Manaaki Whenua
Landcare Research

TECHNIQUES FOR ASSESSING THE IMPACT OF BIOCONTROL AGENTS

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Why measure the impact of biocontrol agents?

An important component of all biological control projects is assessing the impact that biocontrol agents have on their target weeds. Proof of impact is needed to back up anecdotal evidence or hearsay that agents are doing a good job and provide justification for continued investment in biological control. Identifying where agents are doing an inadequate job is equally important so that additional agents can be sought to strengthen the attack or alternative control methods developed.

Where do I start?

Before you can begin to assess the impact of either a single biocontrol agent or the combined impact of several agents you must first monitor to check that they have established (see *Guidelines for keeping track of biocontrol agents*). Only once agents are well established in good numbers, should you proceed further.

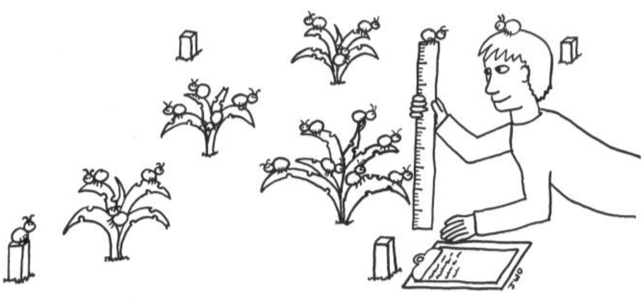
Key considerations

A range of assessment techniques are available, depending on what question you want to answer. Each technique has pros and cons, and all can be technically challenging. The most difficult parts are often designing the trials and analysing and interpreting the data collected. Suitably experienced and skilled people are also needed to apply treatments, make measurements and take photos consistently over many years.

For data to be useful, adequate randomization and replication is essential. Weeds grow across a wide geographic range and are subjected to many different management regimes, so data collected on one property may not adequately reflect the situation on a neighbouring one, let alone in another region. There can also be considerable variation in weed populations from year to year (especially annuals and biennials), so data need to be collected over several years which adds to the cost. Sites also need to be secure enough that assessment can be carried out for as long as needed.

It is most useful to assess all the agents released against a target weed collectively, but this is considerably more difficult than measuring the impact of a single agent, and it may be many years before all agents for a target weed are well enough established to make this feasible.

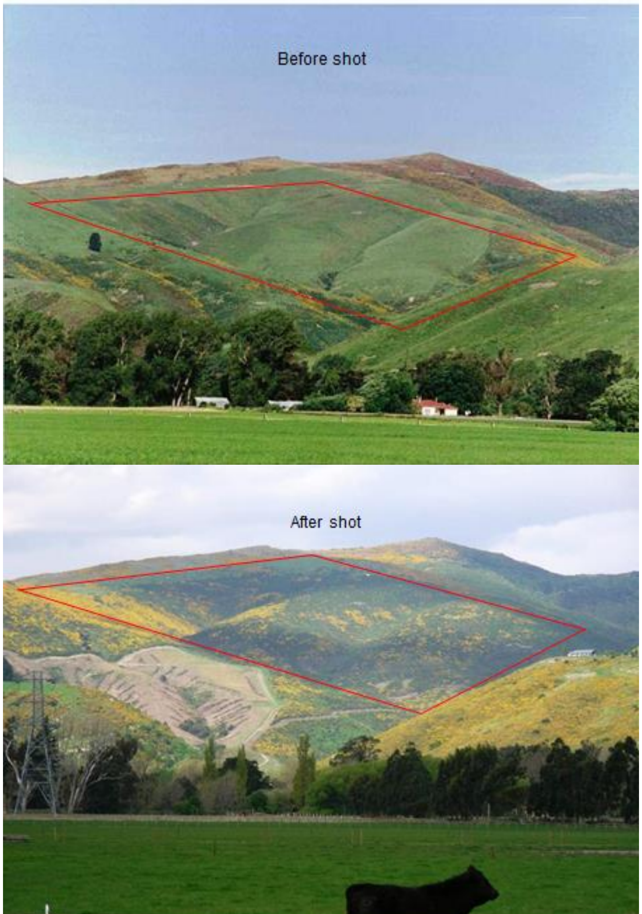
Ideally, we need good information about the target weed's distribution, abundance, population dynamics, and also economic data such as the cost of control at the outset of a project, but this is rarely available. For most weeds, we do not know the threshold of damage that needs to be achieved for a weed to decline. Also, our knowledge of how ecosystems function and respond to change is incomplete, and without this knowledge impact assessment data may not enable us to make useful predictions and assumptions. However, despite these limitations it is still often possible to collect useful data using the various techniques described below.



Techniques that only provide a correlation

A correlation is when two things follow similar (positive correlation) or opposite (negative correlation) patterns of change but one does not necessarily cause the other. Many correlations occur because a third factor causes the other two to change. For example, photos or data from long-term monitoring may show that ragwort declines soon after ragwort flea beetles (*Longitarsus jacobaeae*) have been released at a site. The beetles may indeed be responsible for the decline, but so do many other factors such as improved pasture management. Generally, data that are used to provide a correlation are not considered powerful because they do not prove cause and effect. However, if the data are collected at many sites or over many years, then the probability of actual cause and effect may be greater. Also, if the effect is only observed where the agents are established, this increases the likelihood that they caused the effect.

Taking a series of photos or measures of the abundance, biomass, density or height of a weed infestation and the presence or absence of control agents are examples of the simplest assessment techniques that can be used. If you do this at a lot of sites for many years (the longer, the better), then you may be able to demonstrate some convincing trends; for example, a weed declines in areas once biocontrol agents become established and gets worse in areas where the agents are absent. You need to be careful about what claims you make about this data as you have still not proved impact.



Assessment photos where gorse is measured inside a designated area using software as covering 12% of the assessment area in the top photo and later becoming 88% cover of gorse and broom.

Photos

A series of 'before' and 'after' photos can provide a dramatic visual record and can be taken quickly and cheaply. Be sure to take pictures from exactly the same place. Set up clearly marked photo points and include permanent landmarks or other features where possible (it is a good idea to have 'before' photos with you to refer to when taking 'after' shots). You should take photos at the same time of the year because, for example, a site photographed when an annual weed is flowering over the summer will look dramatically different to the same site photographed during winter.

An example of 'before' and 'after' photos. Note the importance of using several permanent landmarks. The shelter belt got chopped down, but the marker post could still be found ensuing reasonable alignment later.

Be aware that it may take many years for changes to infestations (especially for long-lived plants) to become obvious, and that a set of photos taken over a long period is likely to be more convincing than a single 'before' and 'after' shot. Be careful what claims you make about your photos. They are not proof of impact and are best used in conjunction with more rigorous assessment techniques. As a minimum, you should be able to demonstrate that control agents were actually present during the period that a weed infestation declined. Software is available that allows us to go a step further and rapidly assess changes in photos over time using randomly allocated sample points which are then scored.

For photos to be suitable for assessment, one of the most important considerations is angle or pitch. You need to be able to see all the weeds in your photo to sample them so oblique shots do not really work. You need to try to get some elevation or photograph plants on steep slopes. Some other issues include: poor focus, obstruction (one plant obscuring another), poor resolution (makes it had to identify plants), shadows (caused by strong sunlight on an angle), confusion between species, no landmarks (hard to define a sampling area) and distance shots where again identification of the subject of the sample point is difficult. Ground truthing may be needed to resolve these issues.

Techniques that demonstrate cause and effect

Control agents may severely damage or kill individual plants, which in turn can cause weed populations to decline over time. You can assess both processes.

How do we assess damage to individual plants?
You can show what impact control agents are having on individual plants (see *Case Study: How damaging is gorse spider mite?*). To do this, you need to make a series of measurements that compare the growth of plants under attack with plants free from attack, while keeping all other variables the same. The more sites you make these measurements at and the more years you repeat them, the better the information will be. You must measure several plants (usually the more, the better) at each site, each year. The information collected from studies on individual plants is especially useful when developing mathematical models (see below). What it still doesn't tell you is the consequences of this damage for weed populations, and this is usually the most important question that needs to be answered.

How do we assess damage to weed populations?
There is no quick and simple way to measure what impact agents are having on weed populations. The best way to get this kind of information is by carefully running specially designed experimental trials. A good way to do this is to set up replicated plots that are as identical as possible in every way except for one variable, the presence or absence of control agents. For long-lived weed species like gorse and broom, which also have substantial seed banks, mathematical modelling techniques may be better (see over page). These kinds of experimental trials are most suited to short-lived species like ragwort and most thistles. The two most common techniques used are described below:

Case Study: How damaging is gorse spider mite?
The impact of gorse spider mites (*Tetranychus lintearius*) has been assessed at a site near Lincoln by comparing shoot growth on bushes that had either never been attacked, been attacked for 1 year, or attacked for 2 years in succession.

Damage in year 1	Damage in year 2	Average shoot growth in year 3
No	No	35 cm
No	Yes	16 cm
Yes	No	22 cm
Yes	Yes	5 cm

This study found that shoots normally grow about 35 cm per year at this site. This growth was halved if bushes were attacked by a sizeable mite infestation. Usually, a mite outbreak is not sustained, allowing the plants to recover the following year. However, if the attack was sustained, the bushes hardly grew at all, and many shoots died. This study tells us that bushes attacked by mites are smaller than they would have been if the attack had not occurred. If the attack is sustained, then plants are considerably weakened and may die.

Add control agents and show that the weed population suffers
If the agents are not yet widespread, then you can set up your plots, collect some baseline data about the weed infestation, add your control agents to half the plots, and then measure subsequent changes. These trials take several years to run as you should have at least 1–2 years of baseline data and then at least another 2 years of data once the agents are added. Problems can arise if the agents disperse into control' plots during the experiment'.

Remove control agents and show that the weed population recovers
If the agents are widespread, you should aim to remove them from half of your plots using a suitable insecticide and measure subsequent changes. You can gather useful information in this way in as little as 1–2 years, but the protocol used needs to be carefully thought out and tested so that the insecticide used does not have other serious unintended effects e.g. you must know that it does not affect the plant (other than by removing the agent), and that it does not kill pests that are damaging other plants that compete with the weed. You also need to check that the insecticide does remove the agent that you wish to test.

Measuring Changes in Ecosystems

While being able to demonstrate changes in weed populations is useful, being able to demonstrate how an ecosystem changes as a weed declines is still the ultimate goal. However, ecosystem studies are even more challenging and require even more resources than population studies so will continue to be the exception rather than the rule.

Mathematical Models

For long-lived weed species, it may be necessary to predict what might happen in 20–50 years' time. Computer models (where the population dynamics of weeds are described mathematically) can be powerful tools for making predictions. In such a model, the various population processes (seed production, seed bank decline, germination, seedling survival, response to competition, longevity, etc.) are expressed as mathematical equations. Detailed research is required to find out how these processes work before a model can be developed. Models can also be used to compare the likely consequences of various weed-control strategies. However, models are only as good as the information that goes into them and for many weeds they have not yet been developed.

A Way Forward

Impact assessment studies are of great importance and should be done routinely, but how this could be achieved with current resources has been unclear.

Case Study: Mist flower (Ageratina riparia)
More than 100 plots were set up in the Waitakere Ranges to document changes to vegetation as mist flower succumbed to biocontrol agents and began to decline. Detailed measurements of the species present in the plots, and their percentage cover, were made and repeated annually for 4 years. Initially plots infested with mist flower has significantly fewer native plant species and greater cover by exotic plant species. After 4 years, mist flower had decreased from 74% to 1.5%, and measurements showed that it was being replaced by native species rather than replacement weeds, although there was a weak trend for replacement by African club moss (*Selaginella kraussiana*).

If a project is highly successful, it may seem pointless to channel further resources into a problem which has been solved, when there are so many others still requiring attention. If a project is not successful, then that may also appear to be obvious, although it could be that changes are happening but are too subtle to notice.

While detailed population and ecosystem level studies represent the ultimate goal, in reality it is never going to be feasible to undertake many of these. These high-level studies will need to be reserved for a few flagship projects. However, simpler, more affordable approaches to assessment if done well and repeated across the country should be able to satisfy the needs of many and the National Biocontrol Collective has recently agreed to adopt this approach.

See *National Assessment Protocol*.

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