The Northern Territory's Weed Risk Management system: an application of the national post-border WRM protocol

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Summary
Weed risk management (WRM) is recognized internationally as a useful tool to assist land managers to address the often controversial issue of exotic plant management. A WRM system has been developed for use in the Northern Territory. This WRM system is based on the National Post-border WRM Protocol and includes an assessment of weed risk and feasibility of control. Outcomes from these assessments guide the management response. The system was developed to include questions particularly relevant for northern Australia. Stakeholders have been involved in the development and implementation stages, through engagement in workshops, community forums and representation on committees undertaking policy development, technical development of the WRM tool and its implementation. The NT WRM system will continue to be refined as we develop and incorporate spatially explicit and economic decision support tools.

Keywords: Weed risk management, benefit-cost assessment, stakeholder engagement.

Introduction
The Northern Territory (NT) covers approximately 1.35 million km^2 and includes a great diversity of ecosystems, from the deserts in central Australia to mesic savannas, rainforests and coastal wetlands of the monsoonal north.

The majority of the Northern Territory's landscape is relatively intact and most of the beneficial uses derived from the NT environment rely on an intact and functioning landscape. This is a valued part of the culture of indigenous people, underpins production from the pastoral industry and forms a valuable element of the increasingly important tourism industry. The vegetation is diverse and many elements of it are internationally recognized for their importance to global biodiversity (Woinarski *et al*. 2007). The NT has a strong and growing ecotourism industry which relies on sound vegetation management and provides a viable alternative to some forms of agriculture (Dore *et al*. 1999).

The Northern Territory is largely dominated by native vegetation, although exotic plants are a significant component of the flora. Declared weeds, i.e. those that are given legislative status as weeds under the NT Weeds Management Act, and other alien invasive plants are a major threat to the NT's biodiversity (Landcare Council of the Northern Territory 2005) and threaten sustainability of rural primary industries (Pastoral Land Board 2003). There are currently 120 declared weeds in the NT, but the declaration list is in the process of being reviewed. This review arose from concerns that there were several currently unlisted exotic plants in the NT that should be given legislative status as weeds and claims that some currently-declared species do not warrant listing. Furthermore, there are many species that are not yet recorded in the NT but which may pose a serious threat as they are already recognized as weeds in climatically similar regions of Australia.

In response to these issues, there were requests from both the community and the NT Government for tools to objectively and transparently assess weed risk to assist managers to prioritize management actions for exotic plants already present in the NT and to identify potential new weeds and restrict their entry to the NT. Weed risk assessment (WRA), within a weed risk management (WRM) system, is recognized internationally as a useful approach to achieve these aims (Groves *et al*. 2001, Anon. 2006). Nationally, the need for a weed risk management system has been addressed by the development of the National Post-Border Weed Risk Management Protocol (Anon. 2006). In the NT the need to implement a WRM system was recognized and identified for funding by the Natural Resource Management Strategy (Landcare Council of the Northern Territory 2005). Charles Darwin University, the NT Government, Tropical Savannas Cooperative Research Centre (CRC) and the CRC for Australian Weed Management worked collaboratively to develop a WRM system for the NT that is consistent with the standards established by the National Post-Border WRM Protocol (Anon. 2006). The system has now been officially adopted by the NT Department of Natural Resources, Environment, the Arts and Sport (DNRETAS), who are the lead weed management agency in the NT. The system has also been submitted for whole-of-government adoption.

The WRM development system
The development of the NT WRM system commenced in 2001, and its development coincided with extensive work on weed risk assessment by experts around Australia. This work resulted in separate weed risk systems in several states and regions and the development of the National Post-Border WRM Protocol (Anon. 2006). We therefore reviewed the various systems to identify the most appropriate for adoption in the NT. We chose to modify the South Australian (SA) WRA System (see Virtue, these proceedings) because: (i) it was aligned to the National Post-Border WRM Protocol, (ii) was transparent and relatively easy to use, and (iii) the semi-quantitative analysis within the SA System made it appropriate where there is a lack of quantitative data for many weeds and accommodates a level of uncertainty. These characteristics gave the NT system high acceptance among stakeholders. The NT WRM system therefore represents an application of the National Post-Border WRM Protocol.

The NT WRM system is a systematic process comprised of the six stages described in the National Post-Border WRM Protocol (Figure 1). There are two major decision support tools embedded within the WRM system: a weed risk assessment (WRA, step 3) and a feasibility of control assessment (FOC, step 4). A comparison of the weed risk versus the feasibility of control is used to categorize weed species and prioritize various management actions (step 5), using a weed risk management matrix (Appendix 1).

Stakeholder engagement
Ongoing stakeholder engagement is a central component of the National Post-Border WRM Protocol. We recognized that incorporating the highest level of stakeholder involvement was critical to the successful development and implementation of WRM in the NT. The need for high level stakeholder involvement arises because many weed management issues are highly controversial, such as the legislative and management response to commercially valuable exotic species, and the prioritization of limited resources within the vast and highly diverse region. The key stakeholders identified and engaged include the many branches of

Government involved in natural resource management and primary industry, as well as the range of land users (primarily pastoral production, conservation, defence and horticulture). Aboriginal people own over 40% of the NT, so representatives from indigenous organizations are also key stakeholders. During the development process, many workshops and community forums were held to ensure stakeholder engagement. In addition, a range of stakeholders were represented on the two committees tasked with developing and implementing the WRM system: (i) the WRM Reference Group, which provided input into the development of the system, and (ii) a WRM Technical Working Group which developed and tested the decision support tools that underpin the WRM system. In addition, the Technical Working Group undertook species assessments for weed risk and feasibility of control (see below). Both groups include a range of stakeholders from the Northern Territory Government, Australian Government, non-government organizations and industry. Representatives were based in Darwin, Katherine and Alice Springs to ensure representation across the NT.

Weed risk assessment

In accordance with the National WRM Protocol, a score for comparative weed risk (Figure 1, Step 3) was generated from questions on three main criteria; invasiveness, impacts and potential distribution (See also paper by J. Virtue in these proceedings). The WRM Technical Working Group modified questions from the National WRM Protocol to suit the NT environment and land use systems, deleting questions where they were inappropriate (e.g. on land uses that don't occur in the NT), and adding questions that were considered more relevant to the NT (e.g. adding a question on the impact of the plant on fire regimes, which is a key ecological driver of the NT ecosystems). Comparative WRA questions are multiple-choice and semi-quantitative, with clearly defined categories to assign each score (Appendix 1). Scores for the three main criteria range between 0 and 10. The basic scoring system follows the South Australian WRM system (See paper by J. Virtue in these proceedings), and the final weed risk score is determined by multiplying the three criteria scores (therefore ranging between 0 and 1000).

Feasibility of control

The National WRM Protocol was also used to guide the development of the feasibility of control (FOC) assessment tool. Questions fall into three main criteria; control costs, current distribution of the weed, and persistence (which refers to the expected duration of control work) (Appendix 1). The FOC scoring system also follows the South Australian WRM system, with scores for each of these criteria multiplied (each ranging between 0 and 10) to give a feasibility score out of 1000. As the feasibility of control for a weed species can vary greatly across the NT, separate scores were assigned for the three NT weed management regions (Darwin, Katherine, Tennant Creek/Alice Springs).

Weed management matrix

In accordance with the National Post-Border WRM Protocol, the weed risk and feasibility of control assessments were used to develop a weed management prioritization matrix (Appendix 1). Based on their assessment scores, species were placed into categories (e.g. Low, Medium, High, Very High). Category cut-off scores were determined by developing a frequency distribution based on every possible scoring combination and then splitting the distribution into 25% percentile bands. The matrix is broadly consistent with the National Protocol, but adapted to suit the management requirements in the NT. Weeds that occur in more than one weed management region were assigned to separate categories based on the feasibility of control score for each region. Again, this work was done by both the WRM Technical Working Group and the WRM Reference Group to ensure acceptance and adoption of the outcomes.

Policy framework

We consider a critical component of the WRM system was the development of a guiding WRM policy framework. The framework has been developed in consultation with all key stakeholders and guided by the WRM Reference Group. Central to the framework is a set of guiding principles that clearly articulate the intent of the NT WRM system. For example, guiding principles include that 'the precautionary principle will be applied throughout all stages of the WRM process' and that 'Plants already present in the NT and categorized as high or very high weed risk will trigger nomination as a declared weed and other legislative actions and associated management responses to mitigate the risk posed by these species irrespective of economic benefits'. This makes clear both the intent of the WRM system and identifies a clear policy and management pathway for action.

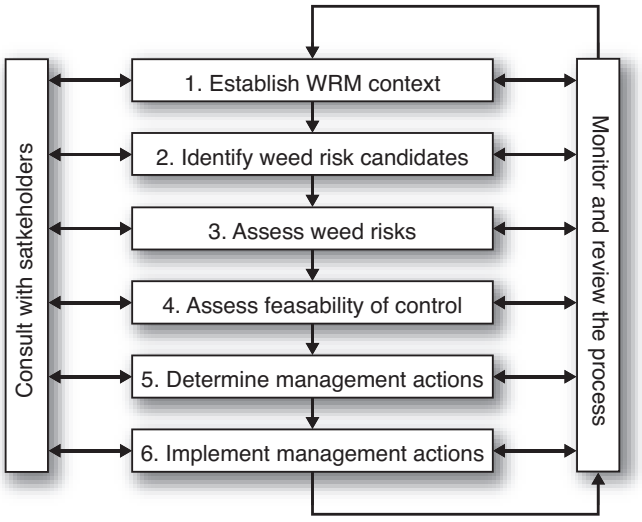

Figure 1. The weed risk management process as described in the National Post-Border WRM Protocol (Anon. 2006).

Current status

To date, over 80 species have been assessed and assigned management actions. These candidate species were chosen to include a range of life forms and distributions across the NT's range of ecosystems. They included a disproportionate number of high impact species within the initial assessment to partially address the aim of a review of the declared weeds list, and also because these are the species for which more information is available and therefore allowed us to answer with confidence. To ensure transparency and accountability, for each weed risk candidate a detailed species assessment document was prepared which cites the sources of information (from literature or expert personal observation) that were then used to answer each question. The final score for each question was reached by consensus by the Technical Working Group.

The initial assessments identified 14 species with a 'high' or 'very high' weed risk which were not declared (e.g. gamba grass (*Andropogon gayanus* Kunth), neem tree (*Azadirachta indica* A.Juss.)). Based on the WRA scores, and the WRM guiding principles, these species should be nominated for declaration and require a strong management response. These assessments

also demonstrated that invasive grasses were not receiving sufficient management focus because eight of these fourteen species are grasses. Thirteen currently declared species had low or medium weed risk (e.g. star burr (*Acanthospermum hispidum* DC.). These species were candidates for removal from the NT Declared Weeds list. Prior to making a final decision on the legislative status of these species, the distributions of these species need to be investigated further, to determine if they are a problem regionally or sub-regionally. Management recommendations made for species already assessed may be improved in the future as: (a) the NT WRM system is refined (b) new information becomes available and (c) distribution maps are improved or updated.

Benefit-cost analysis

In situations where weed species are also commercially valuable, the management response by the NT Government may be guided by an economic analysis of production use versus impacts. As part of research to refine the NT WRM system we completed a review of benefit-cost decision-making tools, and developed a 'cost-avoided' approach to evaluate management responses. The framework was developed as excel-based spreadsheets so that users can select impacts for which they have economic data. The framework developed for assessing the benefits of control of 'conflict of interest' weeds was tested using gamba grass in the NT as a case study. Gamba grass has significant negative environmental and social impacts (Rossiter *et al*. 2003, Drucker and Setterfield 2008), and is currently used as a pasture species. The benefits of control are represented by avoidance/mitigation of costs of the impacts resulting from invasion. For gamba grass, the most detailed data available are on the current costs of gamba grass invasion on fire management and weed management to ensure integrity of land use (e.g. spraying of the rail corridor to maintain visibility, train access and public safety). This therefore represented only a partial accounting of the total economic value of impacts and therefore a lower-bound estimate of the weed management costs. This is sufficient in cases where even partial accounting of impacts is greater than the primary production value. Full accounting will be pursued in future research projects.

Future progress

The NT WRM system has now been implemented and informs NT Government decision making in relation to weed management. It will continue to be improved as new information and risk assessment techniques become available. A significant limitation in an effective WRM in northern Australia is the lack of accurate weed distribution mapping, and we are currently developing and applying methods for mapping high priority weeds. We have commenced research projects that can refine weed risk assessments by developing invasion pathway models and spatially explicit economic analysis tools to evaluate management options. These are currently being developed and tested for the exotic grass weeds, gamba grass and para grass (*Urochloa mutica* (Forssk.) T.Q.).

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Appendix 1. Questions within the (i) Weed Risk Assessment, and (ii) Feasibility of Control tools (Setterfield *et al*. 2008). Questions are based on the National Post-Border WRM Protocol (Anon. 2006).

(I) WEED RISK ASSESSMENT	
Invasiveness	What is the ability of the plant to establish amongst intact native environments?
	What is the reproductive ability of the plant? (a) Time to seeding. (b) Annual production of viable seed m^{-2}or per plant. (c) Vegetative reproduction.
	Do propagules of the plant have properties that allow them to be dispersed long-distance by natural means? (a) Flying animals (birds, bats). (b) Other wild animals. (c) Water. (d) Wind.
	How likely is long-distance dispersal by human means? (a) Deliberate spread by people. (b) Accidentally by people and vehicles. (c) Contaminated produce. (d) Domestic/farm animals.
Impacts	What is the plant's competitive potential?
	What is the plant's potential to modify the existing fire behaviour and alter the fire regime?
	What is the plant's potential to restrict the physical movement of people, animals, vehicles, machinery and/or water?
	What is the plant's potential to negatively affect the health of animals and/or people?
	Does the plant potentially have negative effects on natural and cultural values? (a) Reducing habitat quality for native animals. (b) Threatened species or communities. (c) Sites of natural significance. (d) Sites of cultural significance.
	Is the plant *presumed* to have negative effects on environmental health? (a) Soil chemistry/stability. (b) Water quality. (c) Hydrology.
Potential distribution	What is the CLIMATE suitability score?
	How many broad vegetation types in the NT will the plant potentially naturalize in?
	What is the potential of the plant to occur throughout its favoured habitat in the NT?
(II) FEASIBILITY OF CONTROL	
Control costs	How detectable is the weed? (a) Distinguishing features. (b) Active growth period. (c) Height at maturity.
	What is general accessibility of infestations at the optimum treatment time?
	How expensive is control of the weed in the first year of targeted control, for an infestation that has reached maximum weed density? (a) Chemical cost. (b) Labour costs. (c) Equipment costs.
	What level of sophistication is required for the weed control program?
	What is the general community perception of this weed within the region?
Current distribution	What percentage area of the weeds potential distribution within the region is currently infested?
	What is the pattern of the weed's distribution within the region?
Persistence	What is the likelihood of long-term control?
	What is the minimum time period for reproduction of sexual or vegetative propagules?
	What is the maximum longevity of sexual or vegetative propagules?
	What is the treat of re-infestation from outside the region? (a) Long-distance dispersal by natural means. (b) Long-distance dispersal by human means.

Appendix 2. The Northern Territory WRM Matrix. The matrix was simplified to give 12 management actions, compared to 16 in the National Post-Border WRM Protocol (Anon. 2006).

		FEASIBILITY OF CONTROL		
		Low-Medium	High	Very high
WEED RISK	Low	Assist interested parties	Assist interested parties	Monitor
	Medium	Improve general weed management	Targeted control Improve general weed management	Targeted control Monitor Protect priority sites
	High	Targeted control	Protect priority sites	Prevent entry Contain regional spread
	Very high	Targeted control (inc biocontrol) Protect priority sites	Prevent entry Contain regional spread Protect priority sites	Prevent entry Regional eradication Protect priority sites