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WHEN DOES INVESTING IN CLASSICAL BIOLOGICAL CONTROL RESEARCH MAKE ECONOMIC SENSE?

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ABSTRACT

A simple model is presented which calculates the expected net benefits of classical biological control projects. Estimates of project cost, length, chance of success, and the time value of money are used to calculate the potential benefit necessary to economically justify investment in a typical project. The potential benefit is about $62 thousand per year. The effects of changing key model parameters on the level of the required benefit are explored.
Resumen

Se presenta un modelo el cual calcula los beneficios netos esperados de los proyectos de control biológico clásico. Se estima el costo del proyecto, la duración, el cambio de éxito y el valor del tiempo utilizado para calcular el beneficio potencial necesario el cual justifica la inversión en un proyecto determinado. El beneficio potencial es alrededor de $2 mil dólares por año. Se exploran los efectos del cambio de los parámetros claves en este modelo.

It is generally acknowledged that investment in classical biological control (CBC) has paid for itself many times over. For example, Cate (1990) states that “... over the long term benefit/cost ratios are very high, $30/$1 when averaged across all attempts. This is the highest of any pest control approach.” Simmonds (1967), Simmonds & Bennett (1977) and Norgaard (1988) provide examples of CBC projects which have yielded spectacular benefit/cost ratios.

Most of the benefit/cost ratios reported in the literature have been conservatively estimated. They include as benefits the costs of pesticide treatment and insect damage avoided by the use of CBC, but do not attempt to quantify whatever environmental and human health benefits may arise from reduced use of pesticides. In situations where these latter benefits are important but not estimated, the actual benefit/cost ratios are higher than those reported.

It seems clear that overall, past investments in CBC research have yielded excellent returns. However, for a decision maker concerned with allocating research money, the question is not how well old projects paid off, but which projects to fund next. An evaluation of the likely net benefits associated with different projects should be an important part of the funding process. This paper describes a simple model that can help make the evaluation.

We illustrate the model for CBC projects involving entomophagous insects. Values for the model parameters are taken from the literature and used to estimate how large potential benefits must be to justify a typical project economically. Finally, we examine the effect of changing key parameters on the size of the required benefit. The values we derive are for illustrative purposes only and will not be the same for a project with different parameters.

We want to emphasize that economics is only part of the decision process. If entomologists do not believe a proposed project is biologically viable, then an economic analysis is certainly pointless. Therefore, when we write about the economic feasibility of a project, we are taking for granted that entomologists have already decided that the project is biologically appropriate.

Methodology

Our analysis is based on one of the few propositions that economists agree on - namely, that the benefits of a project should be greater than the costs. The method of determining whether or not this is likely to be the case will vary depending on the desired complexity of the analysis and the data available. We chose seven factors to consider in our model - project cost, the distribution of that cost over time, project length, chance of success, the time value of money, the benefits of success, and the distribution of benefits over time. The approach is an application of classical net present value analysis, described in Levy & Sarnat (1990).
Model Description

For a project expected to yield full benefits immediately upon completion,

\[
\text{Expected Benefits} = P \left( \frac{B}{R} - \sum_{N=1}^{M} \frac{1}{(1+R)^N} B \right)
\]

where \(P\) is the probability of project success, \(0<P<1\), \(B\) is the (assumed constant) annual benefit of success in dollars, \(R\) is the time value of money, and \(M\) is the project development time in years, indexed by \(N\).

The expression \(B/R\) is the net present value of the benefit \(B\) received in perpetuity. Of course, \(B/R\) is not likely to be identical forever. If prior knowledge about the distribution of benefits into the distant future exists, it should be used, though doing so would necessitate changes in this term. We use the simplest case to avoid additional mathematical clutter.

Because successful CBC projects take time to complete, it is necessary to account for the time lag between project initiation and the time when the project begins to yield benefits. The second term in the expected benefits expression merely subtracts the discounted value of benefits that will not be received during project development.

Even successful projects do not usually yield their full benefits immediately. Instead, benefits build up over time. Therefore, most of the analysis done in this paper uses the following expression for expected benefits, which allows for the buildup of benefits over time:

\[
\text{Expected Benefits} = P \left( \frac{B}{R} - \sum_{N=1}^{M} \frac{1}{(1+R)^N} B - \sum_{S=1}^{D} \frac{(D-S)B}{(1+R)^{M+S}} \right)
\]

where \(D\) is the period of years over which benefits build to their final level, \(S\) is the number of years after widespread release of the control agent, and all other terms are defined as before.

We have chosen a linear delay term, and though other forms could have been used, our results suggest that they would not have made much difference. As time passes, the delay term subtracts a decreasing fraction of the annual benefit from the expected benefits expression. For example, given a 5 year project and a 10 year delay, 90% of the annual benefit which would have accrued during year 6 is subtracted from the benefits expression. Eighty percent is subtracted from year 7, 70% from year 8, and so on until no subtraction is made for year 15.

We developed three different expressions for the net present value of project costs. The first is for costs which are spread evenly over the development period:

\[
\text{NPV Costs} = \sum_{N=1}^{M} \frac{1}{(1+R)^N} C
\]

where \(C\) is the total expected cost of the project, and \(M\) is defined as before.

We also allowed for the possibility that project costs could be skewed toward the beginning (front loading) or end (end loading) of the development period. For end loaded costs, our expression for the expected net present value of cost is
\[ NPV \text{ Costs} = \sum_{N=1}^{M} \frac{1}{(1 + R)^N} \frac{2NC}{M^2 + M} \]

where all terms are defined as before.

This expression is admittedly arbitrary - it was chosen because it spreads project costs so that costs in year \( N \) are \( N \) times as great as those in year 1. This skews costs considerably, which allows the effects of cost skewing to be explored. The front loading analog to the previous equation is

\[ NPV \text{ Costs} = \sum_{N=1}^{N} \frac{1}{(1 + R)^N} \frac{2(M - N + 1)C}{M^2 + M} \]

The expected benefit and cost expressions of interest can be combined, subtracting the latter from the former, to obtain an equation for the expected net benefit of undertaking the project. The values for any of the factors can be changed to determine their effect on the expected net benefit.

No model is perfect, and this one is certainly no exception. However, we believe that our model can give valuable insight into the economics of CBC projects, even if its particulars would have to be changed to evaluate specific projects.

Evaluating a CBC Project Using Entomophagous Insects

The model was set up using a spreadsheet program. The program was designed to tell us how large the annual benefit of success has to be in order to justify a project economically, given estimates of project cost, project length, chance of success, and the time value of money.

We obtained estimates of these factors for CBC projects involving entomophagous insects. Project cost ($298,000 and $461,000) and length (4 to 7 years) estimates are from Djerassi et al. (1974). The cost estimates have been adjusted for subsequent inflation. We chose 5 years as our typical project length, though analysis was done with 4 and 6 year development times in order to determine the effect of changing project length.

The time value of money was set at 3 percent annually. This rate is intended to be a reasonable estimate of the inflation-adjusted interest rate the U.S. government has typically paid to borrow funds, though this figure changes constantly and differs according to the term of the note.

The success rate figure (0.16) is from Hall et al. (1980). They report widely different success rates for different insect orders and different situations, which is a good reason why these typical values cannot normally be applied to specific projects.

By success, we mean achieving complete control of the pest - such that it is no longer an economic problem. Of course, many projects achieve partial success - but without more information we have no idea how much to compensate for that. As a result, the values we report are somewhat higher than the figures that would result from taking partial successes into account.

Finally, we created a base-case using the $293,000 cost estimate spread evenly over a 5 year project length, 16% chance of success, 5 year benefit delay, and a 3% interest rate. From that base, we calculated the effect of changing each of those factors individually on the size of the annual benefit required to economically justify the project.
RESULTS

Analysis of the base case scenario indicates that benefits need to be about $62 thousand per year to justify investment in our “typical” CBC project economically. For the higher project cost estimate, the required benefit is about $97 thousand per year. These figures, and those which follow, are probably high because we did not take the potential benefits of partial success into account.

Figure 1 shows the effect of four of the key variables on the required benefit. The intersection of the lines represents the base case. Each line represents the effect on the required benefit of changing one key parameter at a time. We show each parameter being changed plus or minus 20 percent of its base case value. Only the lower project cost estimate is shown, since the results are similar for the higher estimate.

The single downward sloping line shows the effect on the required benefit of changing the probability of success while leaving project cost, project length, and the time value of money unchanged. As expected, the line is downward sloping - the greater the chance of success, the smaller the benefit needs to be.

The interest rate and project cost lines slope upward - the more expensive the project or the funds, the higher the payoff needs to be. The nearly horizontal line shows the effect of spreading the project development time out - and here the line slopes upward, but only slightly.

The required benefit is not changed substantially by changes in the benefit delay. If benefits are assumed to accrue immediately after project development, the required benefit is about $58 thousand per year. Doubling the benefit delay to 10 years increases the required benefit to only about $66 thousand per year.

Fig. 1. Changes in key parameters and their effect on the required benefit.
Insect Behavioral Ecology - '92: Habeck et al.

The same holds true for front or end loading of development costs. The required benefit rises to about $63 thousand per year with front loading of costs, and falls to about $61 thousand per year with end loading.

DISCUSSION

Our model is a simple one and, though it ignores the possibilities of partial success, multiple introductions, and discontinuous project development, we think it produces interesting results. For example, the analysis suggests that CBC projects are typically worth undertaking when the benefits of success are something less than $62 thousand a year. The amount is likely to vary widely according to the characteristics of individual projects, but the figure is so low that many economically important pests would meet the necessary economic criterion.

The analysis also suggests that the probability of success, the time value of money, and project cost are all relatively important in determining what the required benefit is. Project length, benefit delays, and cost skewing are relatively unimportant.

If necessary, the model can be modified to evaluate specific projects, producing estimates of expected net benefit. These estimates could then be used to rank potential projects. Alternatively, they could be combined with project cost estimates to calculate expected benefit cost ratios, which could then be used for ranking projects.

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