fostering research into
the biology and cultivation
of the Australian flora

Research Matters

Newsletter of the Australian Flora Foundation

January 2016

Inside

Meet our new Councillors

We are delighted to welcome two new Councillors, Jennifer Firn and Carolyn Gillard. Both Jennifer and Carolyn were elected at our AGM in December 2015. Here are their brief profiles:

Jennifer Firn, Associate Professor in Ecology, Queensland University of Technology

I am a theoretical and applied ecologist who specializes in linking ecological theory to the sustainable management of degraded grasslands and forests. The driving motivation behind my research is to find smarter, cheaper and more sustainable ways of restoring degraded plant communities. Many of the ecosystem functions that humans need to survive are provided by richly diverse ecosystems, such as oxygen production, water filtration, nutrient cycling, pollination, and carbon sequestration.

Globally, unsustainable land use has led to the degradation of many valuable ecosystems and the loss of irreplaceable biodiversity. I am passionately committed to developing a better understanding of how the loss of native biodiversity impacts on ecosystems and subsequently finding better ways to bring it back.

Carolyn Gillard

I was born and have spent most of my life in Newcastle. After completing high school, I initially trained as a teacher in the early 1970's. After teaching for several years in both Sydney and Newcastle, I resigned to care for my children. During this time, I studied Horticulture and Landscape Design and initiated a business partnership as a Horticultural Consultant and Landscape Designer. At this time, I also joined the Newcastle branch of the Australian Plants Society, and initiated a professional association for landscape designers. I am a life member of APS NSW and a Fellow of the Australian Institute of Landscape Designers and Managers.

I returned to the Department of Education and Training as a teacher of wetland ecology at the Wetlands Environmental Educational Centre at the Hunter Wetlands Centre, and have recently retired from that position after more than 20 years. For the past few years I have been a director on the Board of the Hunter Wetlands Centre, so will be able to continue my involvement there following my retirement. I am also a member of the Australian Association of

Environmental Education and am a former President of Australian Native Plants Society (Australia). I have been married to Geoffrey for 44 years and we are both keen bushwalkers. I also enjoy spending time with my four children and three granddaughters, and enjoy quiet moments quilting.

Young Scientist Awards

For many years the Australian Flora Foundation has been awarding prizes to encourage young scientists to continue studying Australia's flora.
At the Ecological Society of Australia's annual conference in Adelaide in December 2015 the Foundation's prizes were presented to:

Outstanding student spoken presentation

Rebecca Jordan (University of Melbourne) "Assessing adaptive potential of revegetation: comparing genomics of natural and revegetated stands of *Eucalyptus microcarpa*".
Rebecca is a PhD candidate investigating climate adaptation in *Eucalyptus microcarpa* (Grey Box). Her project aims to improve conservation and revegetation efforts by increasing understanding of climate adaptation at both genomic and quantitative trait levels, as well as comparing genomic diversity within natural and revegetated sites.

Outstanding student poster presentation

Freya Thomas (University of Melbourne) "How should we model reproductive maturity in plants?"
Freya is a PhD student at The University of Melbourne in the Quantitative and Applied Ecology Group.

President's Report 2015

Delivered by Dr Peter Goodwin at the AGM on 14th December 2015

Research

The Foundation has been able to fund five projects to commence in 2016:
1. A study by Geoff Burrows, Charles Sturt University, on changes to the lens, the key point for water admission in *Acacia* seeds, in response to dormancy breaking treatments. It has long been known

that the treatments change the lens somehow, so that water can enter the seed. This study will attempt to find out more about what happens, surveying a wide range of native Acacias. With this knowledge, workers in both the ecology and nursery fields will be better equipped to understand the germination responses of their *Acacia* seeds.

2. Research by David Mackay, University of New England, will focus on the ecology of the threatened keystone species, *Ficus rubiginosa,* the Rusty Fig. The results will be of benefit not only to *F. rubiginosa* but also to the many species that depend on it, particularly in the western, drier parts of the species range. It is also likely to have broad application to other threatened communities.

3. Work by Todd Minchinton, University of Wollongong, on the key coastal salt marsh plant species. He will examine the viability, germination requirements, and cultivation of these plants, and particularly how these might vary with temperature. This research will contribute to the conservation of plants in this endangered ecological community.

4. Annisa Satyanti, Australian National University, will assess how climate change will affect the germination success and seedling growth and survival of Australian alpine plants. The study will identify the species with the highest potential adaptive germination capacity and the species which are likely to face the strongest regeneration pressure under future climates, and so inform plans for the management of threatened and endemic alpine species.

5. Monique Smith, University of Adelaide, will run experiments to gain insight into common barriers to restoration of native grasslands, and how these can be overcome to re-establish diverse and resilient native grass communities. Such communities are essential to restore habitat for native fauna, and enable salinity reduction and soil stabilization.

Succession planning for the Foundation

Richard Williams has stood down as Chair of the Scientific Committee. He has been a member of this committee since 1982, when it was established, and Chair since November 1986. We thank him for his service in this vital role for twenty-nine years. The Foundation is fortunate to have found a very able replacement, Michelle Leishman, whom the Council has appointed to replace Richard.

In other succession planning, Jenny Jobling has stood down after 9 years as Treasurer, during which time she streamlined our accounting procedures. The Council of the Foundation now has a new Treasurer, Charles Morris. We thank him for taking on this role, also vital to the functioning of the Foundation.

Finally I should like to thank all of you for your contributions over the year, most particularly members of the executive, members of the Finance Subcommittee, of the Scientific Committee, and members of Council. A special thank you to all donors and benefactors of the Foundation: without you the Australian Flora Foundation could not function. Particularly noteworthy are donations of $5,000 from APS NSW, $5,000 from SGAP Queensland Region and $1,000 from APS Newcastle.

Peter Goodwin
President
14th December 2015

The geology and the soils of the south-west determine where the plants grow

Jim Barrow*

The soils of the south-west corner of Australia are extremely deficient in nutrients, especially phosphate, and therefore carry a large population of *Proteacea*e. Or is it the other way around? Actually it is a bit of both.

When the Earth was very young, it took a long time for the silica-rich "scum" to find its way to the surface, where it formed the rafts which are the base for today's continents. One of those rafts is now the large granite block that forms most of the south-west. Granite is rich in silica, but pretty poor in nutrients such as phosphate, so it started off from a low base. Furthermore it has been quite stable. The surface has not been scraped off by glaciers since about 270 million years ago when Australia was much further south, and indeed the South Pole was located in Tasmania, and there have been hardly any volcanoes. Only a few bits around the edges have crumbled, sunk below the sea, and got a coating of sediments. In many cases, such sediments are little better than second-hand granite, and even more nutrient-deficient. Witness, for example, the Mount Barron Ranges and the Stirling Range in the south.

Left: Fitzgerald River National Park with the West Mount Barren Range in the background. Right: the rugged Stirling Range provides a background to a gravel pit, in which several species of *Dryandra* grow.

Five diverse *Proteaceae* from Fitzgerald River. Clockwise from left*: Hakea victoria, Franklandia fucifolia, Banksia coccinea, Adenanthos cuneatus, Banksia baueri.*

That is the broad picture: when we look at the details, it is not quite so bleak. One of the major influences was the formation, and subsequent breakup, of Gondwana. When continental masses collide, one continent tends to ride up over the other, and this brings the good stuff that sits under the granite up to the surface. So the seams that mark the former junction of continents are occupied by much better soils. This applies to the Porongurup Range and to the Leeuwin-Augusta Ridge that forms the "chin" of the extreme south-west. Both of these are occupied by Karri forests (with very few *Proteaceae* present) – and these days by wineries.

The Karri forest is dominated by tall trees: on the left is the Gloucester Tree, one of the King Karris. Such trees overlooked the forest and were used as sites for fire spotters. These days, aircraft are used, and this tree provides a challenge for tourists to climb to the top. The understory of the Karri forest includes acacias and tangles of flowering creepers such as the one on the right.

Because these soils carried tall forest, it was thought that they must be fertile and therefore suitable for dairy farming. However the early settlers had no idea how much phosphate had to be applied to these strongly P-sorbing soils before clovers and grasses could be grown – a cause of much misery, but which, fortunately, resulted in the retention of much of the Karri forest.

When Greater India was joined to the West Coast, the coast was not a coast at all but an inland region bordered on the west by a substantial mountain ridge. In the Dongara region, a series of swamps backed up behind this ridge gave rise to coal and gas deposits. One of these coal deposits lies under the Mount Lesueur National Park, and is always a potential threat from people who would like to mine it.

Part of Mt Lesueur National Park – the third jewel in the crown of National Parks of the south-west - together with Fitzgerald River and Stirling Range.

One of the ways that *Proteaceae* deal with the low-phosphate problem is by postponing the greening of new shoots, The first step is to grow the new leaves, protecting them with anthocyanins, then reallocate the phosphate to photosynthesis. (*Adenanthos cygnorum*)

It is a reflection of the complexity of the WA flora that this attractive *Melaleuca*, prominent in Mount Lesuer National Park, does not have a certain species name. It is one of a complex of closely-related taxa that has not yet been sorted out.

When Gondwana subsequently broke up, the edges of the crack tended to crumble, sink and be covered by sediments. This is the origin of the coastal plain on which Perth is located. Near Perth, most of the sediments are now covered by dunes of beach sand, which range from very old indeed for the most inland dunes to quite recent for those closest to the sea. This gives rise to a fertility gradient, because the most recent dunes often have a substantial proportion of shells, and therefore an appreciable source of phosphate. They also have very few *Proteaceae* present.




Plants such as *Spyridium globosum*, acacias and Tuart (*Eucalyptus gomphocephala*) (above left), *Diplolaena dampieri* (above right), *Trachymene caerulea* (lower left) and *Diplopeltis huegelii* (lower right) grow on the relatively fertile foredunes.

In contrast, older dunes carry Banksia Woodland, here *B. attenuata*, and *Xanthorrhoea preissii.*

Two prominent Banksias from the older soils of the coastal plain: left, *B. menziesii* flowers in winter, and right, *B. attenuata* flowers in summer. The *B. attenuata* picture was taken in March after about 5 months with almost no rain, yet this plant bursts into flower – another remarkable adaptation. It is also an example of "ecosystem evolution": a year-round supply of nectar is required for vertebrate pollination.

The Darling Scarp, which runs more or less north and south for about 1000 kilometres, marks the breakup of Gondwana. Over the last couple of million years, this land has been uplifted by about 300 metres. This means that the rivers draining this region have been rejuvenated, and have started to cut down sometimes as far as fresh rock.

Here, in John Forrest National Park, at the edge of the uplifted area, a rejuvenated stream has encountered a diorite dyke. As granite magma cools and solidifies, it shrinks and cracks. Molten material from the base of the magma forces its way into these cracks. This material cools quickly and large crystals don't form so you get a fine-grained low-silica rock. This rock is more resistant to erosion, and consequently a waterfall has formed.

In the region of rejuvenated drainage there is more relief and also some gradient of fertility, with the best soils towards the bottom of the slopes. In these landscapes we find *Proteaceae* most notably in the soils of lowest phosphate status. They are particularly well-represented on higher ground which has ironstone-rich soils. They grow there because their roots form root clusters – regions of multi-branched rootlets that secrete carboxylic acids such as citric acid. These dissolve iron and aluminium oxides, releasing phosphate and micronutrients that are locked up within the oxide, and thus giving access to them for the plants.

However, the root clusters are short-lived structures, normally lasting about three weeks. When they break down, bacteria rapidly attack the carboxylic acids: they are a good source of energy. Consequently the dissolved iron and aluminium re-precipitates. These tended to have dissolved most readily from smallest particles but precipitate on the larger particles, so after a few tens of thousands of years gravel forms and phosphate and other nutrients are locked up within the gravel. Hence we can also argue that the soils are phosphate deficient <u>because</u> *Proteaceae* grow there. By the way, this is a neat strategy for giving yourself an advantage. The plants with cluster roots have changed the soil into one in which plants with cluster roots do best.

Above: Cluster roots on *Banksia grandis* in solution culture. Note that one group is already starting to break down.

One of the questions that intrigues ecologists is the extraordinary diversity of plants that occur on such extremely impoverished, ironstone-rich soils. Not all of them are *Proteaceae*: plants from other families, such as here *Leschenaultia biloba* (blue) may be able to “steal” some of the phosphate released by the roots of the *Proteaceae.*

At one extreme of phosphate status, Western Australia is famous for the growth of *Proteaceae*. At the other extreme, it is also famous for the growth of showy annuals commonly referred to as everlastings. Because they are annuals, their strategy is live fast, die young. Phosphate is the governor of the engine of life. Plants can therefore only use this strategy when there is a reasonable supply of phosphate. Everlastings used to be very common in what is now the wheat belt, where they were found on soils in mid-slope positions commonly referred to as York Gum and jam soils (*Eucalyptus loxophleba* and *Acacia acuminata*). These soils were soon recognised by farmers as being good for agriculture and were enthusiastically cleared. Of the few that remain, many are invaded by weeds because of their slightly higher fertility. Spectacular displays of everlastings are now best seen in the region that is just outside the wheat belt in areas of rainfall too low for agriculture and where, as a consequence, the soil is not so badly leached.

A rare sight these days: everlastings growing beneath "jam" trees (A*cacia acuminata*).The pink flowers are mostly *Schoenia cassiniana* and the yellows are mostly *Waitzia acuminata.*

Left. Sandalwood trees are root parasites. They steal their nutrients from other plants and are quite profligate with them, scarcely bothering to recover them from senescent leaves. Consequently there is a ring of higher fertility beneath such trees. The everlastings are almost completely excluded from this region, partly because of the increased growth of weeds such as wild oats, and partly because *Schoenia cassiniana* seems to be particularly sensitive to high phosphate.

Magnificent displays of everlastings photographed here east of Mullewa in “pastoral” country – too dry for agriculture. Such displays only occur in good years, when adequate rain falls at the appropriate time. Such years are becoming increasingly uncommon.

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*About the author

Dr Jim Barrow “retired” in 1992 as a Chief Research Scientist after nearly 40 years with CSIRO. Post retirement he has continued his scientific work, publishing in that period more than 40 research papers in refereed journals - almost a quarter of his total publications of more than 200. He has been recognised as “highly cited”, putting him in the top 1% of scientists. Since retirement, he has also devoted time to his passion for wildflowers, publishing one book and preparing several issues of *Australian Plants*. He has been a prominent member of the Wildflower Society of Western Australia for many years. His roles have included Newsletter Editor, Web-site Manager and President.

The genus *Eremophila* in Australia's arid zone: phylogeny and biogeography

Rachael Fowler – PhD student, The University of Melbourne, Royal Botanic Gardens Victoria

Eremophila (family Scrophulariaceae, tribe Myoporeae) is a diverse and uniquely Australian genus of over 200 described species and a continuously growing list of newly discovered taxa. The name *Eremophila* is derived from the Greek words *eremos* and *-philus*, which translate to ‘lover of solitary or desert places’. This name perfectly describes the genus, which thrives in arid and semi-arid environments throughout Australia.

For the past two years I have been focusing on this fascinating group of plants for my PhD research, which is based at the University of Melbourne and Royal Botanic Gardens Victoria. One major aim of my research is to develop a DNA based phylogeny, or family tree, of all *Eremophila* species. Such a phylogeny would be the first of its kind for *Eremophila*, and will allow us to better understand the genus – using new molecular data in conjunction with traditional morphological methods for an integrated classification. In turn, this classification will provide a framework for formally describing a number of new species, and will help us investigate broader patterns of evolution in Australia’s arid zone.

I am also interested in a number of genera thought to be closely related to *Eremophila*, including *Myoporum* (Boobialla), *Diocirea*, *Calamphoreus* and *Glycocystis*. These groups are predominantly found in Australia, and in the case of *Myoporum*, throughout the Pacific Islands and beyond. While we know them to be closely related to *Eremophila*, including them in an additional phylogeny will shed light on how each of the genera fit together within tribe Myoporeae.

To complete this research I have been awarded a Jim Ross PhD Scholarship, funded by the Cybec Foundation, as well as an

Australian Conservation Taxonomy Award through the Nature Conservancy and the Australasian Systematic Botany Society.

So far I have managed to collect over 450 plant specimens from right across Australia, representing approximately 95% of total *Eremophila* diversity. These collections have been made predominantly in the field, but also include specimens from living botanic garden collections, and private gardens.

Eremophila decipiens (left) and *Eremophila fraseri* (right)

Once collected, I dry a small amount of leaf tissue from each specimen in preparation for DNA extraction, then Next Generation Sequencing (a new technique that allows us to piece together DNA from an organism's entire genome). For this particular research I am interested in the chloroplast genome, a ring of DNA found in all plant chloroplasts that contain genes coding predominately for photosynthesis and protein production.

Earlier in the year I ran a pilot study to test these new techniques on a subset of my samples, and have since been working on putting together and analysing this data. Just recently I assembled the first ever *Eremophila* chloroplast genome, followed by a (very) preliminary molecular phylogeny using data from nine species. The *Eremophila* chloroplast appears to be similar in structure to another distantly-related member of plant family Scrophulariaceae (used as a reference), however I have also observed some significant differences – namely the loss of a stretch of about 3,000 base pairs of DNA including four genes from a duplicate copy region of the genome.

It's still too early to make any solid conclusions, however the sheer amount of data produced using the new Next Generation Sequencing techniques certainly leaves me optimistic in the capability of this novel approach in providing us with the data required to answer my initial questions and make sound conclusions on the evolutionary histories of these plant groups. So for now it's back to the lab to expand my dataset and generate a comprehensive analysis of *Eremophila* and related members of tribe Myoporeae.

Timeframes and other basic aspects of Australian Flora Foundation research projects

Dr Peter Goodwin, President of the Australian Flora Foundation

1. What is the average timeframe for the research, and then the time that is needed to complete the 'writing up' of such research?

There are several timeframes involved:

(i) AFF Council timeframes

The Australian Flora Foundation (AFF) Council sends out the Call for Applications in early December. Preliminary applications are due by mid-March, and short-listed applicants advised after a Council meeting in early May. Full applications are due by a date set in mid-June. These are sent to the Scientific Committee for their advice, and the final decisions on grants are made at a Council meeting in August. Successful applicants are advised. Funds are made available from December. The December Call for Applications is preceded by an AFF Council meeting in November to discuss priorities in the new funding round, and ways the Call can be improved.

Most projects are for just one year, but two year funding is possible. The second year funds are only provided after we have received a good progress report. A final report is asked for, nominally at the end of the last grant year. The reality is that the researcher is flat out acquiring data while they are funded, and most analysis and writing up only occurs once the data has been obtained. <u>We informally allow two years for writing up</u> before pressing for the final report, but of course welcome earlier reports. Note that the final 10% of the grant is only made available when we do get this final report.

(ii) The researcher (supervisor) time frame

This is rather different. They will have a number of projects on the go, as well as teaching and other commitments. They have to consider who will do the work. The best value is to have a good PhD student, who is extensively funded by the University they are enrolled with, but can work at the University or at a botanic garden. A good student will be able to help devise the project, and work with limited supervision. In many cases the student is given responsibility to write the grant application, as part of their training. So they will have been working on developing the project over a year before the AFF grant funding begins. For their PhD they have

to produce high quality publishable new knowledge, so their findings become a permanent addition to our knowledge. They work for three years full time on the project, even if they are only funded for one or two years by the AFF. They also sometimes develop a career working on Australian Plants.
Other options are Postdoctoral workers. They are excellent, but expensive. It's better for short, sharp complex projects. A full-time academic or researcher at a botanic garden will be great, but the demands on their time are so great that they may only have a few days a month free to work on a project. They sometimes employ research assistants to help. Again the research assistants are expensive, and are usually employed for limited periods. In addition the writing up of the work will usually become the responsibility of the researcher.

2. How is the research topic developed?

The researcher will most likely become involved because they see the opportunity to do some good work in a priority area set by the AFF, but also it will need to be in an area they are personally focussed on. This is why we call for the researcher to define the project. It is also far better than trying to pay a researcher to do some specific project, in an area they may not be totally involved in. Defining the idea for the project is very much the art of research, and is a very personal matter. It depends on the researcher deciding this study is worth doing: will it make a difference? They have to be able to sell the idea to a student, or a research assistant, and to the AFF Council and to the Scientific Committee. The latter people also have to be convinced that the researcher can help drive the project to a successful conclusion. This requires a track record of successfully undertaking similar projects.

3. Instead of doing blind research, do researchers write their conclusions first and then attempt to prove them?

Researchers do not do 'blind research'. Sometimes they set out to develop a new process, or commercialise a new plant. Sometimes they do set out to test a specific hypothesis. Scientists call this testing a hypothesis. What researchers call the null hypothesis is that certain simple assumptions are correct. For example a lot of work has gone into trying to show that native plants are not dependent on soil microorganisms (using this as the null hypothesis). In ideal growing conditions they are indeed not dependant, in poor conditions it depends greatly on the microorganisms, the plants and the environment. For good work to be done the experiments have to be designed so that a conclusive result can be obtained. If the results could have arisen from random variation, then the null hypothesis is confirmed. If there is only a small (5% or less) chance that they came from random variation,

they are taken to be significant (don't agree with the null hypothesis).
In addition, if the aim is to publish in a reputable scientific journal (and get an AFF research grant!), it has to be work that has not been done before. For the soil microorganisms they would need to propose to explore the situation for previously untested important plants in an important ecosystem with identified microorganisms. This all has to be worked out before completing the preliminary application, which will be nine months before the funding (if any) becomes available. It takes a lot of time, a lot of talking, thinking and reading, and a lot of experience.

We believe that the end result of AFF funding has been solid new knowledge in the priority areas the AFF has chosen. The results can be seen at http://www.aff.org.au/

Financial

These statements are from the Foundation's audited accounts for the year ended 30th June 2015:-

Income	**$**
Donations	11,163
Membership fees	1,495
Interest, investment income and change in value of investments	40,162
Imputation credit refunds	5,049
Total Income	**57,868**
Expenses	
Grants	59,235
Accounting and audit fees	3,036
Postage, printing, general expenses	1,003
Total Expenses	**63,274**
Deficit for year	**5,406**

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Assets	
Investments and bank accounts	891,788
Debtors	23,307
Total Assets	**915,095**
Liabilities	
Grant commitments and GST	29,784
Net Assets	**885,311**
Accumulated funds	
Balance 1st July 2014	**890,717**
Deficit for year	5,406
Balance 30th June 2015	**885,311**

About us

The Australian Flora Foundation is an Australian not-for-profit charity dedicated to fostering scientific research into Australia's flora. It is totally independent. All members of the Council and the Scientific Committee give their time freely as volunteers.

Each year the Australian Flora Foundation provides funding for a number of grants for research into the biology and cultivation of the Australian flora. While the grants are not usually large, they are often vital in enabling such projects to be undertaken. Many of the researchers are honours or postgraduate students, and their success with an Australian Flora Foundation grant hopefully stimulates their interest in researching Australia's unique and diverse plants throughout their careers.

This work is only made possible by the generous support of donors and benefactors.

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