Economic evaluation of biological weed control

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Summary

The existence of spillovers and new legislation makes it important to evaluate the economics of biologically controlling weeds in Australia before embarking on control. Classical biological weed control has been widely used in Australia with considerable success as measured in different ways, including high rates of return on R&D costs. Cost-benefit analysis has been used to evaluate the biological control programme for skeleton weed, *Chondrilla juncea*, and gave a benefit/cost ratio of 200 : 1. A recent inquiry by the Industries Assistance Commission into the biological control of *Echium* species suggested a benefit/cost ratio of about 10 : 1. Room exists for improvement in the IAC's method of evaluation. Also, the CSIRO's (economic) test of whether a classical biological weed control programme is effective is found to have some deficiencies. Particular improvements are suggested.

Introduction

Most weeds of economic importance in Australia are introduced plants and are often amenable to biological control by natural predators or competitors from their country of origin (Groves and Cullen 1981). But the importation of biological control agents can have a range of environmental, economic and social consequences, not all of which may be favourable or foreseen. While some members of the community may gain from introduction of a control agent, others may lose. Care is needed given the likely irreversible nature of introductions, the difficulties in containing populations once released and the possibility that a control agent may prove, on balance, to be a pest.

Prior to the Biological Control Act (1984) the public had little input into decisions about biological weed control in Australia. Evaluation tended to be the in-house business of the Department of Health administering The Quarantine Act (1908) and the CSIRO in consultation with the Australian Agricultural Council and other organizations importing biological control agents, e.g. The Alan Fletcher Research Station and The Keith Turnbull Research Institute. The Biological Control Act (1984) sets out procedures to be followed for declaring target organisms and agent organisms for biological control. The Act establishes the Biological Control Authority. This Authority must inform the public of any proposal to declare a target organism or agent, and call for submissions. When, after examining submissions, it appears that there could be adverse environmental or personal effects from biological control, a public inquiry may be held. This may be undertaken by the Industries Assistance Commission or by other specified bodies. The first inquiry under the Act, the biological control of *Echium* species, was conducted by the Industries Assistance Commission (1985).

The report of the inquiry is then considered by the Biological Control Authority. The Authority may declare target organisms and agent organisms for biological control if it is satisfied on the basis of the report that the target organism is causing harm; is likely to be controlled by biological means; that 'control throughout Australia of the target organism would not cause significant harm to the environment and/or persons'; and any harm caused (losses or costs imposed) by biological control throughout Australia would be significantly less than the benefits obtained (Industries Assistance Commission 1985). These conditions allow for considerable elasticity of interpretation, particularly terms such as 'significantly less than'. However, as a number of inquiries are completed, precedents will be established. The first inquiry, into the biological control of *Echium* species, used cost-benefit analysis as a means of providing guidance to the Biological Control Authority and this approach to evaluation will be considered below. In any case, the Biological Control Act means that greater emphasis must be placed upon prior economic evaluation of biological weed control than in the past.

Types of biological control

Biological control of weeds may be of the classical type, augmentative or inundative (Tisdell *et al.* 1984*a*, Industries Assistance Commission 1985). Particularly, in the case of classical control, government involvement in the release or non-release of the biocontrol agent is called for on economic grounds (Tisdell *et al.* 1984, Menz *et al.* 1984). Primarily this is because of 'spillovers' from the introduction of a biocontrol agent. Persons not introducing the agent may benefit or be damaged by the introduction because of the mobility and spread of the biocontrol agent. Such favourable or unfavourable spillovers will not be taken into account by individuals because individuals are likely to act in their own self-interest. No individual may find it personally worthwhile to introduce a biocontrol agent even though its introduction would be a net benefit to the community. Conversely, an individual may on occasion benefit from his/her introduction of a control agent though, on balance, it damages the community. Thus there is a need for government evaluation and action.

In addition, decisions involving both economic and ecological factors have to be made about where to release a biocontrol agent, how to assist its establishment and whether to foster its spread and when to augment its population, if at all. These decisions may hinge to some extent on equilibria relationships between the weed (the host) and the biocontrol agent (the predator) (Auld and Tisdell 1985). In some areas, for instance, it may be desirable to maintain a minimum reserve of the weed population so that its host can maintain a viable population.

Biological weed control in Australia and its value

Classical biological weed control has been widely and successfully used in Australia and augmentative control is adopted for some weeds, e.g. for *Opuntia aurantiaca* Lindley, tiger pear, controlled by *Dactylopius austrinus* De Lotto, cochineal, in central western New South Wales (N.S.W. Government Printer 1967). Inundative biological control of weeds has not been used in Australia but fungal pathogens appear to be promising in this respect (Quimby and Walker 1982, Bowers 1982) and research into these is being undertaken in Australia.

Classical biological weed control in Australia has been successful since the programme was implemented in 1926 to control prickly pear, *Opuntia* spp. (*cf.* Haseler 1980). Of 18 weeds in Australia targeted for biological control, only three (*Xanthium occidentale*., Noogoora burr, *Emex spinosa* and *Emex australis*) showed no response to biological control (Burdon and Marshall 1981). At least five species were completely controlled and substantial control was obtained of at least another five species, as interpreted by Burdon and Marshall (1981) from reports in the literature.

The success achieved with biological control may be measured in several ways. For example, by the reduction in the population of the targeted species or the decline in its rate of spread, by its increased susceptibility to control by non-biological means or by the level of increased economic returns achieved. Menz *et al.* (1984) have suggested that a biological weed control programme for the southern wheat–sheep zones of Australia costing between $1 m and $3 m could easily have a benefit/cost ratio of between 5/1 and 14/1. Marsden *et al.* (1980) estimated that on an outlay of $2.6 m for the biological control of *Chondrilla juncea* L., skeleton weed, the benefit/cost ratio was almost 200/1. This could, however, be an overestimate since some forms of *Chondrilla juncea* have proven to be resistant to released strains of the fungus *Puccinia chondrilla* (Groves and Cullen 1981). On the other hand, even when the rust *P. chondrilla* did not kill skeleton weed, it reduced its vigour and hastened its decline when cultivated or subjected to competition from subterranean clover (Groves and Cullen 1981). This raises the possibility that even where a biocontrol agent does not significantly reduce the population of a target weed but reduces its vigour, it may be of economic value by increasing the effectiveness of non-biological controls or reducing their cost (*cf.* Harris 1980).

Cost-benefit analysis and the case of Echium *spp.*

The social cost-benefit analysis of techniques of weed control can be complex (Auld *et al.*, in press). Under some conditions, the net change in incomes received by farmers may be taken as a measure of the benefit, if it is assumed that no significant benefits are passed on to consumers through price reductions or quality improvements in products. If, after appropriate discounting for time-flows, increases in net incomes exceed additional costs of biological control, net benefits are positive and this gives some economic support for the control measure, the support being greater the larger the ratio of benefits to costs. This was the basic approach taken by the Industries Assistance Commission (IAC) in evaluating the biological control of *Echium* spp. (including Paterson's curse/salvation Jane). The Commission estimated a most likely benefit/cost ratio of 10.5/1 (Industries Assistance Commission 1985).

The main discounted costs are seen by the IAC (1985) as loss in income from beekeeping ($10.4 m), loss of income to crop industries because of reduced crop pollination ($1.4 m) and research and implementation costs of CSIRO and State Governments ($3.0 m) amounting to a total cost of $14.8 m. The main benefits were estimated as an increase in income in livestock industries of $131.9 m, increased income to crop growers of $19.1 m and savings in *Echium* control costs by public authorities of $4.5 m, making a total benefit of $155 m. However, it is unusual to evaluate the benefit/cost ratio in this way. It would be more usual for benefits to be calculated by deducting the reduced income of beekeepers, together with that from reduced crop pollination, from increases in net income elsewhere in the economy. If this is done, the relevant benefit/cost ratio becomes almost 48/1.

Some confusion appears to have crept into the IAC analysis. It ought to be concerned with evaluating the return on research and implementation costs of biological control, i.e. the investment in control measures (*cf.* Wise 1977). There is no economic ground for including industry losses as part of the investment even though the procedure does bring attention to the potentially worst-affected industries. This could, however, still be done without confusing the issue. Again, if net losses are imposed on graziers in low rainfall areas by *Echium*, why net out their losses from increased income for graziers in higher rainfall areas as the IAC does? (IAC 1985.) There is an internal inconsistency in its procedure. If the same approach were adopted as for the crop industries, the IAC's benefit/cost ratio would fall below 10.5.

Despite such issues, aggregate net benefit in relation to cost of biological control of *Echium* species is likely to be high. Nevertheless, we need an improvement in the education procedures used by the IAC and better delineation by it between aggregate or overall impacts on incomes or returns, and income distributional consequences.

CSIRO's view of the effectiveness of a classical biological control programme

CSIRO considers biological control to be effective only when it reduces the density of the targeted weed to a level below the 'economic threshold' and so makes other forms of control unprofitable (IAC 1985). While this is a necessary condition for economic gain from biological control in some circumstances, it is not a requirement for economic gain in other circumstances. A gain from the biological control may arise because it increases the kill rate of the non-biological weed control or lowers the cost of achieving a particular kill rate as, for example, suggested for skeleton weed by Groves and Cullen (1981). Moreover, when the cost of controlling a weed by non-biological means rises with its density, biological control may reduce densities from a level at which control is unprofitable to a level where non-biological control becomes profitable. In all these instances non-biological control may continue to be profitable after a biological control programme is implemented. Biological control has an economic benefit despite the dictum of CSIRO (*cf.* Harris 1980). For the traditional type of threshold model in which cost of non-biological control of weeds per unit area is constant (Tisdell *et al.* 1984), the view of the CSIRO does seem well founded provided the cost of non-biological treatment is not reduced or its kill rate raised by the biological control.

Conclusion

The economic evaluation of biological weed control using cost-benefit analysis is a complex task which has assumed increased significance in Australia as a result of the Biological Control Act (1984). While substantial benefits in relation to costs have been obtained and are achievable from biological weed control programmes in Australia, economic evaluation methods and tests adopted by bodies such as the IAC and CSIRO require improvement. Ways to improve these have been outlined.

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