Protecting new markets: quantifying the risks to new carbon markets from invasive species and prioritising areas for immediate action

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Summary Financial mechanisms such as offsets are one strategy to abate greenhouse gas emissions. However, in the case of carbon offsets, if the carbon is released due to intentional or unintentional reversal through environmental events such as fire, the financial liability to replace lost offsets will likely fall on the provider. In order to manage this risk, an understanding of the spatial and temporal distributions of threats is needed. We use the case study of savanna burning, an approved greenhouse gas abatement methodology under the Carbon Farming Initiative in Australia, to examine the risks posed by high biomass invasive grasses, such as gamba grass (*Andropogon gayanus* Kunth), to carbon markets in northern Australia. We focus our analysis on the threat of gamba grass to savanna burning due to its documented impacts of increased fuel loads and altered fire regimes. We build on an initial assessment of the spatial and financial extent to which gamba grass poses a risk to savanna burning programs in northern Australia. We estimate the costs and benefits of three gamba grass management scenarios. The management scenarios prevent up to ~100,000 ha in new infestations which is a substantial return on investment in weed management. Our analysis demonstrates how the use of spatial spread modelling of gamba grass can be used in conjunction with a financial assessment of risk to identify infestations of highest priority for control.

Keywords Carbon market, fire management, risk, exotic grass invasion, *Andropogon gayanus* (gamba grass), spread, management, prioritisation.

INTRODUCTION

The global carbon market is valued at US$176 billion (Kossoy and Guigon 2012) and new carbon abatement and storage methodologies are being developed to support new entry into this growing market. For example, in Australia the Carbon Farming Initiative (CFI, a voluntary carbon offset scheme approved in 2011) presented an important opportunity to develop a carbon market that supports alternate economies with associated job creation, particularly in northern Australia. One of the first methodologies to be approved and applied under the CFI is savanna burning and it is estimated that savanna burning projects would be financially viable across large areas of northern Australia (Heckbert *et al.* 2012). The savanna burning methodology involves the use of controlled fire management across Australia's tropical savanna to achieve annual abatement of GHG emissions by reducing emissions relative to an established baseline. However, a major risk to savanna burning is high biomass invasive grasses because of their impact on savanna fire frequency and intensity and they are listed as a 'specific exception' (DCCEE, 2011) to the vegetation types that can be included under the methodology.

Of these grasses, gamba grass poses the greatest risk and the estimated financial risks of gamba grass to savanna burning are significant (Adams and Setterfield 2013). The potential spatial extent of savanna burning projects across northern Australia is coincident with the potential spatial extent of gamba grass (Adams and Setterfield 2013). In fact, Adams and Setterfield (2013) estimated that only 5% of the area that is eligible for enrolment in savanna burning is out of range for gamba grass while 75% of the region is part of the highly suitable range for gamba grass. However, this initial assessment of spatial coincidence of land suitable for both savanna burning and gamba grass only took into account the current level of invasion of gamba grass and not the potential future distribution of gamba grass given continued spread. For example, in the Northern Territory, gamba grass is estimated to cover 1–1.5 million ha (NRETAS 2010) including a core infestation in Litchfield National Park. Rapid spread of gamba grass has been observed from initial source paddocks in northern Australia and suggests explosive rates of spread analogous to highly invasive plants elsewhere (Northern Territory Government 2009). While the current level of infestation is significant, and poses a major threat to existing savanna burning enterprises (gamba grass has been included in one quantitative risk assessment to conservation and carbon market revenue in Northern Australia, Game *et al.* 2013), this threat is likely to be underestimated by not considering future spread.

We therefore extend the existing financial risk estimates of gamba grass to savanna burning by Adams and Setterfield (2013) to consider the potential future risk from spread of gamba grass. We do this by integrating an existing spread model for gamba grass with the estimated carbon abatement and associated profits (Adams and Setterfield 2013) to quantify not only the current losses from gamba grass invasion but the future losses over the next 10 years. Lastly, we investigate the benefits of two gamba grass management scenarios designed to reflect the current Northern Territory gamba grass management plan and existing savanna burning enterprises. We discuss the value of our approach for quantifying not only the current but future risks from gamba grass to savanna burning enterprises.

MATERIALS AND METHODS

Study species Gamba grass is a perennial C4 grass that forms large tussocks in excess of 3 m high and displaces the much shorter native vegetation (Brooks *et al.* 2010). Gamba grass is one of five species of tropical invasive grasses that have been listed as a national Key Threatening Process (KTP) under the Environment Protection and Biodiversity Conservation (EBPC) Act for Australia and is listed as a Weed of National Significance (WoNS). Significant ecological impacts result from gamba grass invasions including increases in fire severity leading to a reduction in tree canopy and severe impacts on the understory (Rossiter *et al.* 2003, Brooks *et al.* 2010, Setterfield *et al.* 2010).

Study region The current known extent of gamba grass infestations in the Northern Territory extends south approximately 350 km from Darwin to Katherine in the Daly River Catchment. We selected our study region to include the northern most portion of the Daly catchment which encompasses Litchfield National Park extending down past Daly River to include the Fish River Indigenous Protected Area (IPA) (a protected area which is one of the first enterprises to sell savanna burning carbon abatement credits on the market, Brann 2012). This study region was selected to include the boundaries of the core infestation area, key conservation assets such as Litchfield National Park and Fish River IPA, as well as a major savanna burning enterprise (Figure 1). Furthermore, we ensured that our study region includes gamba grass infestations on properties neighbouring Fish River IPA which thus pose a future threat to the carbon abatement enterprise.

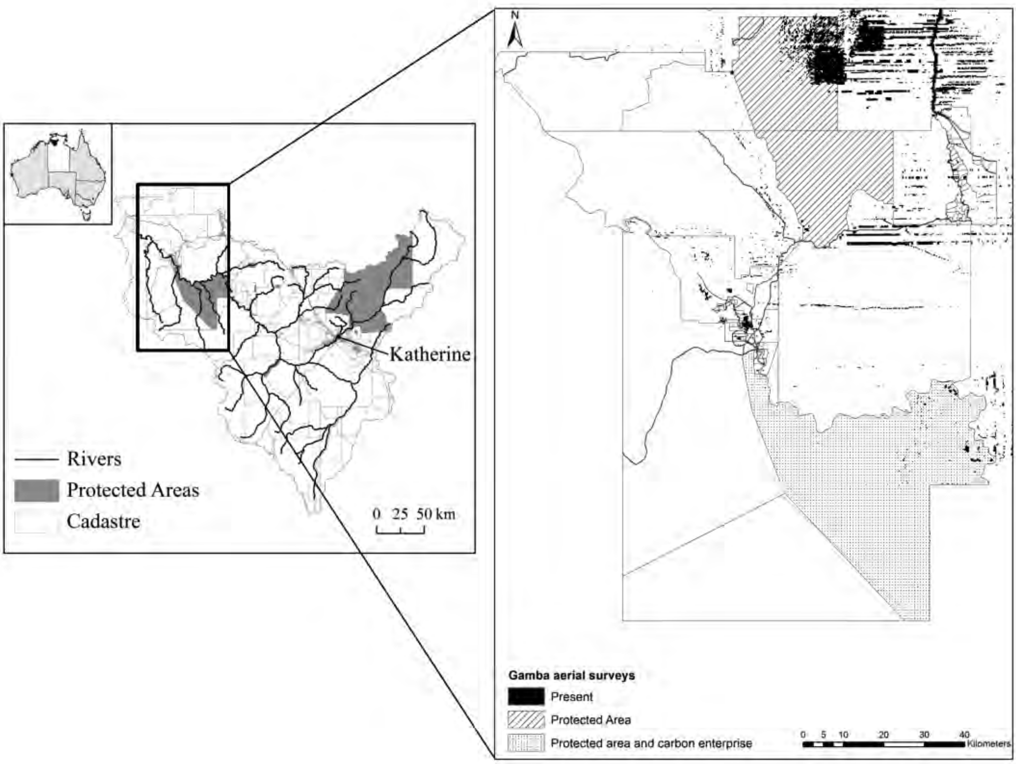

Figure 1. Study area in the northwest portion of the Daly Catchment. Conservation areas including protected areas and carbon enterprises are shown as well as mapped gamba grass density from aerial surveys.

Management scenarios We selected three management scenarios:

1. No management – this scenario is used as a baseline to measure the financial losses from gamba grass invading savanna burning land.
2. Eradication within savanna burning enterprises (local eradication) – this scenario was designed to reflect the likely strategy of a carbon enterprise to managing the risk posed by gamba grass. We assume that the enterprise would engage in eradication within the property boundaries, and that the duration of this program would be 6–8 years based on expert estimates (for more detail see Adams and Setterfield 2013). However, outside of the enterprise boundaries we assume that there is no management of gamba grass and thus spread from neighbouring properties can result in re-invasion.
3. Eradication in the region of savanna burning enterprises (regional eradication) – this scenario was designed to reflect a more regional approach to safe guarding the financial viability of savanna burning enterprises. We assume that both the enterprise and neighbouring properties would engage in eradication of known gamba grass infestations.

Evaluating the costs and benefits of management scenarios For each scenario we used our current mapped distribution for the study region (Figure 1) and modelled spread for ten years into the future using our stochastic spread model. For scenarios 2 and 3 we assumed that the infestations within the designated properties were eradicated and therefore excluded from the current mapped distribution for modelling spread. We used the eradication cost model by Adams and Setterfield (2013) to estimate the costs of management for scenarios 2 and 3 and calculated the net present value assuming a 3% discount rate. For all three scenarios we used the estimated carbon abatement and profits associated with savanna burning from Adams and Setterfield (2013) and the final modelled distribution for each scenario to calculate the total lost carbon abatement and associated profit. We calculated lost carbon abatement and profit for the entire region to demonstrate the potential losses into the future for properties considering engaging in the carbon market (Table 1) and more specifically the lost abatement and profits within the existing carbon enterprise (Table 2). For the current carbon enterprise, the benefits of management are calculated as the prevention of lost profit which is the difference in lost profit in scenario 1 and the relevant management scenario (2 and 3).

RESULTS

Over the ten year period there is a 10 to 11 fold increase in infested area across the three scenarios due to spread. The management scenarios prevent up to approximately 100,000 ha in new infestations which is a substantial return on investment in weed

Table 1. Summary statistics of three management scenarios across study region. Total infested area (ha), annual potential lost abatement in CO_2 equivalents (t CO_2-e) and associated profit ($) are given.

	Initial infested area (ha)	Area managed (ha)	Final infested area (ha)	Annual abatement lost (t CO_2-e)	Annual profit lost ($)
No management	46,740	0	542,260	2410	27,910
Local eradication	46,740	1020	482,150	1950	21,970
Regional eradication	46,740	2090	432,230	1880	21,370

Table 2. Summary statistics of benefits achieved for the existing enterprise over a 10 year time horizon. Management costs are the cost of eradication for each scenario calculated over 10 years with a 3% discount rate. Prevented loss of abatement is the total estimated abatement in CO_2 equivalents (t CO_2-e) over 10 years. Prevented loss of profit is calculated as the NPV profit lost under no management minus any lost profit under the management scenario (NPV calculated over 10 years at 3% discount rate).

	Area eradicated (ha)	Management costs ($)	Area infested t = 10 (ha)	Prevent loss abatement (t CO_2-e)	Prevent loss profit ($)
No management	0	0	69,230	0	0
Local eradication	1,020	979,750	14,080	3900	45,266
Regional eradication	2,090	2,169,750	0	4590	51,926

management. Across the study region up to 2400 tonnes CO_2-e in potential annual abatement could be lost due to invasion (and a corresponding annual loss of approximately $28,000 in profit).

Eradicating gamba grass within the carbon enterprise (Scenario 2) will require an up-front endowment of approximately $980,000 to fund eradication over an eight year management period (Table 2). Eradicating gamba grass within the carbon enterprise and on neighbouring properties requires approximately twice the investment. Over a 10 year period eradication of gamba grass will return an avoided loss of abatement of 3900-4590 tonnes CO_2-e (Table 2). However, in scenario 2, re-invasion into the enterprise from neighbouring properties results in a net increase in total area infested in the region, thus resulting in a much larger required future investment by the enterprise. Thus, although the required investment to eradicate gamba grass within the enterprise and neighbouring properties is twice as large, the benefits of avoided future invaded area are significant (Table 2).

DISCUSSION

The most significant benefit of gamba grass management was the avoided future spread of gamba grass which is estimated as a 10–11 fold increase in infestations (Table 1). Our analysis of the impact of future spread on current and potential savanna burning enterprises demonstrates that current risk assessments such as Adams and Setterfield (2013) underestimate the risk by not accounting for future increase of infestations. Furthermore, our analysis demonstrates that it is important to not only manage infestations within savanna burning enterprises, but to also manage neighbouring infestations which can pose a risk for re-invasion. For example, while the eradication of gamba grass within the carbon enterprise delivers a return on avoided loss of abatement and associated profits, there is still a significant re-infestation from neighbouring properties that will require a much larger investment to manage in the future (Scenario 2, Table 2). Thus, managing the gamba grass invasion in isolation is not as effective as implementing a regional eradication program which eliminates not only infestations within the carbon enterprise, but also neighbouring infestations which can spread into the property (Scenario 3). Those properties interested in engaging in the carbon market through savanna burning will therefore need to think about not only gamba grass infestations within their property but neighbouring infestations. If it is not possible to incentivise neighbouring properties to manage or eradicate their gamba grass infestations, then carbon enterprises will need to strategically manage their boundaries to stop spread into their properties. This analysis thus emphasizes the value of estimating not only current but future infestation levels and taking a regional perspective for management efforts.

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REFERENCES

Adams, V.M. and Setterfield, S.A. (2013). Estimating the financial risks of *Andropogon gayanus* to greenhouse gas abatement projects in northern Australia. *Environmental Research Letters* 8: doi:10.1088/1748-9326/1088/1082/025018.

Brann, M. (2012). Indigenous fire project to earn carbon credits. ABC Rural, Darwin, NT. http://www.abc.net.au/rural/news/content/201211/s3624266.htm (accessed March 2013).

Brooks, K.J., Setterfield, S.A. and Douglas, M.M. (2010). Exotic grass invasions: applying a conceptual framework to the dynamics of degradation and restoration in Australia's tropical savannas. *Restoration Ecology* 18:188-197.

Game, E.T., Fitzsimons, J.A., Lipsett-Moore, G. and McDonald-Madden, E. (2013). Subjective risk assessment for planning conservation projects. *Environmental Research Letters* 8: doi:10.1088/1748-9326/1088/1084/045027.

Heckbert, S., Russell-Smith, J., Reeson, A., Davies, J., James, G. and Meyer, C. (2012). Spatially explicit benefit–cost analysis of fire management for greenhouse gas abatement. *Austral Ecology* 37, 724-32.

Kossoy, A. and Guigon, P. (2012). State and trends of the carbon market 2012. Carbon Finance at the World Bank, Washington DC, USA.

Northern Territory Government (2009). Weed Risk Assessment Report: *Andropogon gayanus* (gamba grass).

NRETAS (2010). Weed Management Plan for *Andropogan gayanus* (gamba grass).

Rossiter, N.A., Setterfield, S.A., Douglas, M.M. and Hutley, L.B. (2003). Testing the grass-fire cycle: alien grass invasion in the tropical savannas of northern Australia. *Diversity and Distributions* 9, 169-76.

Setterfield, S.A., Rossiter-Rachor, N.A., Hutley, L.B., Douglas, M.M. and Williams, R.J. (2010). Turning up the heat: the impacts of *Andropogon gayanus* (gamba grass) invasion on fire behaviour in northern Australian savannas. *Diversity and Distributions* 16, 854-61.