

Winning the lottery: return on investment from weed biocontrol programs

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Summary In >100 years of weed biocontrol in Australia, there have been few economic impact assessments of biocontrol programs. A recent economic impact assessment of all weed biocontrol programs in Australia, both successes and failures, since 1903 demonstrated annual benefits of \$95.3 million from an average annual investment of \$4.3 million, a benefit-cost ratio of 23:1. Benefits came from 17 successful programs, including two usually considered failures where small reductions in the weed problem resulted in large cost savings. The study demonstrated economic returns from partial successes, and the importance of baseline economic data prior to biocontrol programs.

Keywords Cost-benefit, success rate, economic impacts.

INTRODUCTION

In the 100 years since the first weed biocontrol in Australia, there have been very few studies of the economic impact of weed biocontrol. Dhileepan (2003) listed published evaluation studies from Australia, of which 32 reported impacts at plant level, 20 impacts at plant population level, but only three analysed economic impact. Internationally the situation is the same: a recent conference on benefits and risks of biological control contained only one paper on the economic framework for decision-making (Jetter 2005). Yet most weed biocontrol is funded by public money and competes for funding with other government programs. Cost-effectiveness of a control method justifies continued investment in it (Lodge *et al.* 2006). For example economic benefits from pre-introduction screening of plant imports is a justification for an expensive system of border controls (Keller *et al.* 2007).

Increasingly, risk assessment is used for policy decisions at all levels. This requires identification of hazard and benefits, followed by quantitative assessment of the probabilities of these risks (Sheppard *et al.* 2003). It is essential to know the probability that the return from a control program will exceed costs, in order to calculate the risk-weighted return from each control program, which can be used to prioritise resources within a region or state. (Note this is not probability of 'complete' success but only that benefits

will exceed costs). In risk assessment, probabilities are calculated from historic data. It is therefore important to include failures in the analysis, as only this can give real estimates of success rates while also including real benefits from partial successes. For weed biocontrol, it is necessary to measure all research-related costs from all programs undertaken, and assess this against all benefits gained. A similar analysis was undertaken for all programs of the Australian Centre for International Agricultural Research (Raitzer and Lindner 2005), and could be done for weed biocontrol on a country or state basis. Only thus can one calculate the true probability of a positive return on investment, as case studies of successes do not measure the probability of failure.

This overall approach tends to underestimate benefits, because costs are comparatively easy to determine, while benefits can only be calculated where both the baseline data to measure change has been collected and the impact assessments have been done. Benefits may also continue to increase after the assessment period, hence the approach is inherently conservative.

METHODS AND RESULTS

This paper reports results from a study by Page and Lacey (2006). A full description of the methods used can be found in their report. All amounts are in Aus\$ 2005 values.

There have been 36 weed biocontrol programs in Australia in the 100 years to 2004, but for three, although the biocontrol has been largely successful, data on costs or benefits could not be obtained.

Of the 33 programs with economic data, no agent was ever released or established in five. Economic benefits were zero in a further four where established agents proved ineffective. All remaining programs returned economic benefits. In three (alligator weed *Alternanthera philoxeroides* (Martius), groundsel bush *Baccharis halimifolia* L. and *Sida* spp.), successful control of the weed was achieved but the b/c ratio was <1 because the economic impact of the weed was small. For some others where the b/c ratio is <1, benefits are still increasing and the assessments may be premature.

For seventeen programs, economic benefits exceeded costs. Thirteen resulted in very large economic benefits – prickly pear (*Opuntia* spp.), but also ragweed *Ambrosia artemisiifolia* L., nodding thistle *Carduus nutans* L., skeleton weed *Chondrilla juncea* L., rubber vine *Cryptostegia grandiflora* R.Br., Pater-son's curse *Echium plantagineum* L., harrisia cactus *Eriocereus martinii* (Labouret), giant sensitive plant *Mimosa diplotricha* C.Wright ex S.M., *Onopordum* thistles, parthenium weed *Parthenium hysterophorus* L., the three water weeds salvinia *Salvinia molesta* D.S.Mitchell, water hyacinth *Eichhornia crassipes* (Mart.) and water lettuce *Pistia stratiotes* L., ragwort *Senecio jacobaea* L., and Noogoora burr *Xanthium occidentale* Bertol. Surprisingly, the programs against lantana *Lantana camara* L. and blackberry *Rubus fruticosus* L. agg., although not generally considered successes, returned b/c ratios >1 because the losses due to these weeds are so great that small proportional reductions are worth a great deal. Conversely, successful control of bridal creeper *Asparagus asparagoides* (L.) Druce did not bring large economic gains because as a weed of natural ecosystems the direct financial costs are small.

Program costs also varied greatly, as some continued over decades, with years of overseas research and employment of many scientists. The most expensive was *Mimosa pigra* L., with a total cost of \$21.6m. The cheapest successful program was annual ragweed at a cost of \$0.6m, which was low because successful agents were imported against the closely related parthenium weed. Median cost for the 17 successful programs was \$7m and duration 14 to 27 years therefore governments should not expect good results from short-term or small programs.

The overall benefit-cost ratio was 23.1 for the 28 programs where data could be analysed, an astonishing result. As expected, benefits from the control of the prickly pears were enormous, with a net present value of \$3100m and a b/c ratio of 312, even though only data from the Darling Downs in southern Queensland were used in the calculations. This rich agricultural area was almost totally unusable due to prickly pear until after the impact of cactoblastis in the early 1930s. The inclusion of benefits from infested land in central and north Queensland and in New South Wales might double the measured economic return. However, even if the prickly pear success is excluded, the overall b/c ratio is 12.3, and of the total 36 programs (including those where economic analysis was not possible) only nine failed to return economic benefits.

DISCUSSION

Two major messages from this study were the large benefits from partial control of the widespread weeds lantana and blackberry, and the overwhelming importance of documenting the economic costs of the target weed at the start of a biocontrol program. The key issue is to quantify the economic costs of the target weed at the start, so that the benefits from any reduction in its abundance can in turn be quantified. This is best done as an *ex-ante* benefit/cost study by independent economists prior to starting any biocontrol program and made part of the decision process (Jarvis *et al.* 2006). Such analyses clarify where data are not available, as well as identifying the critical outcomes. Assessment must measure the reduction in the weed's harmful impact, i.e. the initial state prior to biocontrol must be properly recorded. For most weeds, even non-production impacts have an economic aspect – if control was cheap or easy, the community would not permit weeds to overrun environmental areas. Economic impact is the sum of many factors: loss of agricultural productivity; actual and potential extent of infestation; spread rate; cost of removal; and frequency of recurrence. Initial measurement of these is essential to make future assessments possible. Analyses can be repeated when more information is available (e.g. whether suitable agents can be found; spread rate of weed). *Ex-ante* studies, using realistic probabilities of success based on historic rates for the country and type of weed, and including the full range of potential costs and benefits, are powerful tools to convince funding agencies. Later *ex-post* analyses based on these data will clarify the true probabilities of failure and therefore return-on-investment for weed biocontrol.

Another issue is the level of scientific proof required. A recent discussion on the assessment of biocontrol in greenhouse crops questions the need for quantitative data from replicated field experiments published in a peer-reviewed journal versus evidence of economic returns from reduced industry use of pesticides (Collier and Steenwyk 2006, van Lenteren 2006). Economic analyses for policy purposes are rarely published in peer-reviewed scientific journals. The Stern Review 'The economics of climate change' was released as a government document in 2006, and not published hardcopy until 2007, and the Raitzer and Lindner (2005) review was published by ACIAR in their Impact Assessment Series.

A related issue is the level of proof required. Detailed scientific studies demonstrate impact in small-scale plots (e.g. Dhileepan 2001) but not landscape-scale reduction in weed costs. Independent economic measures, or properly-conducted end-user surveys

(e.g. Ireson *et al.* 2007), demonstrate cost reductions over several years, but lack proof that this is due to biocontrol. Ideally, there should be both detailed in-field evaluations and independent evidence of end-user cost savings. However, it is much cheaper to start with end-user results, e.g. the reduction in livestock deaths from the ragwort biocontrol program in Oregon, USA (Coombs *et al.* 1996). A dramatic 20 year fall in livestock deaths from pyrrolizidine alkaloid poisoning was used to calculate a 15:1 benefit cost ratio and annual benefit of \$5m. Correlative analysis based on industry-wide data is widely accepted as scientifically valid for policy decisions such as health interventions (e.g. Productivity Commission 2005), and is also valid for biocontrol.

The key messages are: biocontrol is a very cost-effective method with excellent returns-on-investment; and organisations undertaking biocontrol must collect adequate economic data at the start of programs and throughout.

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