Economic analyses of options for weedy Sporobolus grass management

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Abstract. Weedy Sporobolus grasses have low palatability for livestock, with infestations reducing land condition and pastoral productivity. Control and containment options are available, but the cost of weed control is high relative to the extra return from livestock, thus, limiting private investment.

This paper outlines a process for analysing the economic consequences of alternative management options for weedy Sporobolus grasses. This process is applicable to other weeds and other pastoral degradation or development issues.

Using a case study property, three scenarios were developed. Each scenario compared two alternative management options and was analysed using discounted cash flow analysis. Two of the scenarios were based on infested properties and one scenario was based on a currently uninfested property but highly likely to become infested without active containment measures preventing weed seed transport and seedling establishment.

The analysis highlighted why particular weedy Sporobolus grass management options may not be financially feasible for the landholder with the infestation. However, at the regional scale, the management options may be highly worthwhile due to a reduction in weed seed movement and new weed invasions. Therefore, to encourage investment by landholders in weedy Sporobolus grass management the investment of public money on behalf of landholders with non-infested properties should be considered.

Additional keywords: livestock carrying capacity, natural resource management, public funding, weed management.

Introduction

The leaf blades of weedy Sporobolus grasses have low palatability to livestock relative to other pasture species. As the density of weedy Sporobolus grass increases, land condition and livestock carrying capacity decline due to the displacement of palatable and productive pasture species. Farmers have indicated that losses in carrying capacity and production range from 10 to 80% depending on the density of infestations (NRM 2001). If livestock numbers are not reduced in proportion to the amount of palatable forage, growth per animal declines due to limitations on forage intake and quality (NRM 2001).

Weedy Sporobolus grass encompasses five closely related species. Scenarios in this paper are based on giant rats tail grass (*Sporobolus pyramidalis* P. Beauv) and giant parramatta grass (*Sporobolus fertilis* Steud.), which infest significant areas of pasture from the south coast of New South Wales to north Queensland. The lifecycle of these weedy Sporobolus grasses are well adapted to invasion and dominance of grazed pastures (Andrews 1995; Andrews *et al*. 1996; Vogler 2002; Bray 2004; Bray and Officer 2007).

Various management interventions are available depending on land type and infestation density (Bray and Officer 2007). These interventions manipulate the level of weedy Sporobolus grass in a pasture and, therefore, change the productive pasture potential. However, the costs of these interventions are generally high, relative to the return from livestock. Hence, there is a need to determine what is economically possible for the landholder and whether 'external support' may be required to stimulate appropriate weedy Sporobolus grass management. External support may be relevant not only to the landholder with the weedy Sporobolus grass but also neighbouring and downstream properties.

The approach

A hypothetical case study property is generated (e.g. Fig. 1) where weedy Sporobolus grasses are currently or potentially a major issue. The property is designed to be a 'typical' commercial cattle property in size, land types, paddock number and livestock carrying capacity for the region.

Our hypothetical property 'Brig Plains' was generated for the central Queensland brigalow belt (Fig. 1). The property is 5390 ha and has a livestock carrying capacity of 1800 adult equivalents (AE) when in good condition (1 AE = 455 kg dry cow). The property is divided into eight paddocks and two land types. Seven of the paddocks are brigalow-blackbutt country (range in size from 550 to 850 ha with a smaller paddock of 90 ha – Table 1) and one large paddock (1200 ha) of ironbark forest country. The enterprise breeds weaners, which are grown through
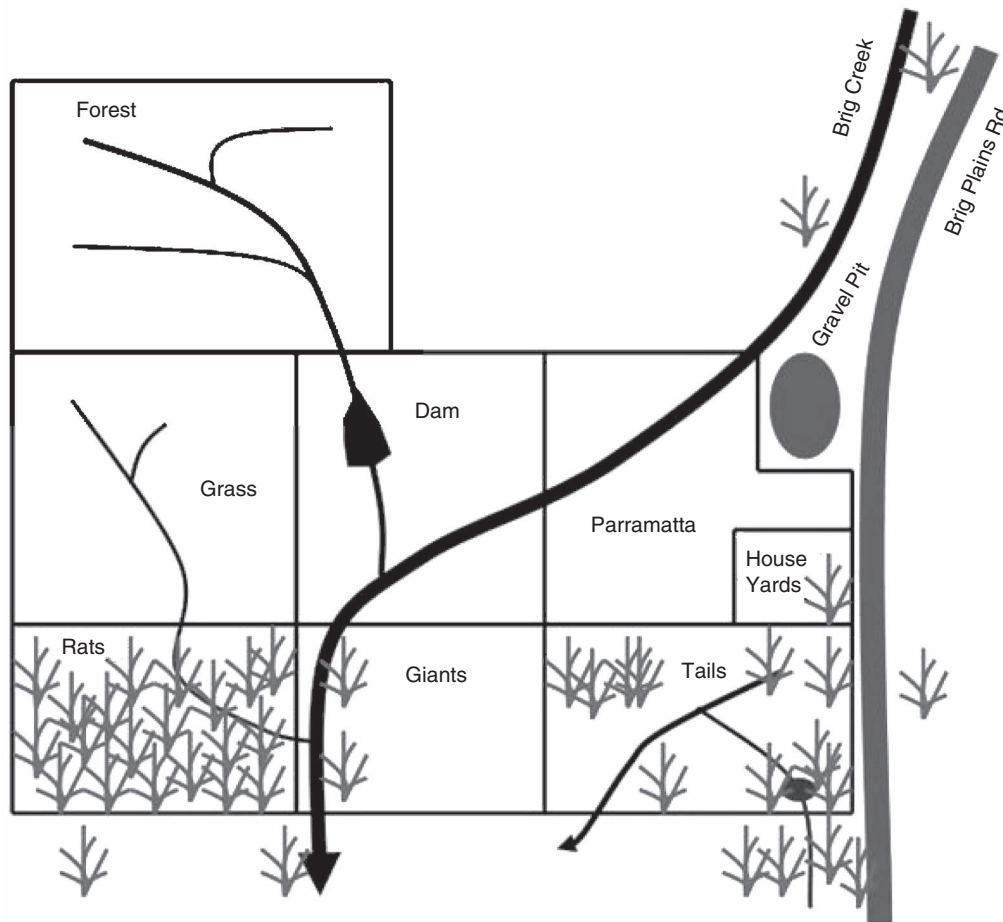
Fig. 1. Map of hypothetical case study property 'Brig Plains'. The stylised plants represent weedy Sporobolus grass infestation.

to bullocks. One paddock is densely infested with weedy Sporobolus grasses (Rats paddock – Fig. 1), one paddock (Tails) has weed clumps and scattered plants, two paddocks (Giants and House) have widely scattered weed plants. The other paddocks are not infested.

To assess the economic consequences of various weed management options, we developed scenarios that compared two different future paths (options). For example in Scenario 1, we compare the expected change over the next 50 years with no weed management ('do nothing'), relative to an alternative 'future', in this case, the broadacre herbicide control strategy. Both options within a scenario start with the same initial (Year 0) situation (e.g. level of infestation) and the different management options begin the following year (Year 1).

The 'STOCKTAKE' livestock carrying capacity calculator (DPI 2004) was used to calculate the number of livestock (AEs) that can be carried at various levels of weedy Sporobolus grass infestation in each paddock. The calculator reduced livestock carrying capacity based on four infestation conditions (Clean, Scattered, Clump or Dense; Table 2). Property livestock carrying capacity was modified during the fifty-year scenarios depending on the expected change in weedy Sporobolus grass infestation

density in each paddock based on pre-determined rules and assumptions (discussed below).

The gross margin (GM) per AE was estimated for the case study property using Breedcow and Dynama software (Holmes 2005). The GM per AE will vary depending on the type of country, animal growth rate, branding rate, type of animals, husbandry costs and sale prices. As mentioned above, livestock carrying capacity will change with the level of weedy Sporobolus grass infestation but individual animal growth rates may also be affected (NRM 2001). The analyses were based on changes in livestock carrying capacity with changes in weed infestation. The GM per AE was not modified based on the density of an infestation as the stocking rates were matched to available palatable forage, therefore changes in AE productivity should be minimised.

An Excel spreadsheet was used to perform discounted cash flow (DCF) analysis on the various scenarios, in each instance comparing a weed control option with 'do nothing' (no weed management) and basing the DCF on the difference in cash flows.

Cash flow from livestock each year was calculated as underlying gross margin (calculated on a stable herd), minus or

Table 1. Parameter values used in the analyses

Parameter	Unit values
Gross margin per adult equivalent	$205
Capital value of one adult equivalent	$600
Interest rate for discounting	6%
Land value/adult equivalent	$1500
Broadacre herbicide application cost	$85/ha
Containment costs for infested properties. Spot spray (limited by landholder time), quarantine (cattle) and containment costs (e.g. wash down facilities, buffer strips, vehicle track control)	$20 000 in year 1 and $10 000 per year thereafter
Preventing invasion costs for clean properties. Quarantine (cattle), property inspection (riparian areas, fencelines), wash down facilities	$10 000 in year 1 and $5000 per year thereafter
Property size total	5390 ha
Tails paddock	650 ha
Grass paddock	850 ha
Parramatta paddock	700 ha
Dam paddock	750 ha
Forest paddock	1200 ha
House paddock	90 ha
Giants paddock	550 ha
Rats paddock	600 ha

Table 2. Infestation condition description for weedy Sporobolus grass infestations and the relative carrying capacity value

Condition class	Description	Proportion of potential carrying capacity
Clean	No weedy Sporobolus grass present. Viable weed seed needs to enter the pasture followed by germination and weed establishment before progression to 'Scattered' condition. To transfer from 'Scattered' to 'Clean' condition, all weed plants and soil seed bank have to be eliminated	1
Scattered	Initial invasion, scattered weedy Sporobolus grass plants, little impact on carrying capacity, but inevitable increase to 'Clump' condition without management intervention. Potential for spot-spray control	0.95
Clump	Weedy Sporobolus grass clumps and plants across the paddock. Moderate impact on carrying capacity and inevitable increase to 'Dense' condition without management intervention	0.8
Dense	Dense weedy Sporobolus grass across the paddock. Substantial impact on carrying capacity. Major management intervention required to reduce weed density	0.4

plus the value of transactions required to increase or decrease stock numbers from year to year to match livestock carrying capacity. Both the gross margin ($205/AE) and the transaction value ($600/AE), were standardised and the same values used for the whole term of the analysis. In making these estimates, the AE standard used was a non-lactating animal of average weight 455 kg, carried for 12 months. Breeders were rated on the same weight basis plus 0.35 AE for each breeder weaning a calf.

Annual weed management costs year by year were included in the cash flow.

The analysis period used was 50 years. A shorter period could have been used, but the longer the analysis period adopted, the less significant will be any errors in assigning end-of-analysis salvage values. Salvage values are assigned as a proxy for continuing the analysis in perpetuity. In this analysis salvage value at the end of the 50-year analysis was taken to comprise the value of additional cattle on hand relative to 'do nothing', and the value of additional carrying capacity as a result of weed control (due to land being in better condition), again relative to 'do nothing'.

The value of additional carrying capacity at year 50 was estimated as the value of annual gross margins accruing beyond 50 years, less the costs of maintaining that level of carrying capacity, discounted back to year 50. If these future benefits continue into perpetuity, the 50-year value of net benefits after year 50 will be the annual net value of utilised increased carrying capacity (extra AE times GM/AE less ongoing weed control costs), all divided by the interest rate.

Economic indices calculated in the analysis were net present value (NPV), annualised return (AR), internal rate of return (IRR), payback period and peak deficit.

NPV is the sum of the discounted (present) values of future annual cash surpluses and deficits, including the year 50 'salvage value'. NPV is a measure of profit from the investment, and is considered the appropriate measure for ranking options, assuming that all options are fundable.

The AR is equivalent to the NPV amortised over the 50-year analysis. AR is an alternate expression of investment profit to which grazing business managers may relate more easily.

The IRR is the interest rate at which NPV would be zero, i.e. the interest rate which if charged would make the project break even. The IRR is effectively the calculated rate of return on the project – in this case extra return on extra investment relative to 'do nothing'.

Payback period and peak deficit are derived from the cumulative cash flow. The cumulative cash flow comprises the accumulating total of annual cash flows, negative and positive, with compound interest. For the weed control scenarios examined, this cumulative cash flow is at first a deficit which increases year by year until the annual benefits come to exceed the interest cost, at which point the deficit begins to diminish and eventually turns into a surplus. Payback period is the number of years until cumulative cash flow, including compound interest becomes positive. The peak (maximum) deficit is one measure of the amount of finance required for the project. The peak deficit and payback period are not measures of investment efficiency as NPV and IRR are, but they may influence the funding of an investment.

An interest rate of 6% was chosen as representing a 'real' rate of interest appropriate to a social or community view of the project opportunities. Estimates of future costs and benefits were at

current values with no allowance for inflation. For an individual investor, a higher interest rate, equivalent to 'opportunity cost', would be more appropriate. A higher rate of interest will reduce NPV, but will leave IRR unaffected, since IRR represents the breakeven interest rate between positive and negative NPV. As a test of decision making in the face of higher interest rates, the analysis was also performed for a 10% real interest rate. Assuming capital is available for any of the weed control options, but that the options are indivisible and mutually exclusive, the appropriate measure of investment ranking is NPV, calculated in the first instance at a rate appropriate to a community assessment of the project (in which case the benefits are underestimated since we should really include the social benefits not captured by the investor, which we have not measured), and at a rate appropriate to the grazier investor (opportunity cost).

The analysis

This paper reports on the analysis of three scenarios. Two scenarios compare two different weed management options against the same 'no weed management' (do nothing) option based on the infested case study property described above (Fig. 1). The third scenario uses the same case study property but assumes it is not initially infested and compares the option of applying strategies that prevent or contain weed invasion, against the option of no weed management resulting in eventual infestation of the property. Parameters used in the analyses are listed in Table 1.

Scenario 1 – broadacre herbicide control strategy v. no weed management

The option of applying the broadacre herbicide control strategy and containment strategies was compared to the option of conducting no weed management.

In the broadacre herbicide control strategy option, both Rats and Tails paddocks (Fig. 1) are sprayed with a broadacre selective herbicide (flupropanate) in Year 1 and Year 3 substantially reducing annual cash flow (Fig. 2). Rats paddock has another broadacre application in Year 14. Giants and House paddocks are spot-sprayed as are Rats and Tails paddocks following the second
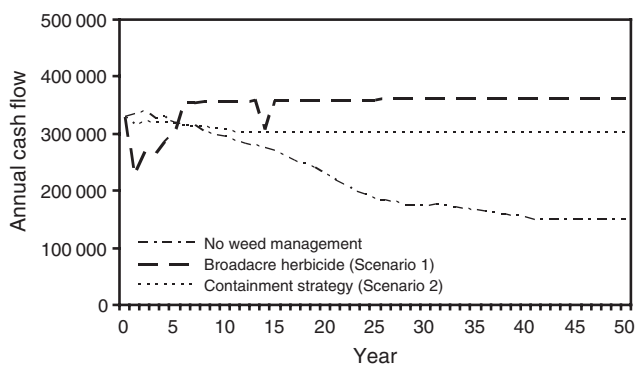
broadacre herbicide application to control missed and newly established plants. Quarantine and weed seed movement containment measures are also established. The rules and assumptions for the option are detailed in Table 3.

The no weed management option steadily increases in density of weedy *Sporobolus* grasses. The rules and assumptions for this option are detailed in Table 4.

Financial analysis at 6% interest (values for 10% interest in brackets) for the broadacre herbicide control option relative to no weed management option indicates an NPV of $1.259 m ($0.340 m), an annualised return of $79 865 ($34 313), an IRR of 16.0%, a peak deficit of $362 260 ($403 325) and a payback period of 13 (16) years (Table 5; Fig. 3). A substantial decline in livestock carrying capacity occurs with no weed management over time (Fig. 4).

This analysis does not include the benefits to neighbouring non-infested landholders from the removal of a weed seed source. Infested landholders may be deterred from this investment by the relatively large peak deficit or the relatively

Fig. 2. Annual cash flow for the broadacre herbicide control strategy (Scenario 1) and the containment strategy (Scenario 2) relative to no weed management.

Table 3. Rules and assumptions for change in weedy *Sporobolus* grass density when applying the broadacre herbicide control strategy (Scenario 1)

Rule or assumption	Details
Pasture condition	Assume good pasture species are across the infested paddocks which can replace killed weedy *Sporobolus* grasses
Carrying capacity in year of herbicide application	In the year of broadacre herbicide application, livestock carrying capacity is 50% of previous year due to the herbicide withholding period and to enable pasture recovery
Carrying capacity in year following herbicide application	In the year following broadacre application livestock carrying capacity is 80% of Scattered condition to enable pasture recovery
Livestock destocking rules when applying broadacre herbicide	Clean condition paddocks are able to carry up to 10% higher stock numbers for two years in ten years, enabling the destocking of sprayed paddocks to be mitigated. Excess livestock are sold
Broadacre herbicide control of Clump condition paddocks	Two herbicide applications are applied two years apart. Clump condition paddocks become Scattered condition in the second year following the herbicide applications and can progress to Clean condition with spot-spraying over the following 10 years
Broadacre herbicide control of Dense condition paddocks	Two herbicide applications are applied two years apart, followed by a third application ten years later (Year 14) to control widely scattered plants not controlled with spot-spraying (important in extensive paddocks). Dense condition paddocks (substantial soil seed bank) become equivalent to Scattered condition in the second year following the first two herbicide applications and require spot-spraying to maintain Scattered condition. Following the third herbicide application the paddock can progress to Clean condition over the next 10 years with spot spraying

Table 4. Rules and assumptions for change in weedy Sporobolus grass density with no weed management (Scenarios 1, 2 and 3)

Rule or assumption	Details
Manipulating infestation levels between Scattered, Clump and Dense condition	Once a paddock is infested (e.g. Scattered condition) it takes 10 years to drop down an infestation level e.g. Scattered to Clump, or Clump to Dense. Adult equivalent numbers decline evenly over the 10 year period (e.g. 5 AE reduction per year, to drop 50 AEs changing from Clump to Dense condition)
Infestation rule for Clean condition paddocks	All Clean condition paddocks become infested over a 10 year period (i.e. go from Clean to Scattered condition). The year in which a particular paddock becomes infested (Scattered condition) is spread evenly over the 10 year period (e.g. 1 of the four uninfested paddocks becomes infested every 2–3 years)

Table 5. Economic indices for comparison of weedy Sporobolus grass management scenarios at two interest rates 6% and 10% (in parentheses)

Economic indices	Scenario 1 Broadacre herbicide control strategy v. no weed management	Scenario 2 Containment strategy v. no weed management	Scenario 3 Preventing invasion strategy for a clean property v. no weed management
Total NPV	$1 258 827 ($340 208)	$813 215 ($227 628)	$1 372 279 ($450 054)
Annualised return	$79 865 ($34 313)	$51 594 ($22 958)	$87 063 ($45 392)
IRR	16.0% (16.0%)	19.7% (19.7%)	31.2% (31.2%)
Payback period (years)	13 (16)	13 (15)	8 (9)
Peak deficit	$362 260 ($403 325)	$84 599 ($104 431)	$43 035 ($48 364)
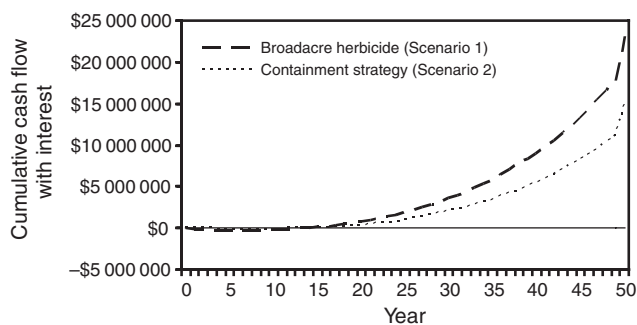
Fig. 3. Cumulative cash flow with interest including sale or purchase of livestock and salvage value at end of analysis for the broadacre herbicide control strategy (Scenario 1) and the containment strategy (Scenario 2) relative to no weed management.
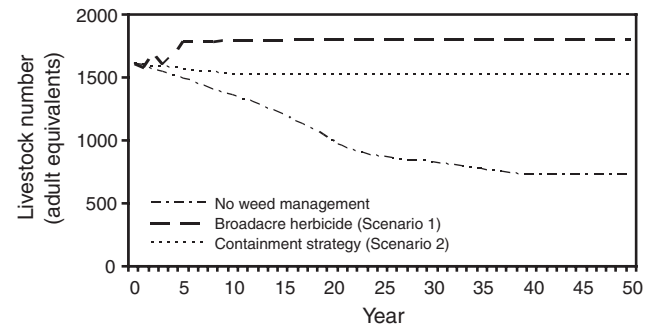
Fig. 4. Comparison of livestock numbers (adult equivalents) for the broadacre herbicide control strategy (Scenario 1) and the containment strategy (Scenario 2) relative to no weed management.

long payback period. There are, however, additional spillover benefits to non-infested landholders for which they do not currently pay. This infers a justification for non-infested landholders (or government acting on their behalf) to contribute to weed control costs on infested properties to protect productivity and land values of the so-far non-infested properties.

Scenario 2 – containing spread on an infested property v. no weed management

The option of containing the spread of weedy Sporobolus grasses was compared to the option of conducting no weed management. This scenario utilises the same case study property as Scenario 1 (Fig. 1). The no weed management option is the same as that used in Scenario 1 (Table 4).

Containment strategies (e.g. livestock quarantine, wash down facilities, buffer strips) cost $10 000 each year. In year 1, an additional $10 000 is required (total $20 000) to control the weedy Sporobolus grass in the riparian areas in the infested Rats and Tail paddocks and in the Scattered condition paddocks (Table 6).

Table 6. Rules and assumptions for change in weedy Sporobolus grass density when containment strategies are applied (Scenario 2)

Rule or assumption	Details
Weed seed spread to clean paddocks can be contained	Implementing a package of buffer strips, quarantine paddocks, wash down areas, vehicle and livestock movement controls and weed control in riparian areas will stop the spread of the weed to Clean paddocks
Clump and Dense condition paddocks	Clump condition paddocks will progress to Dense condition over 10 years and Dense condition paddocks will remain Dense condition. Weed control is conducted in riparian areas in Clump and Dense condition paddocks
Scattered condition paddocks	Scattered condition paddocks can become Clean condition with concerted spot-spraying over 10 years

The predicted NPV over 50 years for containing the spread of weedy Sporobolus grasses *v.* no weed management at 6% interest (figures for 10% interest in brackets) was $0.813 m ($0.228 m), with an annualised return of $51 594 ($22 958), an IRR of 19.7%, a peak deficit of $84 599 ($104 431) and a payback period of 13 (15) years (Table 5; Fig. 3). Livestock carrying capacity remains relatively stable by containing weed spread compared to a substantial decline with no weed management (Fig. 4).

This analysis does not include the benefits to neighbouring non-infested landholders from the containment of a weed seed source. One negative aspect of the containment of spread option is that although the infestation is reasonably contained, it is still a potential source of seed contamination for clean areas on the property and other properties (e.g. downstream), particularly during major flood events, feral animal movement or if containment strategies are not maintained.

Scenario 3 – preventing invasion of a clean property *v.* no weed management

The preventing invasion scenario assumes the case study property was initially not infested with weedy Sporobolus grass and therefore the case study property differs from the other two scenarios. However, infestations are nearby (e.g. the neighbours, upstream, purchased cattle of unknown history) and therefore the property is highly likely to be infested. This scenario tests the option of investing in strategies to prevent or contain weed invasion *v.* the option of no weed management. The prevention of weed invasion option maintains the paddocks in Clean condition throughout the scenario with a $10 000 cost in year 1 to establish strategies to prevent weed invasion (e.g. wash down facilities, livestock quarantine) with an annual cost of $5000 per year thereafter. The no weed management option follows the rules and assumptions in Table 4.

The predicted NPV over 50 years for prevention of invasion of weedy Sporobolus grasses at 6% interest (figures for 10% interest in brackets), was $1.372 m ($0.450 m), with an annualised return of $87 063 ($45 392), an IRR of 31.2%, a peak deficit of $43 035 ($44 121) and a payback period of 8(9) years (Table 5). A substantial decline in livestock carrying capacity occurs with no weed management over time (Fig. 5).

The preventing invasion strategy is clearly the best based on the economic indices, as it has the highest NPV and annualised return (at both interest rates), the highest IRR, the least required
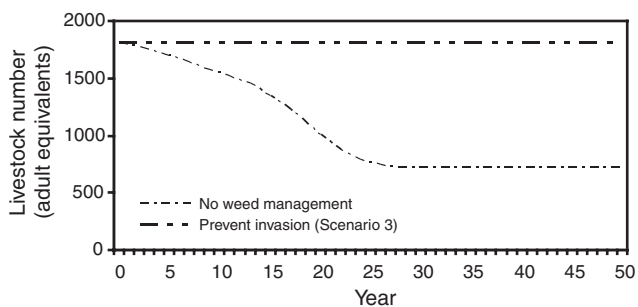

Fig. 5. Comparison of livestock numbers (adult equivalents) for the invasion prevention strategy (Scenario 3) relative to no weed management.

capital, and the shortest payback period of the strategies analysed. This option appears worthwhile for landholders who are currently not infested with weedy Sporobolus grass but are likely to become infested over time. This analysis prescribes some containment strategies in which to invest (e.g. wash down facilities, livestock quarantine), however, some of the investment may be better spent off-property controlling a potential seed source (e.g. an infestation on a neighbours property upstream or a buffer strip inside the neighbours fence). The positive aspect of the preventing invasion strategy is that weed invasion is prevented for a minor investment relative to the substantial financial and productivity penalty of having to manage weedy Sporobolus grass infested pastures.

Considerations for selecting a management strategy

If the preventing invasion strategy was not available, perhaps because the infestation has escaped, the choice would come down to one of the first two strategies (broadacre herbicide and containing spread). NPV alone indicates preference for the broadacre herbicide strategy, though this strategy requires four times the investment of the containing spread strategy. IRR indicates a higher percentage return (on the smaller capital requirement) for the containing spread strategy. The question then becomes whether it is worth putting in the extra capital (nearly $280 000 extra peak deficit at 6% or $300 000 at 10%) to get the extra return.

Discounted cash flow analysis of the cash flow differences between the broadacre herbicide and containing spread strategies indicate a return on additional investment of 13.8% by shifting from the second to the first strategy. If 13.8% is above the opportunity cost of the investor, then the broadacre herbicide strategy would be preferred over the containing spread strategy. Marginal NPV of the broadacre herbicide strategy over the containing spread strategy, calculated from the difference in cash flows, is $445 612 at 6%.

Implications for natural resource management agencies

Preventing invasion (Scenario 3) is clearly the best investment option of the three examined, with the best overall NPV at both interest rates. The preventing invasion strategy should be highly encouraged across regions, not only for weedy Sporobolus grass management but also for the management of other weeds. Only at an interest rate close to zero does the broadacre herbicide strategy (Scenario 1) produce an NPV approximately equal to that of the preventing invasion strategy.

Comparing the broadacre herbicide and the containing spread strategies on infested properties, the broadacre herbicide strategy would be considered the best investment since it produces the highest NPV, however, it does require approximately four times the investment of the containing spread strategy, and notwithstanding the favourable marginal return (IRR 13.8%) on moving up from the containing spread strategy to the broadacre herbicide strategy, the increased investment may be more difficult to finance. However, at the regional scale the broadacre herbicide strategy would be a worthy case for subsidisation relative to the containing spread strategy, since it eliminates the seed source rather than just suppressing the seed source with the ongoing risk of seed movement from the 'contained' infestations particularly

during floods and uncontrolled feral and native animal movement.

The investment scenarios analysed also have a benefit for neighbouring landholders, and indeed for the region as a whole through reduced potential for weed seed spread. Had the regional benefits been included in the analysis, the NPV and IRR would be higher, perhaps much higher, particularly where a property is a seed source 'hot-spot' (e.g. at the head of a catchment). An indication of the regional benefits is provided by the preventing invasion strategy (Scenario 3), where the most efficient investment to prevent invasion may have been to help control the weed in the neighbours' riparian zone.

These analyses highlight the substantial financial cost of managing weedy Sporobolus grass infestations and suggest there is a case for a public financial contribution to infested landholders to 'sweeten' the investment in control strategies on behalf of other landholders who will benefit from weedy Sporobolus grass management on the infested properties.

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