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Revegetation with Australian native grasses – a reassessment of the importance of using local provenances

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Summary

Many restoration guidelines strongly recommend the use of local sources of seed in native plant revegetation projects. These recommendations are based on assumptions that the species used for revegetation are cross-pollinated and woody, and were originally developed for overstorey vegetation in the northern hemisphere. We challenge their validity with respect to replacing or enhancing the native Australian grass component of degraded rangelands. Firstly, obligatory cross pollination has not been recorded in any Australian native grasses except for a few dioecious species. Indeed the majority of Australian native grasses so far studied have revealed complicated breeding systems that provide flexibility allowing reproduction and genotypes to be matched to the variable Australian environment. Secondly, we argue that the genetic dissimilarity among populations of a species is not proportional to the distance between them but is more related to the environmental stresses that have been placed on those populations in the past. We therefore conclude that there is little justification for the recommendation that only local sources of seed of Australian native grasses should be used particularly for large-scale revegetation programs. We provide some general guidelines for deciding on the seed sources to use depending on the purpose of the revegetation and characteristics of the species of choice.

Introduction

Many restoration guidelines require the use of local sources of seed in native plant revegetation projects because of an assumed local adaptational advantage and a lower risk of unwanted genetic effects (e.g. Byrne *et al.* 2011). The data on which the guidelines are based were generally derived from the structural forms present in northern hemisphere woodland and forest vegetation (Byrne *et al.* 2011). Australian recommendations that set the standard for provenance collection zones for seed sourcing (e.g. by Mortlock 1999) are mostly based on these data and continue to be promoted. Native Australian perennial grasses have quite different breeding systems from those of the plant and animal species on which the arguments for local provenances are based. Furthermore, their population turnover times are relatively rapid and mostly <20 years (Groves and Whalley 2002).

Evolution of some modern native grasslands

Self-incompatibility mechanisms in the northern Europe and north American temperate grasses were favoured by the rapid revegetation following the Pleistocene glaciations and mass species extinctions (Mithen 2003). These mechanisms provided an increased potential for creating novel genotypes capable of adapting to new

emerging environments. These grasses evolved the S-Z self-incompatibility system which involves two separate genes (S and Z), each with multiple alleles (Groves and Whalley 2002).

The S-Z self-incompatibility system has not yet been recorded for any native Australian grass species and no obligate outcrossing taxa (except for four dioecious genera) have been described; all appear to be self-compatible (Groves and Whalley 2002). Australian grasses were not subjected to the massive extinction and recolonisation that occurred in the northern hemisphere during and after the Pleistocene glaciation. This has meant that the Australian environment, with its diverse range of ecological niches, has only been subject to slow changes over recent geological time. Under such conditions, taxa with obligate outcrossing waste reproductive energy producing a wide range of genotypes during every reproductive event (Groves and Whalley 2002). Breeding systems that allow for the rapid reproduction of 'successful' genotypes, are an advantage in the Australian environment.

Breeding systems

Dioecism (the production of male and female flowers on separate individuals) ensures cross-fertilisation but is rare in Australian grasses. Four genera are reported as dioecious (Groves and Whalley 2002). The majority of these occur close to shorelines (either present or geological) and in all but one, clonal reproduction is more common than seedling recruitment (see Maze and Whalley 1992).

The flowers of most grass species in the world are hermaphroditic, producing both male and female parts and are generally wind-pollinated. However, Brock and Brown (1961) reported predominantly inbreeding for *Danthonia* spp. (now *Rytidosperma* spp.) although limited intra- and inter-specific hybridisation did occur. A common method of self-fertilisation in these grasses is the dehiscence of the anthers before the florets open and the stamens are exerted.

The production of both cleistogamous and chasmogamous florets within the same inflorescence or in separate inflorescences (e.g. *Microlaena stipoides*, Clifford 1962), is a mechanism that supports mixed mating. Cleistogamous florets have the same micro-evolutionary impact as self-fertilisation and chasmogamy can result in cross fertilisation.

Apomixis, or agamospermy, involves the production of viable seeds without the union of gametes. Many grass taxa have polyploid races and it is often these lines that are apomictic and involve diploid/polyploid cycles combining sexual and apomictic reproduction. The successful combination of sexual and apomictic reproduction can minimize the high cost of sexual reproduction while retaining the capacity for adaptive polymorphism and the rapid reproduction of fit genotypes in specific environments. Such systems have been described for several Australian native grass genera.

These reproductive mechanisms ensure that large numbers of locally fit individuals adapted to prevailing conditions are produced, but that a smaller percentage of cross-fertilised individuals can also occur.

Ploidy levels

Polyploid series within individual species are common and often the diploid races reproduce sexually and the polyploid races apomictically (de Wet and Harlan 1970). It seems that higher ploidy levels are in some way a protection against inbreeding

depression and it also provides a key to the ongoing evolutionary development of species.

Waters *et al.* (2011) systematically collected 28 natural populations of *Rytidosperma* (*Austrodanthonia*) spp. across 75,000 km² in central NSW. Traditional chromosome counts as well as flow cytometry were used to determine the ploidy levels of these populations. The chromosome counts confirmed that the majority of *R. caespitosum* plants were tetraploid or diploid ($2n=48$ or $2n=24$) with $x=12$. The flow cytometry revealed three ploidy races ($2x$, $4x$, $6x$) and two intermediate cytotypes ($1x$, $3x$) but importantly, revealed that co-existent cytotypes were common within any population for *R. caespitosum* (and also within four related species).

Scales of adaptive and genetic variation

Waters *et al.* (2003) collected 11 species of native grasses from 51 sites throughout western New South Wales and southern Queensland and examined the genetic variability among the different populations of the different species. They found a strong relationship between site of origin and plant morphological characteristics but not distance between collection sites. Furthermore, genetic dissimilarities have been detected within very short distances among lines of the predominantly cleistogamous *Microlaena stipoides* growing in association with different companion perennial grasses within one small paddock on the Northern Tablelands of NSW (Magcale-Macandog and Whalley 2000).

General guidelines

In summary, the breeding systems of Australian native grasses have mechanisms that ensure a high degree of inbreeding, together with occasional outcrossing opportunities resulting in limited gene flow from one population to another, even when the populations are in close proximity.

The choice of a seed-source for revegetation plantings of Australian perennial native grasses depends on the species, starting point and the complexity of the desired outcome. This complexity may range from low in amenity plantings such as lawns, moderate for native pasture to high for a conservation reserve or national park where the native grass component is depauperate and the aim is to restore complexity.

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