

## Assessing the financial implications of alternative investment options in weed control

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**Summary** A benefit-cost analysis (BCA) tool for assessing the attractiveness of government investment in long-term weed control within a catchment region or State has been developed. To demonstrate its use, the tool is applied in a partial assessment of the financial impact of Chilean needlegrass (*Nassella neesiana* (Trin. & Rupr.) Barkworth) to the beef and sheep/wool industries in the Corangamite region in Victoria over a 30-year period. The results of the partial analysis of benefits and costs of government-coordinated weed control strategies to these industries and the broader community are presented.

When applied in conjunction with economic surplus analysis, this tool is potentially useful in providing economic information on which to base allocation of strategic public investments in the management of pest plants at regional and State levels. The tool takes into account the likely year-by-year financial costs of weeds and their control at individual farms, industry and the broader community, thus alerting the analyst to a range of potential funders and partners and helping to avoid public funds ‘crowding out’ private investments.

**Keywords** Benefit-cost analysis tool, ‘weighting’ system, weed control, *Nassella neesiana*.

### INTRODUCTION

Simple economic tools that can provide information on the likely outcomes of invasive species management, e.g. pest plants and animals, play an important role in facilitating the resource allocation process either at the micro- (e.g. individual farms) or macro- (e.g. industry, community) level.

Social, environmental and economic outcomes that are positive are the targets of any public investment in weed management. For a given pest plant species, the relevant outcome to the broader community is the difference that the Government can make by investing in weed management. A BCA tool that can partially account for the difference between what could happen ‘without’ and ‘with’ weed management being coordinated by Government is presented.

### MATERIALS AND METHODS

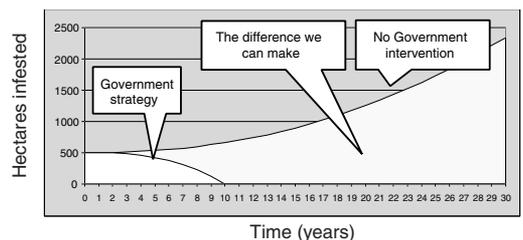
With new information being available, a BCA tool initially developed in a spreadsheet format in 1999 is applied in the partial analysis of the long-term financial

implications of public investment in the control of Chilean needlegrass (*N. neesiana*) in the Corangamite Catchment Management Authority (CMA) region in Victoria. Public investment in weed control largely occurs through the Department of Natural Resources and Environment (DNRE) funding of CMAs Weed Action Plans. The CMAs are charged with ensuring the protection and restoration of land and water resources among other functions.

The BCA tool uses predictions of potential weed distribution and rate of spread to indicate what could happen if no government intervention in that weed occurred. The difference in weed spread between a ‘do nothing’ scenario and the government investing in a 10-year weed eradication program is indicated by ‘the difference we can make’ portion of the graph (Figure 1). The strategy’s benefit would be indicated by the difference in (a) future costs of weed control on public and private land, and (b) production loss on private land, between the ‘do nothing’ scenario and the government investing in weed control through education, extension, monitoring, inspection and enforcement.

A general indication of the current level of *N. neesiana* infestation (ha) and the relative distribution of this weed according to major types of land use e.g., grazing and public lands (per cent of total land presently infested) in the case-study CMA region was extracted from the geographical information system (GIS)-based Integrated Pest Management System records (IPMS).

The best estimate of the maximum potential level of *N. neesiana* infestation in the case-study CMA region was obtained by utilising the weed distribution data from Australia and overseas, linked to climate



**Figure 1.** Difference in weed spread between the ‘without’ and ‘with’ government investment in weed control.

modelling susceptible land use, and vegetation classes (Figure 2). In particular, a climate-matching program that uses temperature and rainfall data from a set of geographical locations to construct a climate profile was used to indicate similar climatic regions in Victoria. This was then overlaid on susceptible land uses (grazing lands and vegetation types) to estimate the maximum potential geographical distribution of this particular weed (Weiss and McLaren 2002).

Economic data including gross margin (\$A ha<sup>-1</sup>) of grazing enterprises (e.g., beef, sheep/wool) in the case-study CMA region, cost of weed treatment by type of land use (\$A ha<sup>-1</sup>), and the yearly public investment associated with the coordination of weed control in the case-study region (\$A y<sup>-1</sup>) were used.

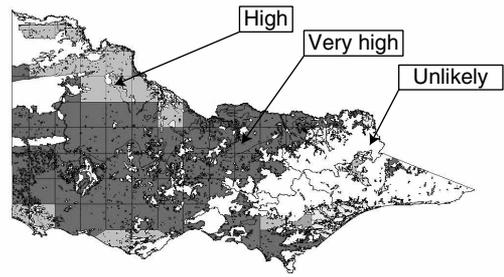
In this analysis a weed control strategy was ‘approved’ if the net present value (NPV) over the life of the investment is positive, that is greater than zero dollars. For cursory comparison, the benefit-cost ratios (BCRs) were also estimated. The BCR was computed by dividing the discounted dollar value of the potential stream of benefits by the discounted costs of the investment stream. The standard discounting technique was used to reduce a stream of benefits accrued or costs incurred over time to an equivalent amount of present day’s dollars. The NPV was calculated using equation 1:

$$NPV = \sum_{t=1}^T \frac{B_t - C_t}{(1+r)^t} \quad (1)$$

Where  $B_t$  is the benefit in year  $t$ ,  $C_t$  is the investment cost in year  $t$ ,  $r$  is the discount rate used to find the equivalent present value of sums receivable or payable in the future and  $T$  is the duration of the proposed weed investment. To remain consistent with BCAs done in Victoria, the discount rate used was 4% and the evaluation period was 30 years.

To account for the fact that *N. neesiana* is not the only weed species infesting grazing lands and public lands in the Corangamite CMA region, a ‘weighting’ system was followed. In this region serrated tussock (*Nassella trichotoma*) has been reported as the most established weed species (75,000 ha) along with six other species referred to here as ‘major’ weeds, and two relatively ‘minor’ species (have not yet established in at least 1000 ha) (Table 1).

The effect of this ‘weighting’ system is to make the estimation of the costs and benefits of controlling weed species likely to be co-located in the region to be based on the level of the weed’s current infestation (‘major’ or ‘minor’) – hence, their relative economic significance. A ‘major’ weed was assigned a weight factor ( $wf$ ) of 0.75 whilst ‘minor’ ones 0.25. A higher  $wf$  means the potential economic costs and benefits



**Figure 2.** Potential distribution of *Nassella neesiana* infestation in Victoria over 200 years. (Source: KTRI).

**Table 1.** Weeds of grazing lands and their current level of infestation in the Corangamite CMA region.

Weed species	Level of infestation (ha)
Serrated tussock	75,000
Cape tulip	1,000
Paterson’s curse	2,000
Ox-eye daisy	1,700
Gorse	4,000
St. John’s wort	1,000
Wild garlic	200
Blackberry	20,000
Chilean needlegrass	500

Note: Bridal creeper (1000 ha) and ragwort (38,000 ha) have also been assessed in this region as priority weeds specifically on public lands. Source: (IPMS).

associated with a weed species would be greater than those weeds with a smaller  $wf$  value.

The annual value of grazing land use potentially at risk from this particular weed (\$A ha<sup>-1</sup>y<sup>-1</sup>) was derived as ( $B_p$ ) in equation 2:

$$B_p = (1 - l)Y * P^v * (wf \div W) \quad (2)$$

where  $(1-l)Y * P^v = GM$

by substitution,  $B_p = GM * (wf \div W)$

where  $l$  is the yield loss rate due to the weed (%),  $Y$  is the yield potential of weed-free pasture i.e., dry sheep equivalent per unit area of land (DSE ha<sup>-1</sup>),  $P^v$  is output price (\$A DSE<sup>-1</sup>),  $GM$  is gross margin for the grazing industries in the CMA region in the presence of this weed (\$A ha<sup>-1</sup>),  $wf$  is the ‘weight factor’ assigned to a ‘minor’ weed and  $W$  is the summation of  $wf$ s assigned to seven ‘major’ weed species and two ‘minor’ ones likely to be co-located on grazing lands in the CMA region.

The annual control cost directly associated with *N. neesiana* (\$A ha<sup>-1</sup>y<sup>-1</sup>) was calculated ( $P^c$ ) using equation (3):

$$P^c = P^b * (wf \div W) \quad (3)$$

where  $P^b$  is the base cost of integrated weed control (\$A ha<sup>-1</sup>) i.e., spot spraying, extra cultivation, harrowing, fertiliser application and pasture sowing on grazing lands; and spot spraying, aerial herbicide application, and scarification on public lands,  $wf$  and  $W$  are as in equation 2.

Weed control strategies that were assessed and compared against the 'without' government intervention are 'total suppression' and 'containment' programs. One study (Gardener *et al.* 1996) has shown that any control method is unlikely to exhaust *N. neesiana* seedbank and eradicate this species in the long term. On this basis, the inclusion of the total suppression strategy as an option was made primarily for exposition purposes.

## RESULTS AND DISCUSSION

**Current and potential weed distribution** Indicative data on the present level of infestation and distribution of *N. neesiana* reported in IPMS records was extracted and then aggregated for the case-study CMA region. Based on infestation records, about 500 ha of *N. neesiana* currently occurs in the Corangamite CMA region. A great majority (98%) occurs on grazing lands and the rest (2%) on public lands.

Using Victoria's pest plant invasiveness model (Weiss and McLaren 2002), the suitability rating of an area to *N. neesiana* in Victoria was derived (Figure 2). The dark-shaded portions of the map indicate areas that are 'very highly' suitable *N. neesiana*, with the light-shaded and clear sections representing areas that are 'highly' and 'unlikely', respectively. The best estimate of the maximum level of *N. neesiana* infestation in the case-study region is about 1.7 million ha. Because the types of potential infestation i.e., 'scattered' or 'dense' could not be predicted with reasonable precision by the invasiveness model, the base-case assumption was that they are likely to be generally scattered. The likelihood of re-infestation from outside the CMA region was assumed to be fairly low (40%) thus, the future spread of this weed would generally be originating from where they are currently occurring in the region.

**Value of land use at risk** The average gross margin for grazing industries in the south-western region in Victoria (includes both Corangamite and Glenelg CMA regions) was used to derive the production value of private land use at risk from weeds. This is about \$A130 ha<sup>-1</sup>. The specific enterprises comprising the beef and sheep/wool industries in the case-study CMA region include vealer, store weaner, steer, bullock, fattening purchased steers, self-replacing Merino, Merino wether, first cross ewe, and Dorset over Merino ewe.

The estimated yearly production value of grazing land use at risk from this particular weed (or the

potential benefit of control)  $B_p$  is approximately \$A5.20 ha<sup>-1</sup> y<sup>-1</sup>:

$$B_p = (1-0.10) * 10 \text{ DSE ha}^{-1} * \$A13.25 \text{ DSE}^{-1} * (0.25 \div 5.75)$$

where 0.10 is the yield loss rate due to a 'scattered' *N. neesiana* infestation, 10 DSE ha<sup>-1</sup> is the yield potential of weed-free pasture, \$A13.25 DSE<sup>-1</sup> is product price, 0.25 is the 'weight factor' ( $wf$ ) assigned to a 'minor' weed and 5.75 is the summation of  $wfs$  assigned to seven 'major' weed species and two 'minor' ones likely to be co-located on grazing lands in the CMA region.

**Weed control cost** A recent national survey on *N. neesiana* (McLaren pers. comm.) has revealed graziers in Victoria incur an average of \$A50.25 and \$A157.15 ha<sup>-1</sup> to control 'scattered' and 'dense' type of infestation, respectively.

One recommended treatment of *N. neesiana* infestation is herbicide application (\$A123 for herbicide, \$A25 for contract sprayer) followed by sowing pasture seeds (\$A50 for pasture seed mix, \$A14 for contract sowing) and fertiliser spreading (\$A56 for fertiliser) (Gardener *et al.* 1996). This would cost graziers approximately \$A268 ha<sup>-1</sup> to implement.

For this case study, the base cost of integrated weed control applied on grazing land consisting of herbicide application (\$A165), cultivation (\$A5), fertiliser application (\$A20), pasture improvement (\$A26), scarification (\$A8) and harrowing (\$A2) is \$A226 ha<sup>-1</sup>. Following the 'weighting' procedure applied in the modelling, the 'adjusted' control cost directly associated with *N. neesiana* on grazing lands is about \$A9.80 ha<sup>-1</sup> y<sup>-1</sup>, that is:

$$\text{Control cost (adjusted)} P^c = \$A226 \text{ ha}^{-1} \times (0.25 \div 5.75)$$

where \$A226 ha<sup>-1</sup> is the base cost of integrated weed control applied on grazing land, 0.25 is the 'weight factor' assigned to a 'minor' weed and 5.75 is the summation of weight factors.

The adjusted on-ground weed control cost on public lands is about \$A17.90 ha<sup>-1</sup> y<sup>-1</sup>. The average yearly cost of coordination activities (e.g. education, monitoring, inspection, enforcement, extension) was derived by considering the CMA region's total yearly budget for one 'weed officer' (\$A73,900 y<sup>-1</sup>) and the 11 weeds that have been assessed as regional priority. The on-ground weed control cost on public lands and the average yearly cost of coordination represent the level of public investment to manage this weed.

**Weed management strategy** A 10-year weed total suppression strategy and a 20-year containment program (i.e., reduce infestation level from 500 ha to 50

ha) were assessed and compared with the ‘do nothing’ scenario (i.e., absence of government intervention). In the absence of public investment in a coordinated control of this weed, the potential level of infestation over 30 years would be about 10,400 ha with a total potential production loss to grazing industries valued at \$A851,194 (Table 2). This partial estimate indicates the likely economic cost of a minor weed species like *N. neesiana* to the beef and sheep/wool industries in this region.

**Investment costs and benefits** A 10% yield loss rate due to this ‘minor’ weed was assumed. This means a reduction in the average yield (DSE) for each ha of grazing land i.e., from 10 DSE ha<sup>-1</sup> to 9 DSE ha<sup>-1</sup> was possible. At this yield loss rate, the cost of control at farm level associated with *N. neesiana* outweighs the value of potential yield, thus a potential net loss to individual graziers of about \$A4.60 ha<sup>-1</sup>y<sup>-1</sup> (Table 2).

To eradicate this weed on grazing lands, a total industry investment of about \$A31,900 over 10 years would be required. The grazing industries in this CMA region would likely be better off by about \$A446,400 to \$A396,300 by jointly investing with Government in the total suppression or containment strategy, respectively. These present value of benefits (or NPV) are in terms of future control costs avoided and the potential yield loss saved over 30 years when this weed and the sources of re-infestation is controlled. These benefits could be delivered on the assumption that this ‘minor’ weed is controlled as part of an integrated pest plant control program targeting all major species that are likely to be co-located with it. A BCR of \$A14.95 per dollar of industry investment in total suppression strategy suggests that it is more economically attractive than an investment in a containment strategy (BCR of \$A8.30).

On the other hand, a \$A73,099 public investment in *N. neesiana* total suppression would deliver an NPV to the broader community of about \$A246,100 over 30 years and about \$A183,300 for an investment of \$A117 164 in *N. neesiana* containment program. A dollar of public investment in a total suppression strategy would deliver a \$A4.35 return (BCR) whilst the same dollar invested in a containment strategy produces a return of \$A2.55.

Overall, total suppression and containment strategies are both financially attractive for industry and public investment. Total suppression is financially more desirable for industry and public investment than containment strategy as the NPV of the former strategy outweighs the latter by about \$A50,000 (for industry investment) and \$A63,000 (for public investment).

Finally, the results provide some indications that

**Table 2.** Model results.

<b>Farm-level: Estimate of profit (loss), one year</b>	
Benefit of control (\$A ha <sup>-1</sup> y <sup>-1</sup> )	5.20
Cost of control (adjusted) (\$A ha <sup>-1</sup> y <sup>-1</sup> )	9.80
Net farm profit (loss) (\$A ha <sup>-1</sup> y <sup>-1</sup> )	(4.60)
<b>Industry-level: Partial investment analysis, 30 years</b>	
a. Total suppression strategy	
Industry investment (\$A)	31,984.00
Potential benefit (\$A)	478,447.00
Net Present value (NPV) (\$A)	446,463.00
Benefit-cost ratio (BCR) (\$A)	14.95
b. Containment strategy	
Industry investment (\$A)	54,005.00
Potential benefit (\$A)	450,313.00
Net Present value (NPV) (\$A)	396,308.00
Benefit-cost ratio (BCR) (\$A)	8.30
<b>Community-level: Partial investment analysis, 30 years</b>	
a. Total suppression strategy	
Public investment (\$A)	73,099.00
Potential benefit (\$A)	319,238.00
Net Present value (NPV) (\$A)	246,139.00
Benefit-cost ratio (BCR) (\$A)	4.35
b. Containment strategy	
Public investment (\$A)	117,164.00
Potential benefit (\$A)	300,466.00
Net Present value (NPV) (\$A)	183,302.00
Benefit-cost ratio (BCR) (\$A)	2.55

Note: Potential *N. neesiana* infestation (ha) over 30 years would be about 10,400 ha.

government-coordinated control strategies for a weed species would deliver varying levels of financial benefits to individual private landholders, industries and the broader community. The difference that government investment in weed control can make appears to be a function of a pest plant’s invasiveness, current level of infestation in the region (‘major’ or ‘minor’), likelihood of re-infestation, productivity of the land use where infestation occurs, and the control technology applied.

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