Genetic risk assessment to complement weed risk assessment in the selection and management of perennial species for agricultural systems in southern Australia

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Summary Agriculturally valuable species may pose a risk to surrounding areas of natural vegetation if not suitably managed. An environmental risk strategy has been developed by the Future Farm Industries Cooperative Research Centre (FFI CRC) to minimise environmental risk when selecting and using perennial species in farming systems. This environmental risk strategy includes weed risk assessment (WRA), genetic risk assessment (GRA), field trial guidelines and species management guides.

The risk of plants escaping and becoming invasive weeds is well recognised and WRA is an accepted tool for germplasm management. In contrast the risk of genetic invasiveness is less well recognised but is an important component of environmental management in agricultural systems. A GRA protocol has now been developed that provides a mechanism for the identification of the genetic risk to natural populations from planted stands of species under evaluation within the CRC. This risk assessment evaluates taxonomic, biological and geographical criteria of species and plantings to determine the risk of genetic invasiveness into surrounding natural populations of the species or its relatives. The application of the protocol is demonstrated using two case studies of species being evaluated by the FFI CRC. Implementation of a genetic risk assessment protocol complements the use of weed risk assessments in minimising risk to natural environments from planted species in agricultural systems in southern Australia.

Keywords Risk assessment, weed risk, genetic risk.

INTRODUCTION

The search to improve the productivity and profitability of agricultural systems has led the Future Farm Industries Cooperative Research Centre (FFI CRC) to develop the use of perennial plants as a primary area of research. The selection of suitable plants for niche environments and innovative farming systems can improve the resilience of agriculture to environmental challenges, such as salinity and climate variability, while improving productivity, profitability and sustainability. Perennial plants have been investigated for a wide range of uses. Extensive root systems enable the efficient use of deep water resources in times of drought or at other times reduce groundwater recharge, thereby lowering the watertable and reducing the impacts of salinity. Woody perennials can provide quick growing biomass that may be harvested for oil or biofuel production. Perennial legumes and grasses can contribute to the productivity of pasture systems by increasing nutritive value, filling seasonal feed gaps or through resilience to climate variability. Salt- or waterlogging-tolerant species can be used to vegetate or rehabilitate affected areas with improvements in productivity and environmental values.

These perennial species may be new introductions from outside Australia, naturalised from previous introductions, or native species now used in new environments and novel ways in farming systems. However many of the characteristics that make a species a successful component of an agricultural system are the same as those that may make it a serious weed in native environments. The Managing Weed and Genetic Risk Project within the CRC has developed an environmental risk strategy with five core elements to help minimise the risk of agriculturally useful species becoming weeds of native environments. The strategy includes:

- an environmental risk policy which defines compliance obligations (National and State) and outlines additional procedures for FFI CRC internal weed and genetic risk management;
- assessment protocols for weed risk (WRA) (Stone *et al.* 2008) and genetic risk (GRA) (Byrne *et al.* 2011) that have been developed to facilitate species selection and to inform management practices and contribute to cost benefit analysis;
- field trial guidelines outlining areas to address when planning research trials to minimise the risk of planted material becoming weeds of the wider environment;
- management guides providing information for

agriculturalists on species promoted by the FFI CRC that have received high weed risk scores, to minimise the environmental weed risk.

RISK ASSESSMENT

Risk is a function of the likelihood of the hazard occurring and the consequences of the hazard should it occur (Wilkinson *et al*. 2003). The concept of post-border weed risk assessment is well established and is usually used to prioritise management of a naturalised species threatening agricultural productivity or biodiversity in the natural environment. However the FFI CRC WRA aims to provide an assessment of the potential risk that a valuable agricultural species may invade native environments if planted. The assessment includes questions on invasiveness, impacts and estimates the potential area of the native environment potentially at risk. These assessments have become important tools for germplasm management.

Less well understood is the concept of genetic risk. In this context genetic risk refers to the movement of foreign genes from domesticated or other non-local populations into native populations *via* pollen and the potential for this to result in negative impacts (Arnold 1992). The movement of genes between planted and native stands may result in hybridisation, where mating systems are compatible, between species, differentiated taxa, cultivars or populations within species.

A genetic risk assessment protocol has been developed which examines the potential genetic risk of establishing a particular species, in relation to the surrounding native environments, on a case-specific basis. The protocol is in the form of a tiered decision tree (Figure 1) considering the relevant taxonomy and biology of the species in the context of the geographic location of the planting. Each section presents a series of questions. Low or negligible risk may be identified at a number of points so that the whole assessment may not need to be completed before an

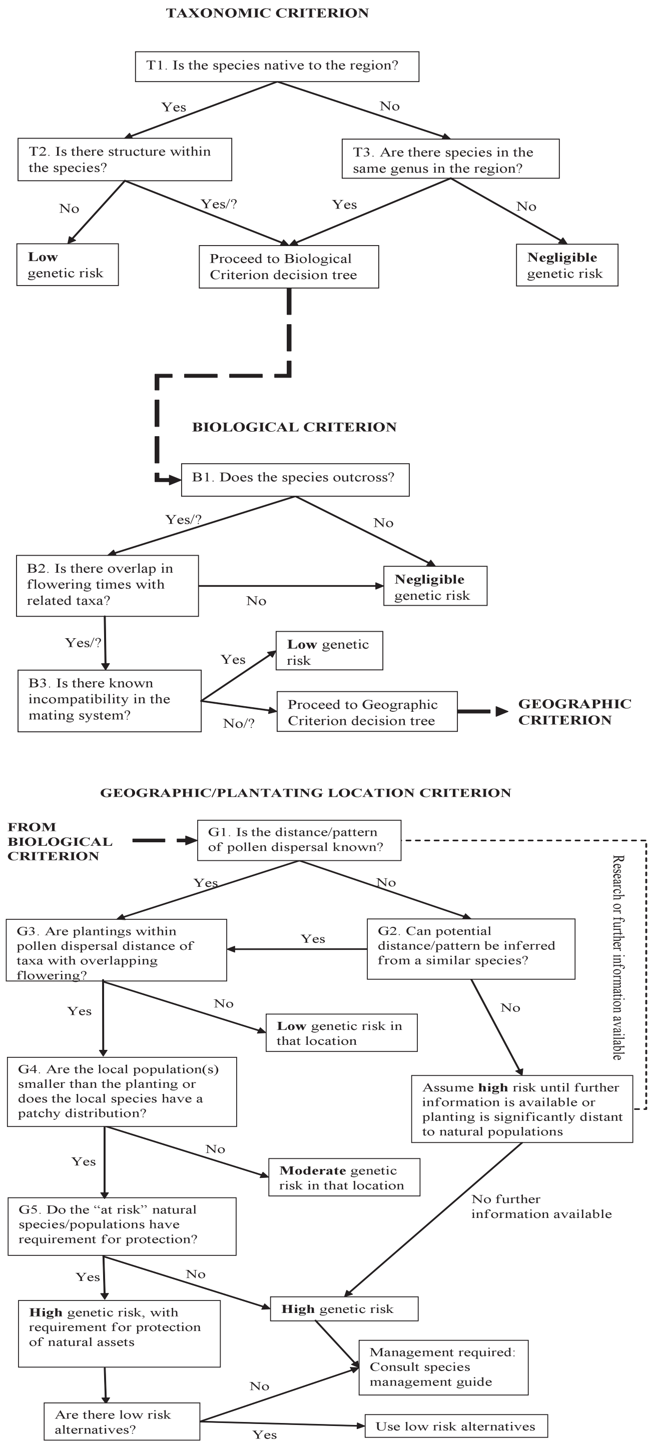

Figure 1. Assessment protocol for analysis and evaluation of risk in native populations of adverse genetic change from revegetation. Taken from Byrne *et al.* (2011).

outcome is achieved. Further evaluation is required as the greater likelihood of risk is identified. The final, geographical section addresses the site specific criteria of the proposed planting.

Completing the assessment, results in one of five outcomes: negligible risk, low risk, moderate risk, high risk and high risk with requirement for protection. Each of these has associated consequences (Table 1).

CASE STUDIES

The genetic risk protocol outlined here has been used in two case studies. The first examined the establishment of a field trial of *Cullen australasicum* Schltdl. (Cullen), a native Australian species with a potential as a nutritious, drought hardy, persistent and productive pasture species for the low rainfall areas of southern Australia. A review of the literature and information from researchers working with the species indicated that although *Cullen australasicum* is a widespread, outcrossing species with known compatibility within its reproductive system, plantings of *Cullen australasicum* at the proposed location (Buntine, WA) represented a low genetic risk to native stands. The nearest known natural stand (from herbarium records) is an excessive distance (100 km+) for pollen transfer and pollen-mediated gene flow. A survey for occurrences of native *C.australasicum* and closely related species within a radius of 2 kilometres around the proposed/existing planting sites is nevertheless recommended.

Puccinellia cilata Bor. is a species originating in Turkey and introduced to Australia in the 1950s. There are Australian native species in the genus, some of which hybridise and/or co-occur with *P. ciliate. Puccinellia ciliate* has an out-crossed mating system and over-lapping flowering times with related taxa. There is known compatibility in the mating system but the distance and pattern of pollen dispersal is not known. The outcome of this case study was that "until further information is available or planting is significantly distant to natural populations, it is assumed *P. ciliata* represents high genetic risk".

The outcome of weed and genetic risk assessments can be used to indicate management actions that can be taken to minimise the risk to native environments. For example, determination of minimum planting distances or buffer zones from native stands or the establishment of suitable species between the planting and the native stand that may block pollen dispersal and protect vulnerable native environments.

DISCUSSION

Genetic risk assessment is an increasingly important component of environmental management in agricultural systems. Assessment of the risk posed by proposed plantings to natural populations should be part of the planning process before establishment. This genetic risk protocol provides the means to assess the risk of proposed plantings and to use the outcome to make informed management decisions.

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Table 1. Factors contributing to risk categories identified in the risk assessment protocol; the factors influencing risk are cumulative and increase with increasing risk category. Taken from Byrne *et al.* (2011).

Risk category	Risk factors	Consequences
Negligible	No compatible species present	
Low	No taxonomic or genetic divergence	
Moderate	Taxonomic or genetic divergence Physical proximity Compatible mating system	Hybridisation
High	Taxonomic or genetic divergence Physical proximity Compatible mating system Large source/sink ratio Patchy distribution	Hybridisation with demographic swamping and/or genetic assimilation
High with requirement for protection	Taxonomic or genetic divergence Physical proximity to populations under protection Compatible mating system Large source/sink ratio Patchy distribution and requirement for protection	Hybridisation with demographic swamping and/or genetic assimilation Population/species extinction

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