Para grass management and costing trial within Kakadu National Park

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Summary Para grass (*Urochloa mutica* (Forssk.) T.Q.Nguyen) is an environmental weed that forms dense monocultures on Australia's tropical floodplains. It is a weed of particular concern for Kakadu National Park managers and the Indigenous Traditional Owners. To inform the design of a large-scale management program of para grass in Kakadu, we collected distribution and control data. This information will be incorporated into a weed risk and management model for Kakadu. Here we report on the initial data collection findings.

The large-scale aerial survey to map the distribution of para grass across the Kakadu floodplains showed extensive areas of infestations in a range of density and size classes. The cover of para grass in Kakadu is now estimated to be over 3200 ha. A field trial was established using six management plots (6.25 ha) to estimate the cost and effectiveness of para grass control. The density of infestations ranged from low (1–10%), medium (10–50%) and high (>50%). Following the current 'best practice' management, plots were burnt and sprayed one month later with glyphosate. Data including labour, vehicle and chemical costs were recorded. Treatment cost for high, medium and low density plots was approximately $2770, $1150 and $520, respectively. Based on the current distribution of para grass it would cost over $2.3 million for an initial treatment of all infestations in the park. Because of the large costs of this approach, this information is now being used to explore more cost effective management strategies including containment areas and aerial spraying.

Keywords *Urochloa mutica*, strategic weed management, weed mapping, management costs.

INTRODUCTION

Invasive weeds cause major ecological, economic, social and cultural degradation in ecosystems around the world (Ehrenfeld 2010). Despite being one of the least impacted regions of Australia, invasive weeds are currently spreading rapidly in the wetlands of the Northern Territory, especially in Kakadu National Park (Kakadu). Kakadu is one of Australia's premier protected area and is listed as a World Heritage area for both its natural and cultural values. The wetlands of Kakadu are also listed under the Ramsar Wetlands Convention and are of international importance. These wetlands are now under substantial threat from a range of high impact weed species (Setterfield *et al.* 2013). Over the past few decades, the control of some weed species has been highly successful (e.g. mimosa (*Mimosa pigra* L.), however the management response to others has been insufficient (e.g. para grass and olive hymenachne, *Hymenachne amplexicaulis* (Rudge) Nees) (Setterfield *et al.* 2013).

Kakadu is now developing a weed management plan to identify a more strategic and cost-effective approach to weed management throughout the park. Data on the distribution of each weed species, as well as the resources needed and effectiveness of control, is required for this process. To assist in the strategic management of weeds throughout Kakadu, large-scale aerial surveys were conducted to map the distribution and density of para grass. A field trial was established to document the required effort as well as cost and effectiveness of para grass control. Combining these two sources of information, we estimate an approximate cost of a single spray treatment of para grass throughout Kakadu and discuss other feasible weed management strategies.

MATERIALS AND METHODS

Study species and region Para grass is a stoloniferous grass that was introduced to Australia in the 1880s as an improved pasture species (Douglas and O'Connor 2004). It was planted in Kakadu for improved pasture for buffalo and cattle in the 1960s. Para grass has now spread across extensive floodplain areas forming dense monocultures, displacing native vegetation, increasing fuel loads, impacting on the habitat of waterbirds such as magpie geese (*Anas semipalmata* Latham), and causing hotter fires which kill aestivating turtles (Douglas *et al.* 2001). Para grass has been assessed as a high risk invasive species in northern Australia (Bayliss *et al.* 2010), and is listed as a key threatening ecosystem process under the Australian *Environmental Protection and Biodiversity Conservation Act* (EPBC Act 1999). Para grass poses a significant management concern for Parks Australia managers and the Indigenous Traditional Owners.

Distribution mapping Mapping of para grass distribution across the Kakadu floodplains was undertaken over several catchments: the southern and central Magela (2009), the northern Magela and Didygeegee (2010), and the Wildman, West Alligator and South Alligator (2012). Surveys were undertaken in the late wet season (April) with observers on either side of the helicopter recording para grass cover over adjacent grid areas of approximately 6.25 ha (250 × 250 m). Cover was estimated using a five-point scale (1: absent, 2: <1%, 3: 1–10%, 4: 10–50%, 5: >50%) (see Petty *et al.* 2012).

Spray trial A field trial on the control of para grass was conducted from October to December 2012 on the Magela Floodplain adjacent to Djarr Djarr Billabong, which is part of Energy Resources of Australia's Mineral Lease Number One (Jabiluka). Six management plots (6.25 ha (250 × 250 m)), designed to correspond with the distribution mapping grid data, represented three density classes of para grass infestation; low (1–10%), medium (10–50%) and high (>50%). Following current 'best practice' management, plots were burnt, and then sprayed one month later with Glyphosate (glyphosate 450 g L^{-1}). Four people conducted the trial using two Quik Spray® units (400 L and 600 L) with a spray pressure of 25 psi and a chemical application rate of 1 L to 100 L of water. Data including: labour (\$50 h^{-1}), fuel used for water trips (\$1.60 km^{-1}), and chemical costs were recorded and used for cost estimates (Table 1). Travel time and fuel usage to-and-from the site as well as vehicle and equipment expenses were not included in the cost estimates.

Management costs Using spray trial costs together with the distribution and density mapping, the cost of a single para grass treatment was estimated across all of the Kakadu floodplains. Average hours per hectare and costs per hectare were used from the spray trial for the low (1–10%), medium (10–50%) and high (>50%) density classes (Table 2). Given the small sample size, cost estimates were also compared with a gamba grass (*Andropogon gayanus* Kunth) cost model (Adams and Setterfield 2013), which had similar cost estimates (i.e. within 10%) for treatment within each density class. Within each density class, time and cost estimates were rounded to avoid a false sense of precision. In order to estimate costs for the rare (<1%) density class, we regressed the cost per hectare and hours per hectare from the spray trial against infested area assuming a power function. We selected a power function to reflect the functional form of the Cobb-Douglas production function which applies a natural log-log relationship between per hectare input costs and management area and can be used to test for economies of scale (Adams *et al.* 2012). Using this approach, economies of scale were detected and the final regression equations were cost $ha^{-1} = \$898.83 \times ha^{-\$0.326}$ ($r^2 = 0.77$) and hours $ha^{-1} = 11.797 \times ha^{-0.356}$ ($r^2 = 0.87$). We used these equations to estimate the rare density class costs and hours (Table 2).

RESULTS AND DISCUSSION

Distribution mapping Aerial surveys across all Kakadu floodplains showed extensive areas of para grass infestations in a range of density and size classes (Figure 1).

The largest core infestation occurs on the Magela floodplain, with high levels of infestation also occurring on the Wildman floodplain. Para grass on the West and South Alligator floodplains are currently limited to small pockets on the floodplain margins. Of the 24,290 floodplain grid cells and 151,812.5 ha, 1998 grids contained para grass for a total cover of 3204.4 ha (Table 3). While most para grass infestations were at low densities (1–10% cover), high density (>50% cover) infestations contributed most to the total area of infested hectares (Table 3).

Spray trial During the spray trial, chemical application ranged between 967–2333 L ha^{-1} and spray time ranged between 2.5 and 7 hours ha^{-1} (Table 1). Not surprisingly there was a strong positive relationship between chemical application and spray time ($r^2 = 0.84$). On average, treatment costs for low, medium and high density plots were approximately \$520, \$1150 and \$2770, respectively (Table 1). Treatment of para grass infestations on a per hectare basis required less effort and less cost within the high density plot compared with the low density plots (Table 1).

Management costs Depending on the density of para grass, a single treatment was estimated to take between 8 and 41 person hours per hectare and cost between \$630 and \$2780 per hectare (Table 2). The per unit costs are higher for low density or scattered para grass as the effort spent searching for plants is much higher and a greater distance must be covered to treat an equivalent amount of para grass. This finding is consistent with most costs functions for invasive species which show unit costs increase exponentially with declining abundance, reflecting more time searching than destroying (Bayliss *et al.* 2008).

A single treatment across all the Kakadu floodplains is estimated at approximately 93,000 person hours and \$2.4 million (Table 3). This equates to a team of 48 people working full time for a whole year. Actual costs are likely to be much higher as a result

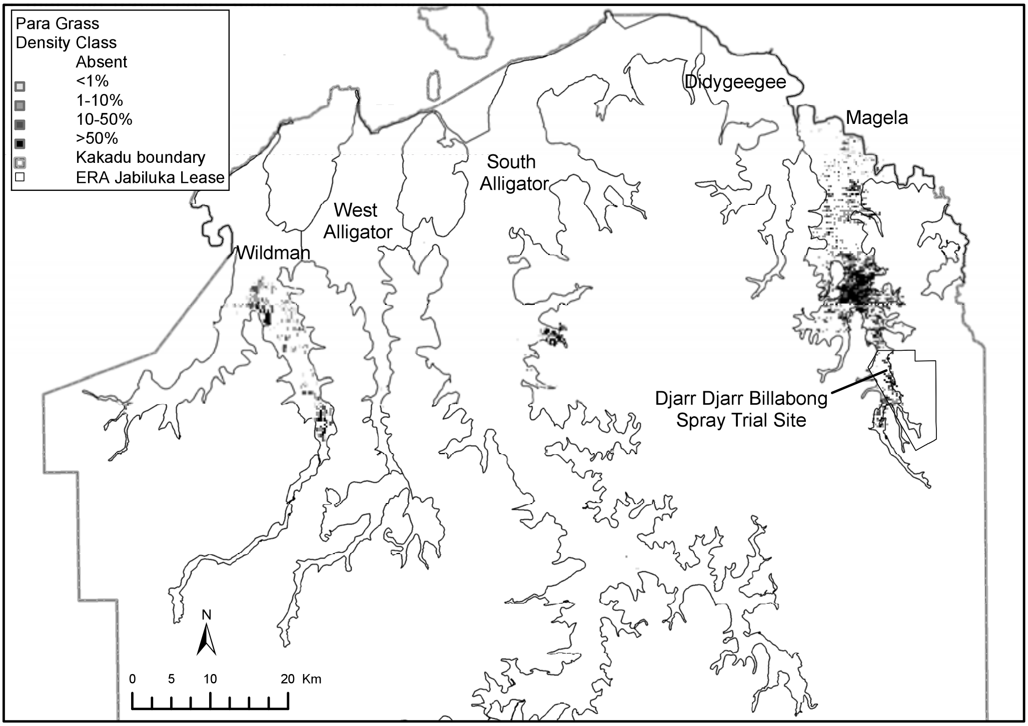

Figure 1. Distribution and density of para grass on the Kakadu floodplains.

Table 1. Effort and cost data recorded from the spray trial.

Plot / Density Class	Infested hectares (ha grid^{-1})	Chemical (L)	Chemical (L ha^{-1})	Spray time (hrs)	Spray time (hrs ha^{-1})	Total time (hrs)	Total time (hrs ha^{-1})	Cost ($)	Cost ($) ha^{-1}
Low (3: 1-10%)	0.45	738	1639	1.7	3.7	5.8	12.9	$ 489	$ 1,087
Low (3: 1-10%)	0.45	1050	2333	3.2	7.0	8.7	19.3	$ 554	$ 1,232
Medium (4: 10-50%)	0.85	1200	1412	3.8	4.5	9.0	10.6	$ 716	$ 842
Medium (4: 10-50%)	1.15	1887	1641	4.3	3.7	14.9	12.9	$ 1,252	$ 1,088
Medium (4: 10-50%)	3	2900	967	7.6	2.5	21.3	7.1	$ 1,495	$ 498
High (5: >50%)	4.4	5550	1261	13.0	3.0	34.8	7.9	$ 2,773	$ 630

Table 2. Costs of a single treatment of para grass for each density class. Note: Costs for Density Class 3–5 are averages from the spray trial values while costs for Density Class 2 are based on regression equations.

Density Class	Ave. Cover	Ave. infested area (ha grid^{-1})	Time (hrs ha^{-1})	Time (hrs grid^{-1})	Cost ($ ha^{-1})	Cost ($ grid^{-1})
1: Absent	Absent	0.00	0	0	$ -	$ -
2: <1%	0.005	0.03	41	1	$ 2,780	$ 90
3: 1-10%	0.05	0.31	16	5	$ 1,160	$ 360
4: 10-50%	0.35	2.19	10	22	$ 810	$ 1,770
5: >50%	0.75	4.69	8	38	$ 630	$ 2,960

Table 3. Costs of a single treatment across the entire Kakadu floodplains based on aerial surveys.

Density Class	No. of grids	Total area (ha)	Total infested area (ha)	Total time of a single treatment (hrs)	Total cost of a single treatment ($)
1: Absent	22292	139325	0	0	$ -
2: <1%	311	1944	10	10	$ 28,000
3: 1-10%	739	4619	231	1160	$ 266,000
4: 10-50%	592	3700	1295	28490	$ 1,048,000
5: >50%	356	2225	1669	63420	$ 1,054,000
Kakadu Total	24290	151813	3205	93080	$ 2,396,000

of fuel and travel costs which were not included in cost estimates.

Furthermore, best practice management may require more than one treatment to be applied in any given year and the complete eradication of a para grass infestation is likely to involve treatment over multiple years (Douglas *et al.* 2001) with follow up monitoring surveys adding additional expense.

Accessibility including vehicle and airboat access, remote areas, sensitive rain-forest areas and culturally sensitive sites is a significant issue for weed spraying across the floodplains. Accessibility to particular areas can also be highly variable throughout the year (and between years), with airboat access limited to a short period of the wet season and vehicle access limited to the mid-late dry season.

The findings from our study are being used to investigate more effective strategies for managing para grass in Kakadu. Our data indicates that a single treatment of para grass across all floodplains in Kakadu would be prohibitively expensive for management and furthermore, even a cost-effective approach to weed management may not involve treating every infestation. For example an optimal strategy may be to target outlier populations while containing core infestations. A strategy to manage high density areas (i.e. Density Class 5) where eradication is too expensive could include declaring these infestations as ‘quarantine or containment areas’ whereby only the perimeters of the infestation are treated to control the spread. Aerial spray trials are also underway to assess if this is a more economical approach than hand spraying within particular areas and density classes, and if this method has a viable role within Kakadu.

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