2013

Research and conservation initiatives for the vulnerable Purple-wood Wattle: a model for plant species conservation in Australia?

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Publication Details

Denham, A., Auld, T., Ayre, D., Forrest, C., Gilpin, A., O'Brien, E. & Roberts, D. (2013). Research and conservation initiatives for the vulnerable Purple-wood Wattle: a model for plant species conservation in Australia?. Australasian Plant Conservation, 21 (3), 22-24.

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Abstract

Research on rare and threatened plants is a major focus of conservation biology. We want to know why species are rare or declining, how best to arrest that decline and what is lost when species become locally extinct. Occasionally, understanding decline is straightforward - e.g. if the species is restricted to fertile soils that are desirable for cultivation. However, managing declining populations is more complex and requires knowledge of genetic diversity and interspecific interactions.

Disciplines

Medicine and Health Sciences | Social and Behavioral Sciences

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Research and conservation initiatives for the vulnerable *Purple-wood Wattle*: a model for plant species conservation in Australia?

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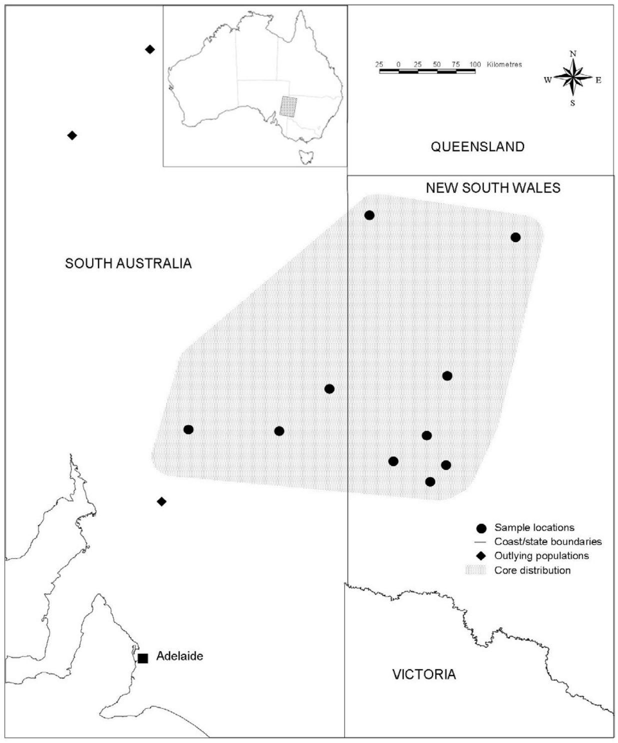
Research on rare and threatened plants is a major focus of conservation biology. We want to know why species are rare or declining, how best to arrest that decline and what is lost when species become locally extinct. Occasionally, understanding decline is straightforward – e.g. if the species is restricted to fertile soils that are desirable for cultivation. However, managing declining populations is more complex and requires knowledge of genetic diversity and interspecific interactions.

Purple-wood Wattle *(Acacia carneorum)* is a Nationally Vulnerable species confined to west of the Darling River in NSW and to eastern South Australia. It reproduces readily by suckering, but fruits have rarely been observed.

Our investigation of the ecology of Purple-wood Wattle exemplifies the knowledge required to understand and manage decline. This includes:

- evaluation of population sizes and extents (evidence of decline or restricted distribution)
- assessment of population viability (evidence of decline within populations)
- investigation of recruitment limitations (restricted establishment and survival of recruits may explain the status of populations)
- landscape genetic assessment (is there evidence of genetic bottlenecks, inbreeding depression resulting from fragmentation or founder effects?)
- detailed genetic assessment and pollination (are some genotypes more successful than others?)
- experimental attempts to overcome failure to produce fruit (can we induce seed production through addition of suitable pollen?).



*Distribution map of Purple-wood Wattle (*Acacia carneorum*), showing sites sampled for molecular (AFLP) analysis.*

Threats

Auld (1990, 1993) made the first systematic assessment of the abundance and extent of the species and the viability of populations. He confirmed many herbarium records, but found no apparent local extinctions. Standing size structure of populations was used as a surrogate for population viability, with most populations showing a lack of juvenile plants suggesting long term recruitment failure. Seeds collected from two fruit producing sites were large and had a prominent aril that may promote bird dispersal. Seeds were moderately dormant suggesting that a short-lived soil seed bank may exist at these fertile sites (Auld 1993).

At Kinchega National Park, southeast of Broken Hill, Auld (1993) also established grazing exclusion experiments that compared survival of new suckers (which emerge in spring and autumn) exposed to: all herbivores; rabbits only; feral goats and kangaroos (domestic stock are excluded from the national park); or no vertebrate herbivores. These indicated that suckers were much more likely to survive if protected from herbivores, particularly rabbits and goats. This then, was one explanation of the unbalanced size structure of most populations and provided a clear management objective to assist in the conservation of the species – reduce rabbit impacts.

In 1995, the rabbit haemorrhagic disease (RHD or RCD) escaped from Wardang Island off the SA coast and rapidly spread into arid NSW. It was hoped that the subsequent reduction in rabbit populations would greatly reduce impacts from rabbits across all tenures. Many commentators predicted rapid transformation of the landscape due to increased plant recruitment. We took this opportunity to further assess grazing impacts on plants, including Purple-wood Wattle, by establishing new exclusion plots and a new monitoring program. Unfortunately, even with greatly reduced rabbit populations, effective recruitment of palatable shrubs such as Purple-wood Wattle, continued to be low outside of exclosures (Denham & Auld 2004). Furthermore, the very slow growth of suckers indicated that under the current level of grazing pressure, fencing will be required for several decades before plants are large enough to survive intense grazing, even within reserves. However, the arrival of RCD also coincided with the start of what is now known as the 'millennium drought', so we hope that an interaction of favourable climatic conditions and reduced grazing impacts might allow better survival and growth of plants in the future.

Genetics

In 2008, we made a study of population genetics of Purple-wood Wattle using molecular markers (AFLPs). We found very little genetic diversity within stands across the range of the species, which was not surprising given observations of root suckering in many stands. We also found that each stand was quite strongly differentiated, suggesting limited gene flow. Our estimates of clonality ranged from 1-10 clones per stand. Consequently, each stand makes an important contribution to the overall genetic diversity of the species. In addition, we found that the two stands known to regularly produce fruit were among the most genetically diverse. This suggested that limited mate choice may prevent seed production in other stands.

In 2010, with a grant partnered by NSW Office of Environment and Heritage and the University of Wollongong (with support from Catchment Management Authorities) we further extended the genetic studies and initiated investigations of pollination and plant breeding systems in order to explore options for genetic rescue of threatened arid overstorey species. We examined a range of acacias at various levels of threat, including Purple-wood Wattle. Landscape scale genetic analyses confirmed many of our earlier findings. However, the microsatellite data suggested that without exception, each stand is likely to be derived from a single seedling. Furthermore, it appears that a few stands are triploid (with three rather than the usual two copies of chromosomes) and are thus likely to be sterile.

Using seeds from the most fecund stand, we found that two-thirds of all offspring are selfed, suggesting that self-incompatibility and the absence of genetic diversity within stands fails to explain the lack of seed set in most stands. However, it may be that rare genotypes are capable of selfing, and thus produce fruit in the absence of genetic diversity. Nevertheless, the remaining one-third of seeds appears to have been sired by plants from the next nearest stand, some 800 m distant or by plants even more distant (more than 3 km away).

Pollination

A study examining the floral ontogeny, flower visitor assemblage and pollination of Purple-wood Wattle had some surprising outcomes (Gilpin *et al*. in review). The species was visited by a diverse suite of native insects, including wasps, native bees, flies and butterflies. These native pollinators carried little pollen and were only moderately faithful to Purple-wood Wattle. In contrast, the common and fecund *Acacia ligulata* was almost exclusively visited by the European Honeybee (*Apis mellifera*) which was a highly faithful pollinator.

*Butterflies (*Nacaduba biocellata*) on flowers of Purple-wood Wattle (*Acacia carneorum*). Photo Andrew Denham*

Floral development (ontogeny) was similar in both *Acacia* species, with little evidence of protogyny (where female phase occurs before male phase in flowers). Since many inflorescences are open simultaneously in both species, many pollen movements are within plants, with outbreeding favoured only through an incompatibility mechanism or selective abortion. We were unable to induce fruit initiation in Purple-wood Wattle through pollination experiments, despite providing pollen from multiple sources. However, pollen tube analysis suggests that we were effective pollinators and that any incompatibility mechanism must be late-acting (sporophytic).

Conclusions and future directions

The Purple-wood Wattle has survived over 150 years of pastoralism, probably solely due to adult longevity. Grazing continues to be the most pressing threat, and as older stems succumb, regeneration from suckers and seed is crucial. Predictions for climate change in arid NSW suggest modest declines in overall rainfall, with a bias toward summer rather than winter rainfall events. The switch from winter to summer rainfall in the southern part of its range introduces additional drought stress as water availability will be reduced due to increased evaporative loss in summer.

We are yet to determine whether pollination failure is the cause of a lack of fruiting. To further explore this, we plan an experiment using beehives to potentially improve pollination in selected stands to see if this alone will increase fruit production. While germplasm conservation of the species seems prudent, at present only a very small fraction of the genotypic diversity can be captured in this way. Hence, maintaining stands in the wild is essential.

Maintaining a consistent approach to solving problems in the ecology of a threatened plant builds on knowledge that allows informed decisions to be made about recovery or management actions. Publication of research findings is crucial to ensuring that knowledge is not lost.

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A phylogenetic and morphological approach in a key Australian plant genus, *Brachyscome*

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Introduction

Understanding the evolutionary radiations of plant species into various habitats is a valuable contribution that can help to predict the adaptive potential of Australian plants. This is especially relevant within the context of climate change as recent climate trends have already had significant impacts on species and ecosystems (Parmesan 2006).

Brachyscome is an Australasian genus in the Asteraceae family, having undergone adaptive radiation in Australia. Currently circumscribed *Brachyscome* are predominantly endemic to Australia, with the exception of two Papua New Guinea and four New Zealand species. With more than eighty species in Australia, *Brachyscome* can be found across the continent growing in a vast array of habitats, from high rainfall zones of coastal and alpine areas to the arid regions of Central Australia. *Brachyscome* species have a significant presence in our native flora, excluding the tropics, with relatively common, widespread species growing across a myriad of Australian conditions. Conversely there are species confined to small pockets of habitat. Some species are geographically isolated, such as *Brachyscome segmentosa* which is endemic to exposed rocky ledges on Lord Howe Island. Many are restricted species, such as *Brachyscome muelleri*, and several are considered rare or threatened. Given the variability (i.e. habitat preference and distribution) within the genus, these native daisies provide an opportunity to investigate the relative susceptibility and adaptability of plant species to a changing climate, from an Australian perspective.

"Predicting what will happen to a species distribution in the future must rely heavily on understanding the factors by which they are currently limited." Lesley Hughes, Austral Ecology, 2003.

The distribution of many terrestrial organisms is shifting in response to climate change (Chen et al. 2011). However key traits dictating responses are not well understood. Will widespread species track climatic shifts and therefore adapt to changing conditions? How will restricted species respond? Hughes (2003) argues that one of the most fundamental questions in ecology relates to finding answers to questions such as those posed above, but little is known regarding how Australian taxa will respond under climate change.

"By considering evolution the likelihood that a key plant and animal species will persist within landscapes under climate change can be increased." Hoffmann and Sgro, Nature, 2011.

The future direction as discussed by Hoffmann and Sgro (2011) regarding climate change and evolutionary adaption highlight the critical need to test evolutionary potential across a broad range of species groups, especially groups which can encompass the polarising extremes of environmental conditions. *Brachyscome* is one such group. It is an ecologically diverse genus of flowering plants found throughout temperate Australia. This study proposes *Brachyscome* as a model genus to examine growth and reproductive differences at the species level, within