# Priorities for conservation of Australia's native flora: achievements and proposals for improvement

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Australia is ranked fifth worldwide in the number of its endemic vascular plant species (Conservation International 2000). This highlights the significance of conserving Australia's rich floristic assets. Given conservation resource limitations, priority-setting is essential (Myers *et al.* 2000). With a paucity of bodies catering specifically for research on Australian flora[1] and greater attention to prioritize research required, priority-setting and outcomes-focused research for conserving Australian flora is imperative to ensure restricted resources are applied to flora at greatest risk and of greatest conservation value.

## *Recognizing evolutionary history*

The particular geological and climatic history, and extreme age of much of the Australian landscape, which has experienced long periods of erosion and nutrient leaching, lack of soil-generating processes (volcanism and glaciation), and long geographic isolation, has provided a context for generating highly diverse, idiosyncratic Australian flora with unique adaptations. Unlike much of the globe, Australian landscapes are deeply weathered, with low relief, have naturally nutrient depauperate soils, and experience variable and low rainfall. Hopper's OCBIL theory (2009) has provided important insights into conservation. OCBIL theory develops an integrated sequence of hypotheses elucidating evolution, ecology and thus best conservation practices for biota on very old, climatically buffered, infertile landscapes (OCBILs). OCBIL theory has been important in recognizing how this unique evolution and ecology means conventional conservation theories developed from and for northern hemisphere vegetation are inadequate, if not outright inappropriate for Australian landscapes. The corollary of Hopper's research has led to the recognition of the importance of identifying contrasting floristic evolution and ecology for different landscapes, which require different conservation strategies.

Conventional theories for flora that occur on young, often-disturbed, fertile landscapes (YODFELs) that dominate much of the globe are not appropriate for the old, climatically-buffered, infertile landscapes (OCBILS) that occur to a greater extent in Australia. A key OCBIL is the Southwest Australian Floristic Region (SWAFR) renowned for its biodiversity, wealth of rare endemics and highly vulnerable nature of its flora. For any conservation project, it is important to consider landscape age, climate and soil fertility. The SWAFR's flora are targets for conservation given evolutionary uniqueness (e.g. Dasypogonales, the world's most localized plant order) with endemic families dating from 40Mya (Hopper & Gioia 2004). The long evolutionary history of this region has resulted in sophisticated, complex

[1] Exceptions do exist i.e. the Australian Flora Foundation provides exceptional support for conserving native flora by fostering research into Australian plants, funding projects, and publishing findings.

adaptations. Implementing conservation management for species requires integrating landscape processes and relative age within regions. Hopper's (2009) findings highlight the significance of researching Australia's native floristic species' ecology and evolution, and how conservation of our unique flora often needs context-specific management as conventional Northern Hemisphere practices are inadequate.

Research often reveals special conservation challenges and opportunities for Australian flora. Hopper (2009) stresses the application of methodological approaches and theories catering for contrasting conservation needs for plants of different landscapes. Flora of YODFELs are highly susceptible to extinction from fragmentation, requiring conservation strategies such as preservation of significant areas of land, creation of corridors for preventing inbreeding depression, disturbances regimes to promote diversity and nutrient enhancement (Hopper 2009); contrarily, OCBIL flora exhibit unusual resiliences and vulnerabilities, showing enhanced ability to persist in small fragmented populations, and natural, common rarity, yet vulnerability to disturbance. Nutrients should be applied with caution, as this often greatly enhances weed establishment and growth, one of the major threats facing native flora (Hobbs & Atkins 1988). Strongly differentiated population systems means introductions from other populations can swamp genetic uniqueness, disrupting coadapted suites of traits. Evolution of reduced dispersability and localized adaptations (local endemism) has led to the importance of using local germplasm in restoration (Hopper 2009).

Successful conservation requires research to create and apply strategies context-specific so as to correspond with local complexity.

***Priority-setting***

Since Australia's native flora are integral to ecosystem functioning, clearing and modification has severe effects on other endemic biota, resulting in not only loss of floristic biodiversity, but the ecological community native vegetation supports.
A key inadequacy of many conservation programmes is a bias towards vascular plants; nonvascular flora suffers from lack of biological and distributional knowledge (New, 1996), yet are vital components of ecosystems. The aquatic environment hosts considerable floristic biodiversity, yet despite their ecological significance aquatic flora are often overlooked. Aquatic flora need greater attention.

Surveying and taxonomic analysis is important for priority-setting i.e. classifying threatened flora, identifying populations of priority species, and for directing funding and creation of reserves. Conservation priorities should aim to protect, conserve and restore Australia's natural biodiversity. Identification of `biodiversity hotspots' – areas of exceptional concentrations of endemic species undergoing exceptional loss of habitat (Myers *et al.* 2000) – is a strategy aimed at supporting and conserving maximum species for the least cost. SW WA is a global "biodiversity hotspot", a mega-biodiverse region on a world scale (SER 2001). Advocated as a target for conservation, it is internationally recognized for high diversity (7380 native vascular plants), endemism[2] but also highly threatened status[3]. Only 10.8% of the original extent of primary vegetation remains (Myers *et al.* 2000).

At the species level, catalogues identifying and listing threatened species direct management projects and funding. The Commonwealth Threatened Species List is responsible for assigning threat categories and uses IUCN procedures (i.e. Critically Endangered, Vulnerable etc). Problematically each State has its own classification system, producing discordance for a given specie's status between Federal vs. State assessments and between States. Better integration is required for rankings to be effective. Degree of threat is most frequently the main factor in priority-setting (Hopper 2000). However, Jensz (1996) states the large number of threatened plants and inadequate fiscal resources make the conventional approach determining priorities for conservation solely based on perceived threat-status inadequate. *Potential for recovery* as well as state of endangerment being the criterion for conservation prioritization may be more effective. Also, the IUCN system has numerous drawbacks, is essentially comparative, and lacks quantitative data. An improved alternative should be adopted using relative rankings, involving a flexible system using demographic and distribution data but significantly including scoring of life-history variables, conservation actions and supplementary variables. Such a ranking system is employed by WA DEC (Millsap *et al.* 1990). It provides a more robust means of ensuring conservation resources are allocated on a priority basis to most threatened taxa. Given incomplete datasets and the impossibility of assessing conservation status for every species, a multi-species approach aimed at recognizing and conserving threatened ecological communities would be an improved use of available funds; this would enable the conservation of many species, both known and unknown, in diverse, unique and threatened communities. Conservation should expand from revolving around concentrating only on species to focusing on ecological communities, with the benefit of a greater potential for conservation priorities to be more resistant to vagaries of taxonomic uncertainty, acting as a surrogate for unknown plant taxa but also for genetic variation within a given taxon.

***Ex situ conservation and genetic techniques***

Genetic techniques have made important contributions: analyses supplement priority-setting, contribute towards knowledge and management of threatened species, to constructing conservation units based on phylogenetically distinct populations, and have been used to enhance adaptive capacity of populations.
Ex situ cultivation and reintroductions requires genetic studies to prevent inbreeding depression or heterosis, especially given Byrne (2007)'s phylogeographic studies elucidating highly divergent, localized populations. Understanding historical processes producing current plant assemblages is relevant to how we manage them

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[2] 49% of vascular plant species, including 8 – 11 endemic families; 1 endemic order.
[3] 2500 species are of conservation concern (Hopper & Gioia, 2004) with currently 391 Declared Rare Flora (List of currently threatened flora (DRF) under the WCA 1950, 2010), representing almost 25% of WA's vascular flora recognized as rare, threatened or poorly known and at risk of extinction in the coming decades, the majority of which are endemic (Threatened Flora Seed Centre, Western Australian Herbarium, Science Division, 2008).

under future environmental change. In WA, Kings Park Botanic Gardens & Parks Authority (KPBGPA) Conservation Genetics team applies modern molecular techniques into vital research that can be applied to practical outcomes in conservation, community restoration, molecular ecology, propagation and phylogenetics. Genetic techniques have enabled management of genetic variation in ex situ propagation and been important for reintroductions[4]. A recent field, conservation genetics should be incorporated into conservation for effective prioritization and management of rare flora. Modern molecular tools, e.g. DNA fingerprinting, microsatellites and DNA sequencing, provide powerful genetic contributions for an integrated approach to conservation and ecological restoration of native flora. To effectively conserve biodiversity, genetic diversity needs greater attention and is critical for the management, conservation and restoration of biodiversity across all scales. Genetic studies lead to understanding of the extent, and geographic patterning of genetic variation within species, as well as processes that affect these and their consequences.

A cardinal project in conserving Australia's floristic diversity is the involvement in the international Royal Botanic Gardens' Millennium Seed Bank Project in Kew, UK (Krauss 2006). Seeds of native flora were collected and sent to UK to be stored in state of the art facilities. Seed collection and storage is a step towards safeguarding and securing a long-term commitment to conserving Australia's iconic species, especially those that are rare, threatened, and poorly known, and is of utmost importance for saving plants and genes into the future[5]. Improvements can be made so to conserve diversity at finer scales thereby increasing and conserving genetic diversity, aided by identifying genetically distinct populations across a given species' range. The integration of seed science research into conservation strategies for threatened species also improves the efficiency of native seeds in restoration[6]. Biotechnological research such as that conducted by KPBGPA is critical to the success of both ex situ conservation of rare and endangered species, and the subsequent translocation of endangered plant species[7].

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[4] This includes data revealing genetics underlying efficient plant breeding; genetic delineations of local provenance seed collection zones; assessments of genetic rarity and uniqueness to direct conservation resources; understandings of mating, dispersal and genetic erosion for different population types; and greater elucidation of phylogenetic relationships and taxonomic clarification (KPBBPA 2008)

[5] According to Dr. Paul Smith, Head of the MSB, "There is no technical reason why a single species of plant should ever now become extinct" (Smith 2008).

[6] Such projects are undertaken by Botanic Gardens & Parks Authority, which include: developing seed enhancement technologies including seed priming and application of seed coating polymers and anti-stress agents, understanding seed dormancy mechanisms, devising germination methods, understanding the role of smoke and germination-active chemicals isolated from smoke in seed germination, and optimizing storage methods for effective seedbanking (KPBBPA 2008)

[7] Methods include: in vitro technology (tissue culture, micropropagation, somatic embryogenesis) for propagation of rare and threatened plants, advanced tissue culture techniques to produce artificial seeds for restoration programs, and researching methods for cryostorage and mass production of plants for restoration/translocation projects (KPBBPA 2008).

### *Addressing climate change*

One of the most important priorities for directing conservation of Australian flora is developing plans addressing climate change. Under all ICPP scenarios Earth is committed to some warming and anthropogenic climate change induced changes (IPCC a, b) and governmental conservation agencies must take this into account when planning biological conservation. In Australia minimum and maximum temperatures are projected to increase in all regions and seasons by 1°C by 2030 for mid-range emissions scenarios; extreme rainfall deficits are predicted in central and southern Australia with increased evaporation, increased drought and substantial reductions in soil moisture[8], and higher frequency of extreme fires (CSIRO 2007). As the Australian flora has been climatically buffered over millennia, and the current rate of climate change is unprecedented since the last mass extinction 60Mya, climate change poses one of the most serious threats. The inevitability of climate change means this *must* be factored into *all* conservation plans; this is presently lacking. Adaptation and mitigation strategies specifically designed for flora species and communities should be given utmost priority. Important steps include identifying climate impacts upon threatened native species i.e. developing a screening tool to determine the impact of climate change on seeds (e.g. Ainsley & Guerin 2009). Phylogeographic studies i.e. Byrne *et al.* (2007), have enabled predictions of responses of species to future climate change and identified areas of refugia.

A successful venture is the Great Western Woodlands Collaboration[9], which aims for "Recognition, protection and integrated management for one of Australia's great natural areas through the involvement of local communities and stakeholders and for the benefit of people, nature and future generations" and works to recognize and manage the area as a single entity rather than as fragmented, separate parts. The Great Western Woodlands has received conservation priority as it provides the opportunity to retain a functioning environment still retaining most of its native species, as well as habitat for reintroductions. The Great Western Woodlands is the largest remaining intact area temperate woodland in the world, and such a large, intact functioning ecosystem is critical to preserving the ecosystem and its many component species (WSWA 2010). The GWW collaboration is important in recognizing the need to conserve what remains, repair and restore where damaged, and extend cover where possible to intact forests. Furthermore, with global warming and ongoing vegetation clearing accounting for 1/5 of global carbon emissions (WSWA 2010), this adds further value to protecting large woodlands which function in carbon sequestration, as well as retaining biodiversity both known and unexplored.

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[8] However, precipitation projections show considerable uncertainty

[9] An alliance of four conservation organizations; The Wilderness Society, Pew Environment group, The Nature Conservancy and GondwanaLink.

***Disturbance regimes: fire***

Biota differ in their response to disturbance. Natural disturbances i.e. low intensity fires can promote growth, with many plant communities and species being in fact dependant on disturbance, especially for regeneration. It is critical to determine natural historical disturbance regimes and replicate these accordingly; specific plants require specific disturbance regimes. For endemic flora of the OCBIL of SWAFR, an overarching conservation strategy is to minimize human disturbance. Due to the flora evolving and persisting in climatically stable, oceanically buffered landscapes they are extremely vulnerable to disturbance.

Fire has been significant in the evolution, development, and maintenance of Australian flora; the importance of applying appropriate fire regimes has gained increasing attention. Floral ecosystems have suffered from altered fire regimes since European colonization: inappropriate fire regimes are a major threat to floral diversity (SER 2001). Inappropriate fire regimes can cause extinctions and reduce floral diversity (in terms of species richness, and structural and spatial diversity). Species and communities vary in their response to and reliance on fire. This means research into understanding the life histories and attributes of native plants and animals, and their relationship to fire in particular ecosystems is important. Knowledge of how species respond to different fire regimes along with knowledge of Aboriginal fire regimes should be used to develop ecologically based fire regimes. Fire needs to be applied appropriately since it can either threaten or stimulate species and communities.

Many conservation projects (e.g. Burrows & Abbott, 2003) are concerned with developing prescribed burning for managing plant diversity, involving ecological use of fire by prescribed burning of small patches, with input from Indigenous landowners regarding pre-European burning regimes. The fire plans aim to create a mosaic of burnt and unburnt patches creating a matrix of assemblages at different successional stages (Shedley 2007). For flora species of high conservation priority, fire regimes should be applied to suit their explicit needs i.e. those requiring fire for germination or seed dispersal.

Considerable research must be undertaken before implementing a fire regime: fire can favour weeds to recolonize burnt areas at the expense of natives, and alter community composition; especially the case in OCBILs. Application of inappropriate fire regimes threatens biodiversity (SER 2001). Despite fire regimes being critical in affecting distribution and abundance, knowledge of different resiliences to different disturbance regimes is extremely limited (Shedley 2007). Research into identifying key fire-sensitive species, interactions between fire and weeds, feral animals and salinity, and the effect of a fire regime on communities with differing life attributes and adaptations to fire should be a priority. The diversity of biomes across Australia means species and communities vary greatly in their adaptation and resilience to fire as well as their influence on fire. Thus thorough research on life histories and attributes of a community in a given region need to be undertaken to ensure tailoring and application of appropriate prescribed burns.

Prescribed burns are often applied to achieve conservation outcomes, aiming to protect natural biodiversity. Ideally the burns incorporate scientific and indigenous knowledge of fire responses and life histories of native plants. A significant framework for identifying an optimal burning regime using decision theory has been developed by Richards *et al.* (1999). WA's DEC has implemented a fine-grain fire mosaic of fuel ages in forest and shrubland via the Walpole Fire Mosaic Project. This is designed to address important questions relating to fire and biodiversity management including on what scale should old and young fuels coexist in the landscape, and how this influences biodiversity and fire intensity (Burrows & Wardell-Johnson 2004).

***Disturbances: disease***

*Phytophthora cinnamomi,* a soil and water-borne parthenogenic root oomycete, causes dieback disease. This is one of the direst factors threatening Australian flora, and is recognized as a key threatening process by the National Strategy for Conservation of Biological Diversity and listed as a threatening process under the EPBC Act, and thus is a national priority. This pathogen occurs in all States and lethally affects a wide range of vegetation, having an exceptional host range (Weste & Marks 1987). *c.*40% of the SW WA hotspot's flora are susceptible to infection, and 1120 taxa highly susceptible (Shearer *et al.* 2004). The disease can eliminate susceptible plant species from sites, changing the composition and structure of the entire vegetation community (Shearer *et al.* 2004). Despite world-class scientific research by DEC scientists demonstrating phosphite reduces spread and is effective and safe in the natural environment in most cases (DEC 2004), there is no cure. Dieback acts synergistically with other threatening processes leading and perpetuating dieback; but these remain poorly understood. There is thus need for understanding causes and developing a cure or means of immunity. It is critical ongoing research into methods to enhance resilience and prevent infection and spread are developed, including identifying genotypes resistant to pathogenic attacks to propagate and introduce into other populations.

***The significance of a holistic ecological approach***

Greater research into identifying and understanding ecological interactions of flora in their communities is needed. Particularly important are biotic interactions; to conserve any plant species, it is often necessary to expand conservation projects to other organisms that exist in complex symbioses (i.e. mycorrhizal fungi, pollinators, dispersal agents) critical to survival of native flora[10].

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[10] In the SWAFR hotspot, there is an accentuated degree of ectomycorrhizal partnerships, myrmecochory, and exceptional levels of vertebrate pollination (15% of flora), high levels of invertebrate pollination, and globally unusual high levels of bird and marsupial pollination (i.e. Honey Possums, Western Pygmy Possum). Mutualisms are also abundant in the flora of the Queensland Wet Tropics, another speciose region.

Pollination drive floristic diversity and is necessary for persistence, yet these processes are greatly threatened due to local extinction of key pollinators from land clearing and climate change, signaling flow-on extinctions for such plants.
The prevalence of mutualistic symbioses highlights the importance of expanding conservation strategies to not just consider plant species in isolation but rather to protect communities to ensure survival of a myriad of fungi, vertebrates, invertebrates, and many other organisms.

### ***Conclusion***

Persistence of Australia's amazing and unique floristic diversity is dependent upon concerted and integrated conservation involving research, ex situ conservation and habitat protection. Crucially, ecological conservation plans need to be designed involving conservation management for not only individual plant species, but also targeted at ongoing monitoring and protecting of ecological communities, including mycorrhizal networks, cycling processes, microbial communities, seed dispersal agents and pollinators. Only by adopting an integrated multi-dimensional approach can we effectively conserve the many species warranting conservation protection. Approaches must be responsive to current threats but be proactive, considering future threats and be flexible and adaptive to environmental and economic fluctuations.

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