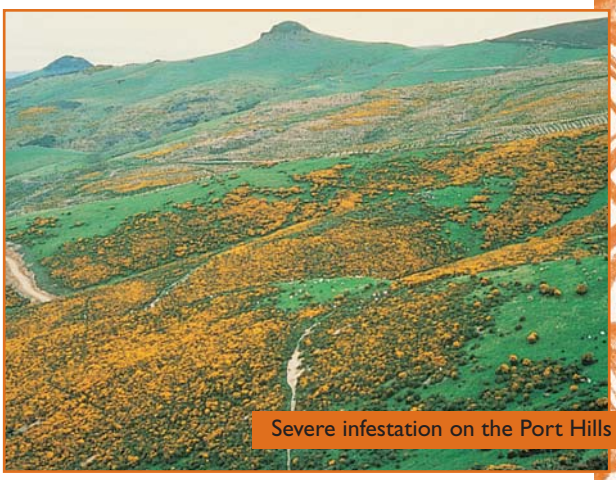
ENHANCING BIOLOGICAL CONTROL OF GORSE BY USING MODELLING PREDICTIONS

Mathematical models have been developed for broom and gorse (see *Enhancing biological control of broom by using modelling predictions, Techniques for assessing the impact of biocontrol agents*) that enable us to make a series of predictions about the impact of various management regimes, including biological control, in the long term. The likelihood of successfully controlling these long-lived woody weeds may be compromised if the impact of management techniques is not understood. Below we summarise some key conclusions.



Severe infestation on the Port Hills

Commonly used management techniques

Until about 15 years ago fire was the most important technique used for controlling gorse. The use of fire can be enhanced by desiccation with herbicides or crushing to reduce stem moisture beforehand. Sometimes stumps resprout, but carefully managed fires can result in almost complete mortality. Soon after burning a gorse infestation, a thick cover of gorse seedlings appears because fire helps to break the dormancy of the seeds and provides nutrients for growth. So burning is often followed up with herbicide spray 1–2 years later, or oversowing with perennial pasture plants (e.g. *Lolium perenne, Trifolium repens*) whose seeds are destroyed by fire. Gorse seedlings compete poorly with the pasture plants and if a thick sward is established, the survival of gorse seedlings is poor. Once a thick sward is established the addition of sheep can reduce the survival of seedlings even more by grazing and trampling. Manual methods, like root-raking, are also used extensively.

Sounds simple, so why do we still have so much gorse? The cost of control can be prohibitive, especially on marginal land. The terrain may make it difficult to carry out control. People make a start but don't follow through, or they get the timing of control activities wrong. This is why gorse continues to be a serious weed and why a biological control programme has been initiated.

Biological control

Two seed-feeding agents, the gorse seed weevil (*Exapion ulicis*) and the gorse pod moth (*Cydia succedana*), have been introduced to reduce the amount of seed produced by gorse. Five foliage-feeding agents have been introduced to reduce the vigour, biomass, and longevity of gorse bushes: gorse colonial hard shoot moth (*Pempelia genistella*), gorse soft shoot moth (*Agonopterix ulicetella*), gorse spider mite (*Tetranychus*

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lintearius), and gorse thrips (*Sericothrips staphylinus*). It is too soon to know what collective impact these agents will have in New Zealand. A classic study carried out in the 1960s and 70s in the UK indicated that natural enemies have a major impact on the growth and mortality of broom bushes and we expect the same is true for gorse. Our work suggests that our biological control agents may be able to reduce the size of plants, the maximum age of plants, seed production, the rate of spread, and the probability of recruitment of replacement plants.

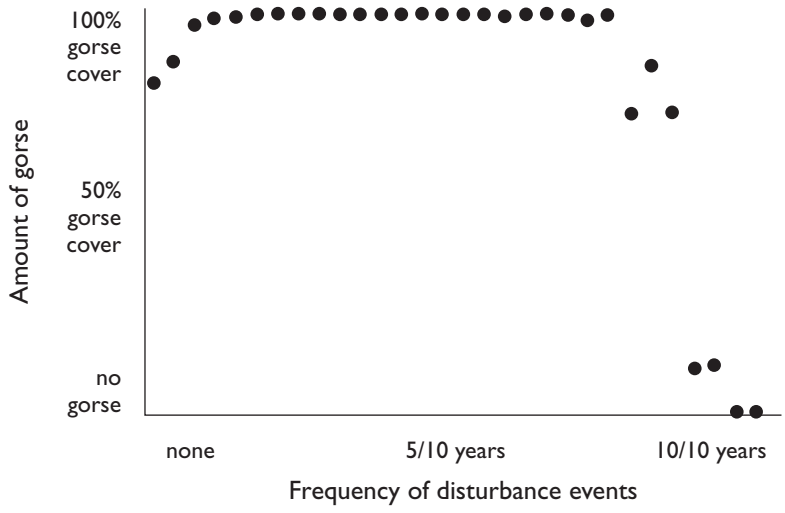
See also *Gorse colonial hard shoot moth*, *Gorse pod moth*, *Gorse seed weevil*, *Gorse soft shoot moth*, *Gorse spider mite*, *Gorse thrips*.

What do we know about gorse population dynamics?

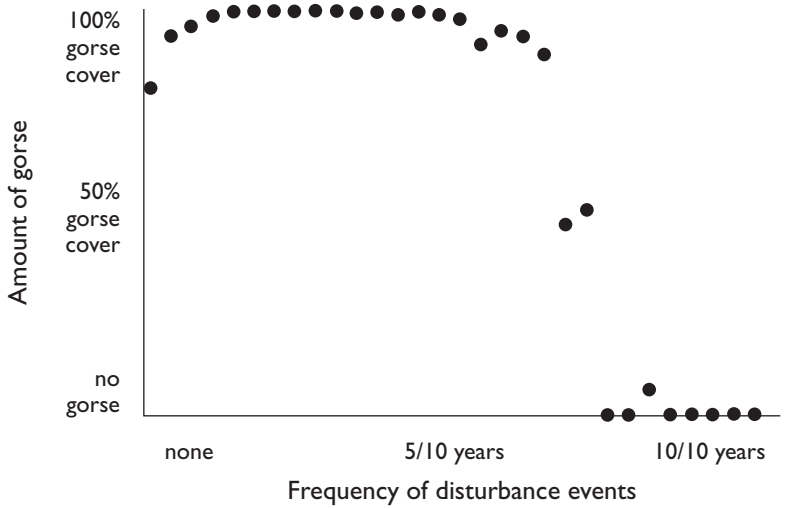
In New Zealand gorse usually grows about 2–4 m tall. Gorse tends to grow in even-aged cohorts and recruitment does not usually occur under mature plants (perhaps due to shading and lack of moisture). Recruitment becomes more common once gaps appear as individual gorse plants begin to die or disturbances occur (e.g. fire). Individual plants can live to around 30 years. Plants start flowering around 2–3 years old. Flowers are produced in spring and autumn, and although mature plants can produce more than 20,000 seeds per year, almost all fall within 5 m of the parent plant. A high proportion of seeds are dormant and substantial seed banks can accumulate in the soil and survive for decades. They cannot germinate if buried deeper than 5 cm.

What does the model predict?

If a gorse infestation is subjected to frequent large-scale disturbances, e.g. herbicide, fire, ploughing etc., that prevent any gorse plants from ever seeding, then the infestation must eventually die out as the seed bank becomes exhausted. This means that if you treat your gorse infestation at least every 2 years in a way that ensures no plants set seed, then eventually you will win. It is also critical to treat outlying plants because otherwise they will be able to set up new seed banks and replenish old ones. However, if you cannot maintain this pressure for as long as it takes to exhaust the seedbank (which could be several decades), or you miss the odd treatment along the way (allowing some plants to set seed), then you will be fighting a losing battle (see *Graph 1*). Obviously this is likely to be impractical, so how can biological control ease the burden?



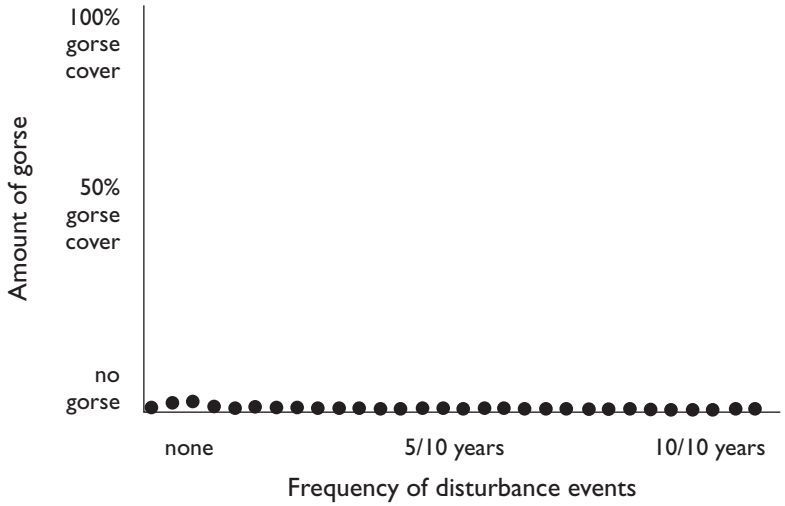
Graph 1: The predicted amount of gorse cover (without biological control) assuming large-scale disturbances kill 95% of plants. The model assumes a long time period (at least 50 years).



Graph 2: The predicted amount of gorse cover assuming 95% of seeds are destroyed by seed feeders and there is 50% survival of seedlings that grow from the remaining 5% of seeds. The model assumes a long time period (at least 50 years).

The more seeds that gorse produces the higher the likelihood that infestations will spread around the edges and that some seeds will find their way to new areas. Therefore seed feeders should reduce the rate with which gorse invades new areas.

The model predicts that under certain conditions seed feeders could also help to reduce existing gorse populations, but only if they are used in conjunction with appropriate and careful management practices. For example, even if seed feeders are able to destroy nearly all of the seeds produced each year (95%), gorse infestations are unlikely to decline if management practices allow the few remaining seeds to grow – there will still be more than enough new plants to replace old ones (see *Graph 2*). However, if these few remaining seeds are not given a good environment to grow in, then gorse infestations should begin to decline (see *Graph 3*). Reducing the survival of seedlings is the key to control,



Graph 3: The predicted amount of gorse cover assuming 95% of seeds are destroyed by seed feeders and there is only 1% survival of seedlings that grow from the remaining 5% of seeds. The model assumes a long time period (at least 50 years).

and this can be achieved by promoting competition from grasses and avoiding disturbance. The occasional use of fire can make the problem worse as it creates ideal conditions for recruitment, and is likely to kill biological control agents and the seeds of competing plants. Herbicides may also kill control agents, depending on the chemical used and the method and timing of application.

Modelling also suggests that if we can shorten the life span of gorse plants, then this will also cause infestations to decline. We don't actually need to kill plants, just shorten their life span, and we expect that the five foliage feeders will be capable of doing this.

Possible control scenarios for severe infestations

Low input option

Every year spray any plants that appear around the boundary and any outliers in the general vicinity, so the infestation does not get larger. Make it difficult for seedlings to grow by promoting a dense sward of pasture plants (by oversowing, applying fertiliser etc.), and minimising disturbance (perhaps fence the entire area off; avoid fire, excessive grazing or trampling; light grazing may be acceptable). Ensure that all possible biological control agents are present and if necessary introduce them into the infestation.

High input option

Spray your whole infestation and any outliers at least every 2 years so that no plants ever get to set seed. Continue with this regime until the seed bank is exhausted.

Regeneration option

Under certain conditions (adequate moisture and access to a suitable seed source) gorse infestations, if left for a long time, can regenerate back to native bush. If this is the desired outcome, then disturbance must be minimised. If fires are allowed to go through regenerating areas, then gorse will persist, as its seedbank will allow it to quickly recolonise again and get a head start on other more desirable plants.

Reference

Rees, M. & Hill, R.L. 2001. Large-scale disturbances, biological control and the dynamics of gorse populations. *Journal of Applied Ecology* 38:364–377.

For further information contact:

Hugh Gourlay
Landcare Research
PO Box 40, Lincoln 7640
NEW ZEALAND
email: gourlayh@landcareresearch.co.nz
Ph (03) 321 9683
Fax (03) 321 9998

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