Genetic integrity as a target for native plant restoration: Framework for determining the risks

Cathy Waters, Pastures and Rangelands Program, Agricultural Research Centre, Trangie NSW 2823.

There is considerable debate about how to assess the risks that "non-local" provenance seed in restoration and revegetation activities posing to maintain the ecological integrity and utility of re-established native plant populations.

In this presentation I used the results of a recently completed study of a widespread native grass, *Austrodanthonia caespitosa,* and four close relatives to illustrate that it is over simplistic to state that "local seed sources are always the best" because it ignores the complexity of the ecological processes of adaptation. Instead, a risk assessment framework is offered as an alternative.

Austrodanthonia study

The genetic variation among and within wild populations over a 75,000 km^2 area in central western New South Wales was examined. This area is characterised by anthropogenic disturbance and landscape fragmentation that is typical of many seed collection areas within eastern Australia.

Most populations comprised at least four *Austrodanthonia* species and so any wildland harvested seed may be expected to contain a number of *Austrodanthonia* species. Considerable overlap in environmental factors related to the occurrence of these species. For example, the habitat range for *A. caespitosa* was broader than other closely related species but associated with large-scale, regional trends in climate. *Austrodanthonia caespitosa* tended to occur in regions where rainfall was highest and *A. setacea* where rainfall was least, but these trends could be modified at a smaller site-scale where *A. caespitosa* occurred the more exposed and presumable drier sites.

Apart from finding multiple species at most sites, co-existent cytotypes (plants with different numbers of chromosome) were also found at most sites. Typically, different chromosome 'races' can be associated with different adaptive niches. However, for *A. caespitosa* there were no common ecological factors (climate, edaphic or micro-site) that clearly distinguished these chromosome races. Molecular markers revealed low levels of differentiation between populations suggesting considerable geneflow. This evidence along with supporting evidence from molecular studies seems to suggest that inter (between species) or intra-specific (between chromosome races within a species) hybridisation occurs and that little ecotypical variation occurs. Overlapping flowering times between species provides a possible mechanism for hybridisation. From this it could be concluded that sourcing seed from any location within the study may not have any implications for adaptation or genetic integrity. However, most of the variation in morphological and flowering characteristics for all species occurred amongst populations. For example, southern populations (which come from more winter dominant rainfall regions) grew and flowered in spring and northern populations (from more summer dominant rainfall regions) flowered and grew predominantly in summer. So translocating southern populations to northern locations (or vice versa) may have implications for successful re-establishment of this species. Considering all this information together reveals the current evolutionary architecture of *A. caespitosa* is complex and is probably a result of overlaying and interacting effects of broad scale and ongoing gene flow between populations and, importantly ploidy levels. This creates significant genetic variation for a range of ecologically important traits

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that is subsequently acted on by natural selection in diverse environments across these species range.

So if things can be this complex, how can we derive some simple guidelines for seed collection that address the issues of maintenance of genetic integrity?

I suggest a risk framework to guide decisions for determining acceptable seed collection ranges for any native plants (Waters *et al.* 2007). This framework needs to evaluate the trade-off between the costs of sourcing various seed sources against their biological value. A risk framework should also highlight where further research is needed before a particular revegetation proposal can proceed. This framework is based on consideration of seeding objectives, known and unknown ecological adaptations, risks, and net economic benefits (Figure 1).

Risk framework

Seeding Objectives

The site potential and the desired landscape will influence the seeding objectives. It is assumed that natural regeneration is not possible and that reseeding is required.

Known Ecological Adaptations

Where available some prior knowledge of ecological adaptations or genetic variation can be used in the development of the initial seeding strategy.

Risks in Maintaining Genetic Integrity

The method suggested here for assessing the risks of genetic integrity loss also factors in the potential economic benefits. Consideration of genetic integrity is based on natural capital benefits of revegetation, condition of the seed collection site, required seed collection range, and individual species characteristics.

Determination of Natural Capital Benefits

These are based on enhancement of biodiversity and amelioration of environmental problems. In allocating one of the four benefit values (low, medium, high, very high) the restorationist needs to consider the conservation significance of the restoration site, irreversibility issues if wrong seeding choices are made, and potential impacts on surrounding ecosystems (Table 1).

Determining the Condition of the Seed Collection Site

This needs to be considered using a number of locations, landscapes, populations, and individual plant attributes (Table 2).

Required Seed Collection Range

Assessment of the environmental benefits of the revegetation and the condition of the seed collection site are then combined to determine the required collection range for native seed (Table 3). The collection range should be narrow where both the value of the seed collection and revegetation sites is high. Conversely, a regional seed collection might be acceptable if the collection sites are of low quality and the selected restoration localities have low genetic integrity.

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Individual Species Characteristics

These are important in determining an acceptable collection range (Table 4). They are not intended to provide prescriptive boundaries, rather that local knowledge should add detail where appropriate. For example, pollination characteristics or flowering times may be important where local fauna and flora have specific requirements.

Determination of Risks

Risk scores can be derived from the combined assessment of the revegetation and collection sites (Table 2) and the assessment of species characteristics (Table 4) Where the predicted collection range (Table 3) matches the assessment of species characteristics (Table 4) a low risk can be obtained. An identical match will result in a a moderate match a value of and a complete mismatch will result in a high risk to maintaining the genetic integrity of the restoration site.

Applying the Risk Framework

If the risk is high, then the restoration proposal should proceed only if it involves seed from within the acceptable collection range and it can be justified on economic grounds. Seed from outside the limit is unacceptable as it is likely to result in a loss of biodiversity assets that are critical natural capital. Their loss may be irreversible or considerable uncertainty could exist about the effects of introducing new genetic material. In this case, the decision to protect the restoration site from possible genetic pollution or maladapted seed sources can be made and the onus is on the restorationist to prove that using seed from outside the collection range is acceptable in terms of the restoration project goals and risks to neighboring natural capital stocks.

Where the risk is moderate, the net economic benefits need to be significant to use seed from outside the acceptable collection range. For example, use of such seed should enhance the restoration site without causing irreversible damage and biodiversity losses. If the risk is low (no loss in natural capital), revegetation can take place with seed from any source, provided that this is soundly based on economic grounds.

Waters C.M, Young, A.G and Crosthwaite J. (2007). Genetic integrity as a target for natural capital restoration: weighing the costs and benefits. *In: Restoring Natural Capital- Science, Business and Practice.* Eds. J. Aronson, S.J. Milton and J.N. Blignaut. Island Press, Washington. pp. 85-93.

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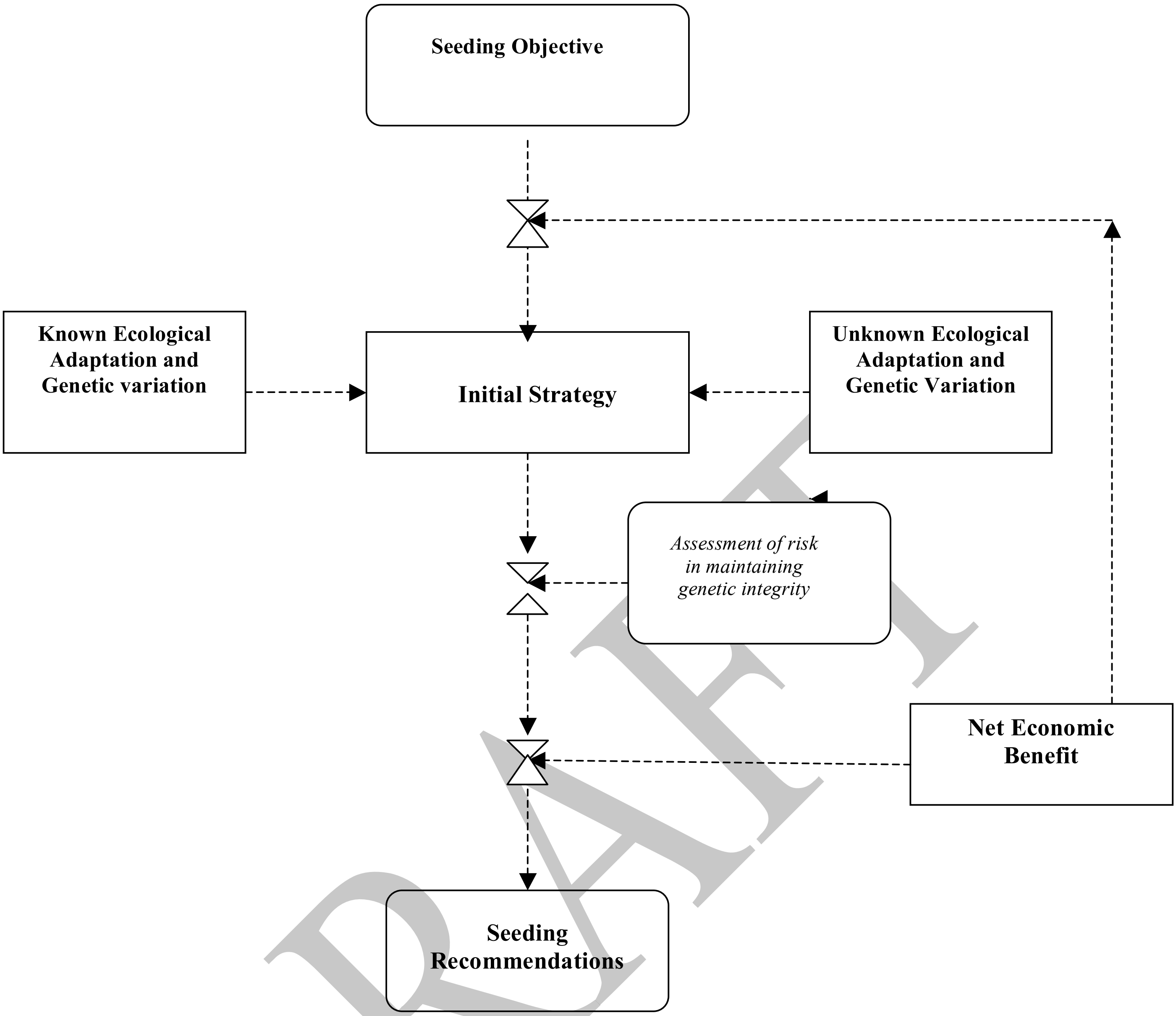

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Figure 1. Risk framework for making recommendations for native plant reseeding. (adapted from Jones and Johnston 1998)

Table 1. Determination of natural capital benefits of the proposed restoration.

Benefit	**Biodiversity**		**Environmental amelioration**
	Conservation Status	**Other attributes**	
Very High	Endangered Vulnerable Rare	Sites representing unique values of national significance	Faunal habitat restoration
High	Endangered Vulnerable Rare Depleted	Sites representing rare values of State-wide significance	Amelioration identified within regional plans
Medium	Vulnerable Rare Depleted Least concern	Sites representing uncommon values of State or regional significance	Amelioration identified within national or state legislation
Low	Depleted, Least Concern		

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