TECHNIQUES FOR ASSESSING THE IMPACT OF BIOCONTROL AGENTS

Why measure the impact of control agents?

An important component of all biological control projects is assessing the impact that control 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 control agent or the combined impact of several agents you must first monitor their establishment success (see *Guidelines for keeping track of biocontrol agents*). Only once you are sure of good establishment can you proceed. A range of assessment techniques are available and the pros and cons of each technique are described below, beginning with the simplest first.

Assesssment is easier if agents have been released with this in mind.

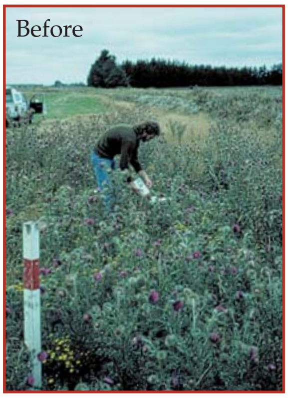
See *How to release biocontrol agents in a way that facilitates assessment.*

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 may 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.

Case Study: How correlations can be misleading

In the 1950/60s there was decline in the number of people attending cinemas. At the same time the usage of motor cars increased. You could draw misleading conclusions if you assume that these two events were linked in some way because they happened at the same time — people were too busy driving their cars to go to the movies. This could blind you to the real reasons for declining cinema attendance — people were buying television sets.



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

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What about photos?

A series of 'before' and 'after' photos can provide a dramatic visual record. Be sure to take pictures from exactly the same place, and preferably with the same camera and lens. Set up clearly marked photo points and include permanent landmarks or other features where possible (it is a good idea to take 'before' photos along with you to refer to when taking 'after' shots). You should also 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 the winter. Be aware that it may take many years for changes to infestations (especially for long-lived plants like gorse and broom) 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.

What about long-term monitoring?

If you monitor a lot of sites for many years, then you may be able to demonstrate some convincing trends; for example, a weed declines in areas once control agents become established and gets worse in areas where the control agent is absent. To do this you need to set up plots and use them to make a series of comparative measurements (e.g. the infestation level of the weed and the presence or absence of control agents) usually at least annually for many years – the longer the better. Be careful about what claims you make about this data as you have still not proved impact. To demonstrate cause and effect you need to use one of the techniques below.

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 I 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?* this page). 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.

Case Study: How damaging is gorse spider mite?

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

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 the 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 attack is sustained, then the plants are considerably weakened and may die.

How do I 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. These kinds of experimental trials are most suited to short-lived species like ragwort and thistles. For long-lived weed species like gorse and broom, that also have substantial seed banks, mathematical modelling techniques may be better (see over page). The two most common techniques for setting up these experimental trials are described below:

Remove control agents and show that the weed population recovers

If the agents are widespread, then you should aim to remove them from half of your plots using a suitable insecticide and measure subsequent changes (see *Ragwort flea beetle assessment technique*). 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 effect on your plots; for example, 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.

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 (see *Case Study: How damaging is ragwort flea beetle?* this page). 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.

Case Study: How Damaging is Ragwort Flea Beetle?

The following tables show data collected from an assessment trial in North Canterbury. The experimental plots were set up far enough apart (several hundred metres) to minimise the likelihood of the beetles dispersing between them while maximising the probability that the environmental conditions would be as similar as possible. After establishing a baseline of the density of the ragwort infestation for 2 years, beetles were released in half of the plots. Ragwort subsequently declined in the beetle-infested plots. Ragwort increased in one of the beetle-free plots but declined in the other. This unexpected result highlights the need for extreme care when setting up plots. It turned out that the buffer allowed was too small to prevent the beetles invading beetle-free areas during the course of the experiment.

Number of ragwort plants/m²

	Replicate One		Replicate Two	
Year	Without beetles	With beetles in years 3–4	Without beetles	With beetles in years 3–4
1	10	9	9	8
2	9	10	9	9
3	10	8	12	10
4	5	0	15	2

When should I use mathematical models?

For long-lived weed species it may be necessary to assess what might happen in 10–50 years time. Computer models (where the population dynamics of weeds are described mathematically) can be powerful tools that enable you to make predictions. Mathematical models are like model aeroplanes in that they are made up of a set of realistic-looking parts that must be assembled according to a strict plan. In the case of weeds, the parts of a mathematical model are the various population processes (seed production, seed bank decline, germination, seedling survival, response to competition, longevity etc.) expressed as mathematical equations (e.g. a seed bank that declines 20% each year might be described as $S_{(year\ 2)} = 0.8 \times S_{(year\ 1)}$). Detailed research is required to find out how these processes work before a model can be developed (see *Case Study: Gorse* this page). Mathematical models can also be used to support anecdotal reports of field observations. For example, many people have claimed that nodding thistle is declining. A recent computer model suggests that if at least 65% of nodding thistle seeds are destroyed, then the population begins to decline. Studies have shown that the nodding thistle agents are capable of doing this, so people may be seeing what the model has predicted. Mathematical 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.

See *Enhancing biocontrol of broom by using modelling predictions*, *Enhancing biocontrol of gorse by using modelling predictions*.

Case Study: Gorse

A model has recently been developed to describe gorse population dynamics. A key step in its development was to measure gorse seedling survival, and some gorse stands were cleared so that the subsequent recruitment of gorse seedlings could be studied.

Number of seedlings/m^2

	Otago	Canterbury
Spring	250	54
Summer	2700	200
Autumn	2900	43
Winter	2900	4

These results show that in some places (e.g. Otago) gorse recruitment is high, and in others (e.g. Canterbury) it is low. In the Otago plots gorse seedlings died due to overcrowding, which led to self-thinning. In the Canterbury plots most seedlings died from other causes (e.g. drought). To better understand these other causes some additional plots in Canterbury were manipulated by watering, burning the litter, clearing the litter, shading, and weeding to remove other species.

Treatment	Number of seedlings/m^2
Control	2
Shaded	0
Watered	1
Litter removed	300
Weeded	380
Litter removed & weeded	490
Burnt	590

These results show that any processes that remove the litter layer, and competing plants, promote dense stands of gorse. The information from these studies has been incorporated into the gorse model. The model predicts that, even if seed feeders can destroy most of the seeds that are produced, gorse infestations are unlikely to decline if people continue to use practices that allow the few remaining seeds to grow, as they will still produce more than enough new plants to replace any old ones. However, if these few remaining seeds are not allowed to grow, then the model predicts that gorse infestations should begin to decline.

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