cut through the rising sandstone producing spectacular gorges and sea cliffs. It must have been slow enough to preserve the meanders.

A small area along the coast is overlain by limestone. The disconformity can be see on the coastal cliffs. Because the soils differ and because of the stronger winds plus the salt input, the suite of plants differs somewhat,

Kalbarri, is a fair way north and rainfall is low and unreliable. Of course the scenery is always there, but plant growth can be poor. Best places are often the roadsides where the extra runoff produces a low "hedge" of better growth..



Prickly plume Grevillea (*G. annulifera*) growing on a roadside at Kalbarri. Note that as the flowers age, they turn pink. A change from cream to pink/red occurs in many unrelated WA plants and appears to be a signal to pollinators. Photo Lin Barrow

Moving south, we come to the north part of the Perth Basin near Dongara. Here there were incursions of seas over the period from 250 to 65 million years ago and various sedimentary deposits. These give rise to natural gas accumulations and these are utilized to provide gas to Perth. They also include coal seams dating back to Permian times. Seams are exposed in the Coalseam National Park, between Mullewa and Mingenew. Here the Irwin River cuts through the deposits and — unusual for southern WA — fossils are visible in the river bank



The Irwin River cuts through the Coalseam National Park. The lateritised surface is seen in the foreground and in the background. The pale yellow in the valley is a massive display of the yellow form of the everlasting daisy *Cephalipterum drummondii*

Further south, the coastal plain, on which most of us live, has two main systems: the coastal dunes and the river deposits. The dunes are, of course, nearest the sea and they in turn have three main units. Furthest from the sea is the oldest dune system. It dates from well before the last retreat of the sea at the beginning of the most recent ice age. That started about 18 000 years ago and these dunes are thought to be much older than that. They are coarse, deeply-weathered sand dunes.

The ice age developed in a series of stages and so the sea did a kind of slow ballet, now retreating now advancing. At each still-stand it left a beach ridge. One of these beach ridges underlies many of the coastal suburbs including the site of the Wildflower Society's office. The shells from the beach mean that the soils are alkaline, often with limestone near the surface. Closest to the sea are the modern beach ridges and in some places they have broken inland to form steep-sided coarse dunes that are more or less parabolic.

Between the dunes and the Darling Scarp there is a riverine plain. Near Perth, it is fairly narrow; further south and also north, it widens. This plain also reflects the many different sea levels and there are soils formed on river deposits of a range of ages. Generally the nearer the scarp the sandier the deposits as the rivers dropped their coarse material first.

The coastal plain used to be very wet indeed. It was heavily utilized by aboriginal people in summer but they retreated inland in winter. In the many temporary pools, there were complex ecosystems in which sequences of plants flowered as the water retreated in spring and summer. However, in the 1930s, major drainage schemes were installed and much land was cleared. Consequently these sequences of flowering can now be observed in only a few places. One such place is the Brixton Street reserve in the Perth Metropolitan area. This reserve is only 19 hectares but has 307 species recorded. It is sited on soils derived from river deposits. They are heavy and drain slowly.

Small but important areas on the Coastal plain are occupied by ironstone soils. These were at first confused with laterite (see later) but their origin seems to be different. The ironstone soils are formed where groundwater comes to the surface. The reduced iron present in the water is oxidised on exposure to air and the iron is precipitated. This has two important consequences: the soils are often waterlogged and the phosphorus status is unusually high. Consequently plants that grow on them are well adapted to poorly drained soils of higher P status. An example is *Grevillea curviloba ss incurva*, which is widely cultivated,

but reduced to a few plants in the wild. The high phosphate status also means that they are the only places on the Coastal Plain where masses of everlastings can be seen.



Tiny *Isotoma pusila* growing on the edge of a pool in the Brixton Street Reserve



Pink sunray (*Rhodanthe manglesii*) growing in an ironstone area near Gingin. W.A.

On the south coast, the Fitzgerald River National Park is (as usual) partly granite and gneiss. South of the granites there is a folded and metamorphosed sequence of sedimentary rocks: the Mount Barren Ranges. However much of the park comprises sediments laid down in warm water 40-50 million years ago (Eocene).



The top member of the Eocene sequence is a curious rock called spongolite. It is formed from sponge spicules. The rock is fairly soft and is easily cut into blocks that can be used for building. Hence the "benches" visible here.

Uplift and earth movements

Landscapes are greatly affected by earth movements. One major episode in the south west was the "squeezing" that gave rise to the Stirling Range, and the Barrens of the Southern areas. The other was the uplift of the Darling Scarp.

During the Pliocene, about 2 to 5 million years ago, the Darling Scarp was uplifted to its present height of about 300 metres. This meant that streams that had previously meandered over a plain now had a gradient to work with. They were rejuvenated, and they began to cut back into the plateau. Consequently the valleys in the south west are relatively steep near the scarp – though still pretty flat by most standards. As they cut back into the rock, they got below the deeply weathered material and so the valleys are relatively fertile and have been used for orchards. As we go inland the valleys become wider and eventually we move beyond the rejuvenated valleys into an old broad flat landscape in which the few rivers scarcely know which way to flow.

As you move east from Perth, you pass from the zone of rejuvenated

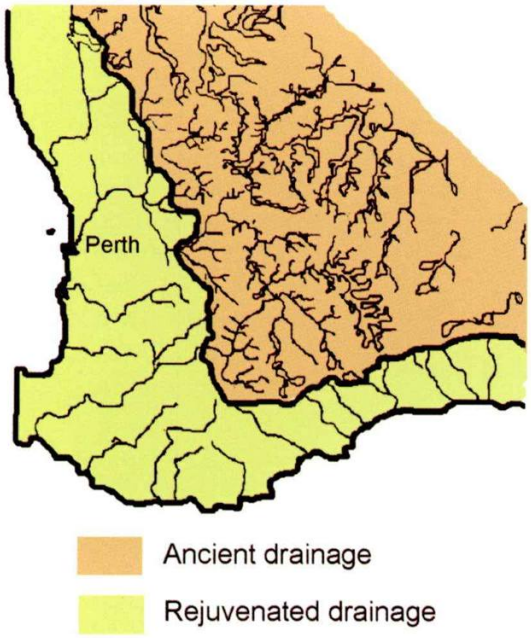


Diagram showing boundary between the zone of ancient drainage and the zone of rejuvenated drainage - the Meckering line. Original in: Mulcahy M J 1967 Landscapes, laterites and soils in southwestern Australia. In: Landform Studies from Australia and New Guinea (eds J N Jennings & J A Mabbutt). Australian National University Press, Canberra, 211-230.

drainage into the zone of ancient drainage just to the west of Quairading. The boundary line has been called the Meckering line (this is a little confusing because Meckering was the site of a considerable earthquake in 1968 and so there is also a "line" there from the earthquake).

The transition is not sudden, and even in the zone of rejuvenated drainage, the areas distant from the streams carry the old surfaces.

From rock to soil

If you look closely at granite, there are usually three main minerals: glassy grains of silica; pale grey to yellow crystals of an aluminium silicate called feldspar; and a black mineral – usually black mica. The combination looks grey from a distance.

Western Australia does have a lot of sand. They don't call us Sandgropers for nothing! Ultimately the sand comes from the granite. The silica grains are easily the slowest to weather and so after eons of weathering, there tends to be a lot of sand around.

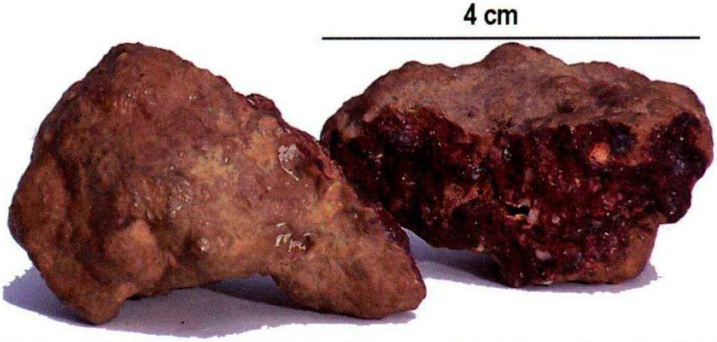
The sand doesn't always remain "in place". During dry periods, large movements have occurred, giving rise to sand plains. The sand of our beaches and of the coastal plain soils has of course originally come

from this source as have the quartzite deposits built into the Mt Barren ranges near the South coast.

But we also have a lot of gravel, often present as 'ball bearings' of iron oxide but you can get massive deposits forming sharp "break-aways". The ultimate source of this iron oxide is the black mineral in the granite. But how did it get organized into gravel? Iron oxides are normally very, very insoluble. That is why most soils are brown. The colour is due to iron oxides which hang around. But in order for the gravel to form, we have to have a mechanism by which the iron becomes soluble, moves around in soluble form, and then deposits on existing lumps so that they grow.

Gravel

It is still widely thought that about 20 million years ago, the southwest climate was warm, and semi-tropical but with alternating wet and dry seasons. During the wet season, the soils became waterlogged. This caused the iron to be reduced to a less oxidised form that was more soluble. Capillary movement upwards of the resulting solution caused the iron to oxidise and re-precipitate. According to this theory, the whole landscape was covered with a mantle of iron oxide (laterite) and this has subsequently been dissected by the rejuvenated rivers. However, this theory does not explain how aluminium also accumulates in gravel as is evidenced by the mining of bauxite in the Jarrah forest.. And where is any independent evidence for a tropical climate – when we were about 1000 km further south? Further, just look at a lump of gravel. The surface is smooth and shiny. Doesn't look like something that has been weathering for 20 million years.



A lump of gravel, broken to show that it has grown by cementing together small granules. Note that the surface of the lump is smooth.

Is there any other theory? About 2000, an alternate view was published. This said the gravel is much younger and is still forming. The mechanism that provides for alternating dissolution and precipitation of iron is the secretion of large amounts of organic acids – like citric acid – by many of our native plants and especially the Proteaceae. They do this in order to get phosphate (P) from the soil. The acid dissolves the iron and aluminium oxides that lock up the P and so release it to the plants. Subsequently, bacteria build up and feast on the citric acid and so reprecipitate the iron and aluminium around existing lumps. According to this theory, the soils are gravelly because Dryandras grow there – rather than the other way around.

Consider the evolutionary consequences of this strategy. Soils derived from the granite are usually very low in available phosphate. The long-term effect of this citric acid strategy is to tie up the remaining phosphate even more tightly and thus make it very difficult for any plants that do not use this strategy to survive on these soils. There is therefore a very strong tendency for natural selection to prefer such plants.



Dryandra nobilis growing in very gravelly soil at the top of a breakaway. The trees in the background are brown mallet (*Eucalyptus astringens*), a species well adapted to clay soils of the steep face of a breakaway. A "mallet" is a small tree with a slender trunk from which the branches form a steep angle.

"Break-aways" are places where the landscape abruptly falls away. They are characterized by a massive capping of laterite which is underlain by a "pallid zone" high in kaolinitic clay.

It is argued that break-aways mark local areas of higher than average iron content arising from basic intrusions into the granite. As a mass of granite cools, the silica-rich fraction tends to crystallize first, and the rest of the magma becomes more basic — lower in silica. As further cooling proceeds, cracks occur in the solidified part, and some of the more-basic magma can find its way into these cracks. Because the cracks are relatively narrow, the magma cools quickly resulting in fine-grained basic dykes.



A break-away in the Badgingarra district. The photo shows a typical outline and also the pale clay that lies beneath the ironstone layer and is exposed on the steep face.

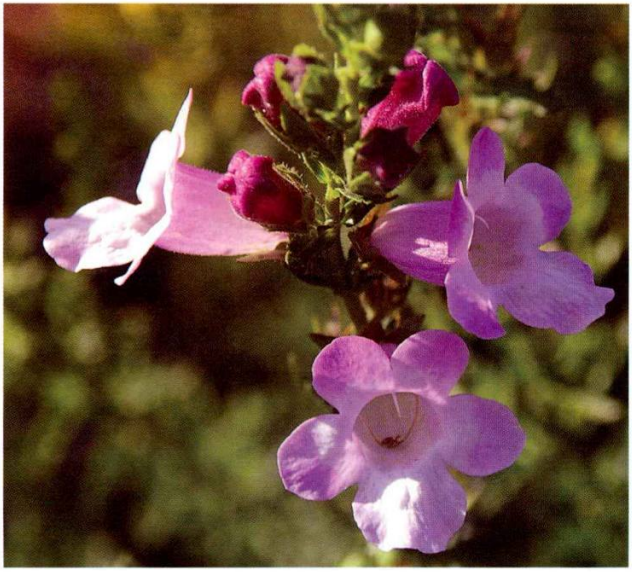
The "rocks"

Mostly, the granite is well buried beneath weathered material. However, in many places a dome of granite protrudes forming an "inselberg"; literally an island mountain. These rocks were very important in the early days of settlement because they provided a catchment from which water could be collected. Many wheatbelt towns are sited near such rocks, and some are named accordingly: Bruce Rock, Morine Rock.



Sandford Rock near Westonia. The small tree growing in the depression near the centre of the picture is *Eucalyptus crucis* which grows only on a few widely-separated rocks.

For wildflower enthusiasts, they provide good hunting grounds, because run-off around the rock produces a zone of (effectively) higher rainfall, and especially because small depressions in the face of the rock form mini-gardens in which grow many special plants.



Pityrodia teckiana grows in moist depressions on granite rocks.

Plants in the landscape

Because most of the original vegetation has been removed for farming, it can be difficult to discern the original patterns of vegetation.

In the wheat belt, the lowest points in the landscape are occupied by salt lakes. They are salty because, over thousands of years, winter rains have picked up salt spray from the ocean and brought in a couple of kilograms per hectare per year of salt. The annual input is small but for many thousands of years rainfall has been too low to leach out much of the salt. Furthermore the drainage gradients are also low. The result is an enormous accumulation of salt, much of it in the groundwater. The removal of most of the natural vegetation over the last hundred years or so has meant that less of the incoming water has been used by the deep rooted native plants and more has passed through to the groundwater. Consequently, the water table has risen bringing more salt to the surface. Most salt lakes are therefore surrounded by a zone in which native plants have been killed by the increased salinity.

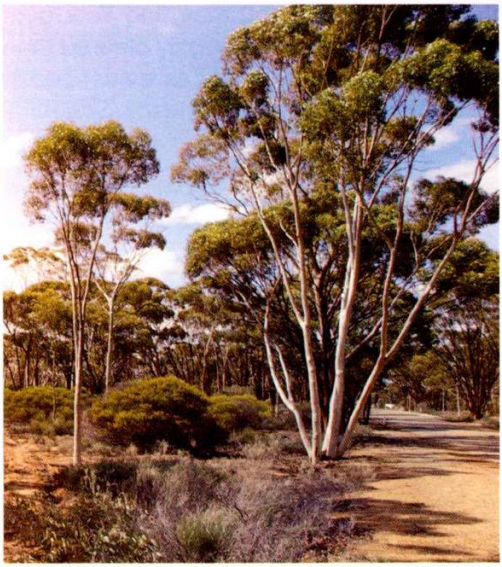


Lake Magenta. Photo: H Dempster.

The salt lakes are usually fairly desolate places with few wildflowers.



An exception is provided by occasional patches of round leaf pigface *Disphyma crassifolium*. Photo Lin Barrow



Slightly further up the slope, the heavy soils of the valleys are occupied by salmon gums (*Eucalyptus salmonophloia*) and gimlets (*E. salubris*) (background) here photographed near Westonia. These soils were recognized by the early settlers as being more productive and were cleared fairly thoroughly.



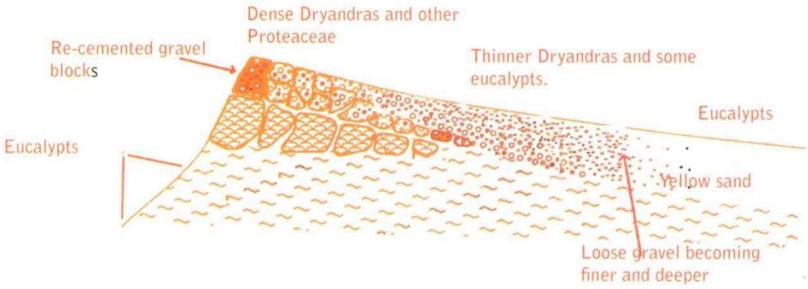
As you move up the slope, these are replaced by other eucalypts. The particular species varies with the location. In the picture above on loam soil at Dryandra Woodland, the eucalypt is Wandoo (*E. wandoo*) with an understory of *Hypocalymma angustifolium.* Wandoo woodland often provides good hunting for orchid lovers.

Yet further up the slope on the sandy loams, you may find York gum and jam. These have perhaps been even more thoroughly cleared than salmon gums because of their inherent higher fertility as evidenced in the picture below by the prolific growth of annuals (mostly *Schoenia cassiniana).*

"Jam", or "Raspberry jam", the main tree in the photo from near Merredin, is so called because of a fancied resemblance to the smell of the cut wood. (The early settlers often did not have much to eat.)



As you go further up a slope, you may approach a breakaway and see the following sequence.



Redrawn from Australian Journal of Botany (2001) 49. 429-560



The ground just below the breakaway is often fairly bare, as shown in the above photo, for two reasons. First, the slopes are steep and the soil is clay. The ground therefore tends to shed water so that this is a dry environment. Second, the bark of the eucalypts that occur here is often high in tannins. In this case, north of Perth the trees are Powder-bark Wandoo (*E. accedens)*. Further south, for example near Narrogin, the trees are brown mallet (*E. astringens*).

Nevertheless, such apparently unpromising ground is a good place to hunt for orchids. For example, the above area produced the following.



A *Caladenia* species, possibly *C. footeana.*



Two plants occurring on top of a breakaway near Corrigin. Above, the common (and attractive) *Isopogon divergens* and below the rare (and also attractive) *Dryandra feruginea* subsp *obliquiloba*.



Coping with the environment

Our plants live, and often thrive, in a very hostile environment. They have to cope with, in many cases, extreme phosphate deficiency, and with a long hot dry summer. To add to their problems they are not infrequently subject to fires. How do they manage?

Be an Annual

You might think that an obvious way to escape the hot dry summer would be to "live fast, die young". In other words, to be an annual. The difficult part of this strategy is the living fast. Phosphate is the governor of the engine of life. When it is in short supply plants cannot live fast. Consequently you will find few native annuals in those parts where phosphate has been tied up by plants that secrete citric acid from their roots. You will of course see many *agricultural* annual plants in these areas, because the application of phosphate enables them to grow quickly. Mostly, native annuals grow best in the areas that are too dry for Banksias and Dryandras and where the shrubs are mostly Acacias and Sennas.

It is unfortunate that we tend to say "everlastings" to describe these annual plants for this suggests that they are mostly daisies. But many of the most attractive plants are in other families.



Velleia rosea, an attractive annual. (Goodeniacae.)



Velleia rosea, faded to almost white, fills the spaces between Acacia bushes which have an under storey of *Waitzia acuminata (yellow).*

Resurrection plants

A rather more bizarre strategy is to seemingly die over the summer. This is not unusual for lichens growing on a bare rock but it is extremely unusual for higher plants. It is the strategy adopted by the several species of *Borya*. Even the individual cells shrivel. With the onset of the next season's winter rains the apparently dead plants return to life.



Borya constricta, a "resurrection plant" growing in shallow soil over a rock, photographed in Spring. Some of the plants are already starting their summer aestivation. The pink flowers are the Stylewort, *Levenhookia leptantha.*

Geophytes.

When things get tough, retreat to an underground storage organ. This is a common strategy both in WA and in South Africa, which is why their plants are such effective weeds in our environment.

Over 85% of 153 tuberous species recorded in Western Australia occur in the State's South West. At least one tuberous species from the South West (*Platysace deflexa*) has considerable horticultural potential and market appeal. It produces numerous relatively large tubers and mother plants appear to rapidly recover and sucker following tuber harvest. Tuberous species of *Platysace* (and other genera) from south western Australia were important food sources for aboriginal people.

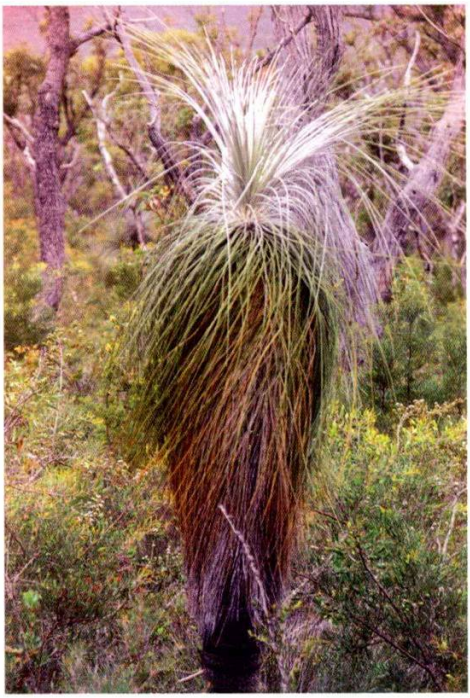
Most famously, the strategy of retreating underground is adopted by orchids. In the South West, we have 28 genera and 394 species of terrestrial orchids including 119 species of *Caladenia* - the spider or fairy orchids.



The rare Grand Spider Orchid, *Caladenia huegelii* .

Stilt roots

The surface of the soil can become baking hot in summer. Some plants develop stilt roots and this seems to be an adaptation that lifts growing points above this layer. An extreme case of stilt roots is provided by *Kingia*. This plant is superficially similar to *Xanthorrhoea* but is only distantly related. The "trunk" is made up of adventitious roots that arise from the leaf bases and travel to the soil. It is therefore thinner and more flexible than that of *Xanthorrhoea* for which the "trunk" comprises fused leaf bases.



The southern form of *Kingia australis* for which the leaves are covered with fine hairs giving them a silky appearance.

Dual root system

Some plants have two distinct root systems. Surface roots develop during the winter and grow cluster (proteoid) roots. These are involved in nutrient uptake. The nutrients may be stored in the stems rather than used immediately. The surface roots die off as summer approaches (and their nutrient content is recovered). There is also a distinct set of sinker roots tapping soil moisture in deeper layers. These provide water and this, plus the stored nutrients, may be used for growth and flowering during summer.



Banksia grossa flowering at the end of March 2008 at Badgingarra.

Be hairy

Cut down evaporation by developing dense felting layers of hairs. This strategy tends to be best developed in plants adapted to the more arid end of the environment. It is unusual in Boronias.



Barbalin Boronia (*B. adamsiana*) near Muckinbudin September 2006.

A dense covering of hairs is more usual in the group that used to be regarded as a separate family called *Chloanthaceae* but which has now become part of *Lamiaceae*. A good example is "Red Velvet". It grows near Muckinbudin and deserves to be elevated to the status of "Icon Plant" – the one that the tourists have to see – along with the Wreath Leschenaultia, the Sydney Opera House and Ayres Rock.



Red Velvet (*Hemiphora elderi*) near Muckinbudin, September 2006.



Native Foxglove (*Pityrodia terminalis*). The Northern form – as here from near Mullewa – is deep pink. As you move South, the flowers are paler and are mostly white near Corrigin.



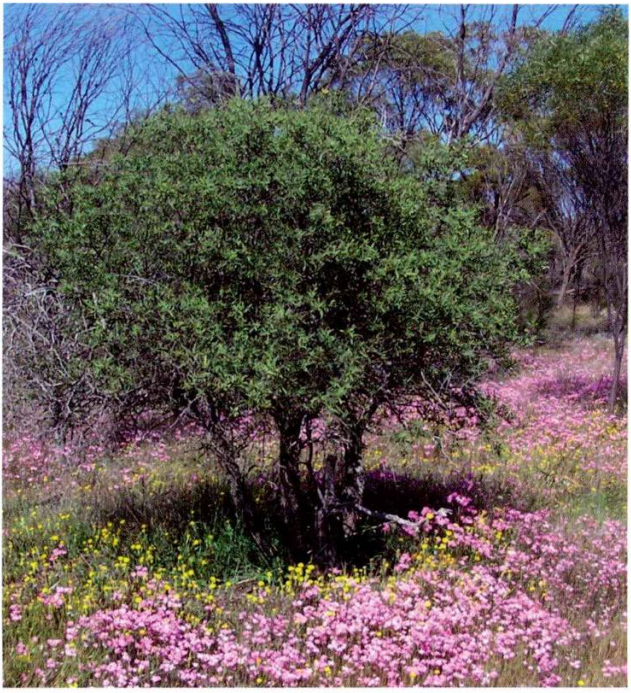
Lambs tail (*Lachnoatachys verbascifolia*) Kings Park garden, June 2006.

Be very parsimonious with nutrients

Our plants have hard thick leaves with very low concentrations of nutrients - especially Phosphorus (P). They grow slowly if you measure growth relative to leaf mass, but the P is efficiently used and indeed they grow quickly if you measure growth relative to mass of P. They hold on to their P very tightly and recover it almost completely before a leaf is allowed to die. On the other hand, they are extraordinarily generous to their offspring, pumping the scarce resource (P) into the seeds. For example, *Banksia hookeriana* has been found have 48% of its above ground P in its seeds even though they were only 0.05% of the mass.

Be a thief

The obvious solution to the water and nutrient problem is to steal someone else's supply: to be a parasite. Stem parasites include the almost ubiquitous dodders (*Cassytha* sp.), and most mistletoes; root parasites include several genera in the sandalwood family (*Choretrum*, *Exocarpos*, *Leptomeria* and *Santalum*). Especially for the early settlers, sandalwood (*S. spicatum*) was very important because the wood was so valuable. Pulling sandalwood trees and cutting down Jarrah trees



A sandalwood tree (*Santalum acuminata*) near Merredin. Note the ring of fertility around the base of the tree. The pink flowers are *Schoenia cassiniana* and the yellow are *Podotheca gnaphalioides*.

were the two main sources of income – until gold was discovered. Because sandalwood steals water and nutrients from its neighbours, it does not bother to conserve them. The bushman's means of identifying sandalwood was by feeling the leaves; they felt cool on a hot day because of all the transpiration. Nor does it conserve nutrients – see the picture on the previous page..

Surely the most famous of our parasites is the Christmas tree (*Nuytsia floribunda*) which bursts into its flame orange flowers in late November - and is therefore seldom seen by our spring visitors. It is classified as a mistletoe even though: 1) its seeds are dry and papery not sticky as most mistletoes; 2) it parasitises roots not stems; 3) it does not have haustoria but a curious scissor-like mechanism by which it snips off roots; and 4) it is a tree.



Flowers of the Western Australian Christmas tree (*Nuytsia floribunda*) photographed in Kings Park 1 December 2009.

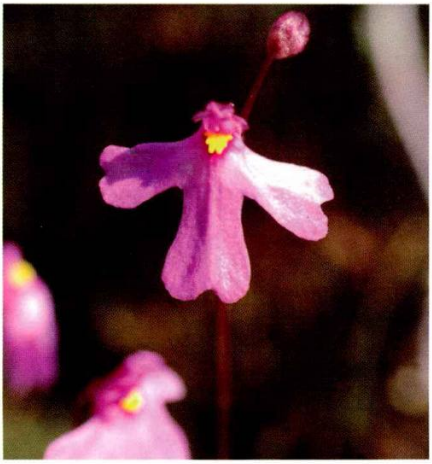
Eat meat

When nutrients are scarce, a sensible strategy is to utilise the passing supply in the form of insects; to be carnivorous. This strategy is adopted so successfully by the Droseras that there are about 100 species in the South West. These range from twining forms for which the flowers can appear at hip height to the tiny pigmy forms for which the rosette of leaves may be smaller than a 20 cent coin and the flowers a few

centimeters above the soil surface. However the carnivorous habit brings a problem. The plant wants insects to go to the leaves and stay there, but it also wants other insects to go to the flowers and leave, taking pollen with them. Flowers are therefore well separated from the leaves.



A pigmy Drosera (*D. platystigma*) growing amongst gravel at Dryandra Forest). The cream hand-like objects are spent Conospermum flowers.



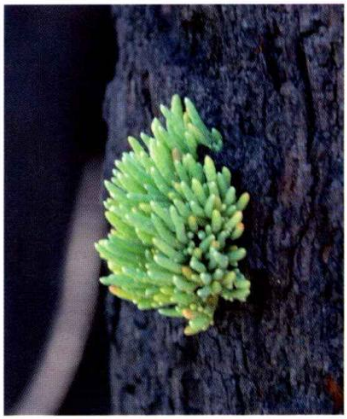
The bladderworts catch tiny animals using modified roots that suck their prey into a bladder. They are therefore found in damp soil or in water. About 15 species occur in the South West with many more in the Kimberley.

Pink petticoats (*Utricularia multifida*) photographed in a damp spot on Boyagin rock.

Either a seeder or a sprouter be

Fire has always been part of the environment. In the millions of years prior to aboriginal occupation, fires would have been infrequent and very large. For at least 50,000 years aboriginal people used fire for land management and to hunt, but there is much argument about the frequency with which it was used. Currently, our forests are subject to control burns at intervals of about a decade.

Plants have adopted two contrasting strategies to deal with fire. Some are "sprouters"; they have thick corky bark that resists fires plus many buds from which they can re-sprout after fire. Some are "seeders"; they retain their seeds within woody capsules that open after the fire.



Shoots emerging after fire through the bark of a sheoak (*Allocasuarina fraseriana*).



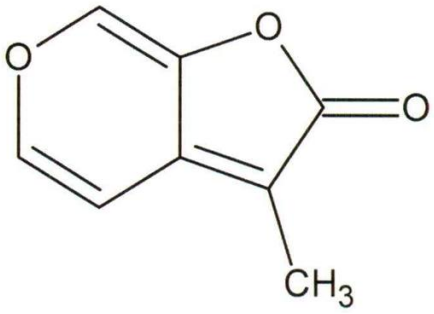
Rose Banksia (*B laricina*), so called because of a fancied resemblance of the seed cone to a rose, retains its seeds until a fire.

There are three separate effects of fire on germination. The first is that it opens the follicles on plants such as Banksias by melting the resin that holds them shut. In some cases the "separator" prevents the seeds from shedding until the cone has been moistened by rain.

The second effect of fire is to damage the coat of those seeds for which germination is prevented by an impermeable seed coat, a very common mechanism for legumes including acacias, and these often germinate profusely after a fire.

The third effect is to break seed dormancy. Many seeds remain dormant, that is "asleep", for many years. The dormancy is controlled by the balance between two hormones: auxin which inhibits germination, and gibberellin which stimulates it. Smoke from fires wakes up these sleeping seeds. Scientists from Kings Park and from the University of Western Australia have shown that this effect is due to particular water-soluble chemicals found in minute proportions in smoke. These chemicals have been given the name "Karrikins" and the abbreviation "KAR". The name is derived from the Noongar word for smoke: "karrik", plus the "in" ending used for many plant hormones such as auxin and gibberellin.

There is now good evidence that the mechanism by which the Karrikins react is to stimulate production of gibberellin within the seeds. They are extraordinarily effective, working at concentrations of one part per billion. The little packets of sugar you get when you buy a cup of coffee usually contain about 4 g of sugar. Imagine dissolving half of this in an Olympic size swimming pool. That is about one part per billion. What is more, they are effective at a 10^{th} of this concentration and even have some effect at 100^{th} of it. Unfortunately, attempts to market these chemicals, and thus to provide ANSP(A) members with a simple and effective way to germinate difficult seeds, seem to have stalled.



The structure of KAR_1 the first Karrikin to be isolated. The other members of the group have an extra CH_3 group.

Pollination wars

Fortunately for us, our plants initiated an "armaments race", a race to see who can have the most flamboyant and attractive flowers. Once started, this kind of race becomes self-perpetuating.

In many cases the plants are vying for the attention of birds. Bird pollination tends to become self perpetuating because our "honey eaters" are also insect eaters thus doing plants the extra favour of eating pests but also decreasing the effectiveness of insect pollinators.



Banksia coccinea has the typical properties of a bird pollinated flower – large, red inflorescence on a robust stem.

Sometimes the adaptation for bird pollination is not so obvious. For example, there are several Grevilleas with flowers that appear to us as black. However, we have only three kinds of colour-detecting pigments in our eyes whereas birds have four. To them these flowers are presumably brightly coloured.



Grevillea apiciloba.

If bird pollination is to be effective, it is a good idea to place the pollen where it is most likely to be picked up. Most of the genus *Calothamnus* have claw-like bundles of red stamens plus a substantial nectar reward. The reward is enthusiastically sought by small honey eaters such as the New Holland whose beak fits nicely in to the flower. A quite similar flower architecture is used by other plants – for example the Kangaroo paws.



Flowers of *Calothamnus graniticus.*

The red flowers of the rare *Darwinia sanguinea,* also suggest bird pollination but the flowers are displayed on the ground outside the plant (Photo Mount Lesueur).



Darwinia sanguinea.

Be big

When you are competing for attention, bigger is always better. At least this seems to be the evolutionary path chosen by many of our plants. An easy way to be big is the simplest. Mottelcah is well named as "*Eucalyptus macrocarpa*" because its flowers can be 10 cm in diameter. Note that the plant does not develop adult foliage but rather retains the juvenile rounded leaves.



Eucalyptus macrocarpa.

It is also possible to be "effectively" big by gathering several individual flowers into an inflorescence. In *Eucalyptus macrandra* (below) the inflorescence is a loose one. In the case of *Eucalyptus conferruminata,* the individual flowers are fused together. To achieve big "flowers" the stamens need to be long and this poses a packing problem when they are in bud. For many of our species, this problem is solved by having a long, narrow, horn-shaped bud cap.



Partly open group of flowers of *Eucalyptus macrandra.* When fully open the flowers form a fluffy ball.

The strategy of gathering several individual flowers into an inflorescence is well known in daisies where a common arrangement is an outer ring of ray florets around an inner group of disc florets. An analogous arrangement is adopted in the genus *Actinodium* which (surprisingly) is in the *Myrtaceae* family. Two species are now recognised. The larger flowered species (pictured) has been referred to as *A. calocephalum* but this is now regarded as an error (Florabase).



Actinodium sp
Fitzgerald River.

Be tricky

The organ on the right of the photo of the King-in-his-carriage Hammer Orchid resembles a female Thynnid wasp. It emits a pheromone which attracts a male. When he attempts to take off with his supposed girl friend, the orchid flexes at the "hinge", banging him against the column and leaving and/or picking up pollen.



King-in-his-carriage Hammer Orchid
(*Drakaea glyptodon*).

Be showy

Many of our plants display a dazzling array of colours and the colours are achieved in several different ways. The bud caps of *Eucalyptus erythrocorys* are bright red and these contrast with the bright yellow stamens arranged in four clumps at the corners of the flowers. This small eucalypt flowers in late summer and makes a welcome addition to most gardens. It is widely planted in Perth but less well known in the eastern states.



Illyarrie (*Eucalyptus erythrocorys*) showing flowers and buds.

Pop flower (*Glischrocaryon aureum*) is often seen along roadsides in spring. The remarkable thing about this plant is that it is a member of the family Haloragaceae. Many other members of this family are aquatic, with inconspicuous flowers. The other land-based members of this family also have inconspicuous flowers.



Pop flower (*Glischrocaryon aureum*).

A different strategy is used by the Tinsel Flowers (*Cyanostegia*). In this genus, the calyces are brightly coloured and persist after the flower is spent. The effect is therefore of a brightly coloured bush that can be seen from afar even when only a few flowers are present. In several Eremophilas (eg *E. fraseri*, *Australian Plants* 199) the calyx is also brightly coloured and persists.



Cyanostegia angustifolia.

A simple strategy, and one that is widely used in WA, is to produce a large number of flowers that are so closely crowded that the whole plant is effectively one inflorescence. This strategy is used by several species of Verticordias and is one of the reasons they are so popular.



The pink form of the woolly featherflower *V. monadelpha*.

Pull the trigger

Trigger plants (*Stylidium sp* from the Greek stylos: a column) are a very successful genus in the south-west of Western Australia, with about 200 species currently listed in FloraBase. They are so-called because of a sensitive column that reacts to being disturbed with a reaction time of as little as 15 milliseconds This may be more than an effective means of transferring pollen to an insect visitor; it may also be a defence mechanism discouraging flower-eating insects.

They are present in just about every environment in the South West. Many have a basal tuft of leaves but there is great diversity with even two scrambling species with hooks at the ends of their leaves.



Cow Kicks (*S. schoenoides*) is appropriately named and well known to little boys (and to big ones). It has the largest flower in the genus – about 5 cm from top to tail. The left and centre flowers have not "fired"; the right one has.



The small lobes in the centre of this beautiful Queen Triggerplant (*S. affine*) prevents access to the nectar unless the insect lands on the lower petals.



The tiny *Levenhookia stipitata* is a member of the same family but without the trigger. Named for Leeuwehoek - inventor of the microscope.

Beat the rush

In the peak flowering period, there is much competition for pollinators. An effective strategy is therefore to flower "off-peak". This strategy is specially effective when the pollinators are vertebrates (birds or mammals), because they are likely to be there all year. It is widely adopted by Banksias and is enabled by their dual root system: it seems there is always at least one banksia in flower. The spread of flowering also helps the pollinators to survive through the year.



Firewood Banksia (*B. menziesii*). Late April 2008.



Swamp Banksia (*B. littoralis*). Early June 2008.



Shell Hakea (*H. cucullata*). South Coast June 2009.



Cockie's Tongue (*Templetonia retusa*). South Coast June 2009.

Mimicry

Many plants save themselves the cost of providing a reward for pollinators by mimicking something else. The yellow and brown flowers of donkey orchids mimic similar colours of "bacon and egg" peas which are a rich source of nectar. Similarly some of the blue *Thelymitra* orchids mimic blue lilies. Most Pimeleas have pale flowers and a sweet scent and are pollinated by moths. *P. physodes* (Qualup Bell) is an exception. Its flowers are hidden within coloured bracts which mimic the bells of several species of *Darwinia* that occur in southern regions.



Pimelea ciliata plus moth visitor photographed in John Forrest National Park.



Qualup bell (*P. physodes*) photographed in Fitzgerald River National Park.

Diversity

South-western Australia is a centre of exceptionally high plant species richness and endemism. It is one of the world's 25 biodiversity hotspots. Furthermore, within this region, researchers have identified seven sub-regional centres of biodiversity. Why is this so?

Understanding diversity follows from an understanding of our landscapes. This developed slowly. Early explorers, noting the deep sand, the subdued to flat topography, and prevalence of salt lakes thought they were looking at a young landscape recently emerged from the sea. Even Charles Darwin advocated such a view. Yet marine fossils were conspicuously absent across most of the south-west inland. The notion that most south western Australian landscapes were very old and infertile gradually became undeniable when people tried to grow crops. This is now well accepted and indeed we have our very own acronym for such landscapes: OCBILS. It stands for Old Climatically Buffered Infertile Landscapes. This acronym was introduced by Stephen Hopper in 2009. He contrasted such landscapes with "YODFELS" which stands for Young Frequently Disturbed Fertile Landscapes. Better get used to these acronyms; you will probably hear them with increasing frequency!

The notion of "climatically buffered" needs some explanation. As we all know, over the last several million years, the Earth has passed in and out of ice ages with a periodicity of about 100,000 years. During the ice ages, much of the world was covered by glaciers. These removed the vegetation and the top soil, and further, as the glaciers retreated, glacial winds blew ground-up rock dust over the environment. The consequently rejuvenated soils provided a good environment for those plants that could grow quickly and could spread their seed widely. Climatically buffered regions were not unaffected by these changes but they were not glaciated. Rather they presumably passed through alternating cycles of dryness and wetness. These did not destroy the existing vegetation but they must have changed the balance of advantage.

It used to be thought that tropical rainforest provided the acme of diversity. From the ground, many of the trees look quite similar but from the top it was clear that the problems of growing in such an environment had been solved by many different species. Yet here in the Southwest, with its harsh conditions and often stunted vegetation, the problems of survival have also been solved by many different species as has been indicated earlier in this issue. But why has no particular strategy "won" and so come to dominate the landscape?

One reason seems to be that in our harsh environment wide dispersal of

seed is not a very successful strategy. It is probable that the best place to grow is somewhere near the parent plant rather than much further away. Despite the limited range of dispersal for each generation, some plants have large ranges. For example *Banksia prionotes* extends from Shark Bay to Wagin, a distance of about 1000km. Imagine how long it must have taken to achieve such a spread.

Another reason is that growth is slow. It is limited by phosphate supply. Consequently, if a particular species develops a really successful set of strategies, it is going to take a long time to spread those strategies over a wide area. Before this can happen, the Earth has probably moved in or out of an ice age, and thus in or out of a wet period, so that set of strategies is no longer advantageous.

Alternating wet and dry periods have probably also played a direct role in speciation. Evidence for this is provided by the current distribution of some species. For example Jarrah (*Eucalyptus marginata*) mostly grows in a fairly high rainfall region. However, there is an isolated occurrence around the base of a rock near Kulin in a low rainfall area. Run-off from the rock means that the water supply is somewhat greater than would appear from the rainfall values. Presumably this is an isolated remnant from a period when the rainfall was much higher. There are analogous isolated occurrences of eucalypts, for example *Eucalyptus caesia*, on widely separated rocks. Presumably in some previous climate, such species were more widely spread and were in contact with each other. Such isolation enables local selection pressures to favour different characters. If the period of isolation is long enough and the selection pressures strong enough, the plants may differ sufficiently to be considered different species. A reversal of the climatic change may bring them together, as different species.



Jarrah blossom (*Eucalyptus marginata*) October 2004.

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