Biocontrol Systems: Impacts of Climate Change

Climate change will have a direct effect on the composition, distribution and life cycle of the weeds and pests of our pastures, crops, orchards and forests. By 2090, New Zealand's climate is predicted to be around 2°C warmer, on average, than in 1990 and rainfall is expected to increase in the west and decline in the east. Extreme weather events are expected to be more common.

The future distribution and local abundance of pests, weeds and their biocontrol agents will be influenced by these changes, together with changing patterns of land.

Biocontrol

Biocontrol is a method of using natural enemies to control pests through predation, parasitism, herbivory, or other natural mechanisms. Classical biocontrol is the term used when one or more natural enemies from the country of origin of the pest are identified, and one or more are imported and released to control the pest.

Biocontrol is important to New Zealand

New Zealand is vulnerable to invasive exotic weeds and invertebrates because it is a geographically-isolated land mass. However, just as these invasive species may thrive and reach pest status through the absence of natural enemies and little competition, so can many introduced biocontrol agents.

Biocontrol is used to reduce the need to use pesticides; provide affordable long-term control of pests; to conserve natural habitats and to foster sustainable pest management systems utilising natural processes with minimal intervention.

Since introduction of the first biological control agent in 1874 there have been 720 introductions of 518 control agents against 126 targets.

How will climate change impact New Zealand's biocontrol systems?

The plant species grown in a region are expected to change over time with climate change as growers choose those crops and forages that optimise economic returns. For biocontrol, agents the two traits most likely to affect how a species deals with climate change are thermal sensitivity and dispersal ability. Studies indicate there can be big differences between groups and species in the way they are affected by these factors.

Changes to distribution of species

As climate change is a gradual process it is predicted that most insect pests and their natural enemies will move with the shift in in farmed crop and forage species. However, some species, such as predatory mites, may have low dispersal rates, affecting the rate at which they integrate into new areas. Most weeds are likely to expand or shrink their geographic ranges in response to temperature and rainfall, and existing biocontrol agents are likely to follow. Our greatest risk from climate change is colonisation by new invasive pest or the emergence of 'sleeper pests'. In most instances, novel invasive species arrive without their co-evolved natural enemies and those already present provide poor control

'Sleeper pests' are those already in the country but are kept in check by factors such as host unavailability and cold; they may be relatively common plant species (e.g. sorrel, acacias, and prairie grass) that may become problematic in some regions as the climate changes.

Changes to distribution of species - Ragwort suppression

Ragwort flea beetle's suppression of ragwort is likely to fail when mean annual rainfall exceeds 1670mm. Climate change predictions of increased rainfall in western regions of New Zealand suggest an expansion of the area where the biocontrol will fail because conditions are too wet. But larger areas in northern North Island will attain suppression as rainfall decreases. In eastern regions, ragwort control will result from expansion of the area of low rainfall where ragwort will not grow.

Changes to single species populations

Changes in CO_2, temperature and water availability are likely to affect individual species in a biocontrol system differently. With winters insufficiently cold to check insect reproductive activity, species like aphids and thrips will multiply and predators may not keep pace and control the population.

The effect of warmer temperature can be expressed in many different ways: invertebrates can change feeding behaviour; the pathogenicity of fungi may be changed; and commonly the survivability of parasitized hosts appears to be enhanced.

Similar change in plant life cycle is likely as a result of climate change: timing and duration of seed germination, bud burst, and flowering and lowered nutritional value of plants in response to elevated CO_2 levels.

Climate variability and extreme weather events such as droughts are expected to increase. Extreme weather events can frequently be followed by pest population explosions because of the loss of natural enemies. Parasitoids are generally more sensitive than their hosts, and lag behind in population recovery further impairing parasitoid effectiveness.

More pest generations developing each season - Tomato fruitworm

This pest has a very wide host range. The fruitworm normally has three generations per year in the north, but in cooler summers and regions there are often only two generations. Even with two established parasitoids, the third generation can cause significant crop losses. Under the 2090 climate scenario, four generations are expected in the North Island and three in the South. It is not known how the parasitoid system may respond.

The key parasitoid, *Cotesia kazak*, is not currently present in the South Island. This parasitoid has not been effective at controlling this pest in warmer areas overseas; the future viability of the current integrated pest management system may be compromised.

Changes to interactions between species

The number of generations a species can produce each year is primarily determined by day length and temperature. The pest and its natural enemies may react differently to climate changes allowing the pest to multiply faster than the biocontrol. Changes in temperature and day length could also change the timing of flowering and maturation in the host, and reproduction and emergence in the biocontrol agent. Any of these changes can cause the host-enemy synchrony to fail.

Climate change has the potential to alter how biocontrol agents interact with other species in their environment apart from their target host. There may also be cases where the biocontrol agents are present but the plant parts they normally specialise on are absent, leading to a change in behaviour of the parasitoid and the potential for 'spillover' damage to non-target species.

Changes to interactions between species - Lucerne weevil and its parasitoid

The relationship between the lucerne weevil and its parasitic wasp in New Zealand appears to be unique. In the current climate a small proportion (about 3%) of weevils over-summer in lucerne stands and support a population of the parasitic wasp, enabling more generations and higher numbers of this predator. In Mediterranean Europe and Australia this over-summer behaviour does not occur, and the wasp is less effective in controlling the weevil. As temperature rises and New Zealand's climate approaches that of South Australia, there is a risk that biological control may become less effective.

Population adaptation

Species have responded to climate changes throughout their evolutionary history. A concern is that a rapid rate of climatic change could exceed rates of adaptation. If species cannot adapt at the pace of climate change, then major changes in distribution are likely, particularly for species at the edge of suitable habitats. As many introduced populations of natural enemies are likely to possess relatively little genetic variation they could have reduced potential for rapid adaptive evolution.

Biocontrol agent adaptability - Argentine stem weevil

Continuing biocontrol suppression of the Argentine stem weevil may relies on a parasitoid biotype complex, involving two genotypes of a parasitic wasp. These two populations appear to each be adapted to favour either cooler or warmer seasons, their prevalence in New Zealand locations fluctuating accordingly.

Under climate change both genotypes are considered likely to persist, the balance in population alternating between warm and cool seasons. With this wasp, genetic variation enhances performance.

The low genetic variability of many other biocontrol agent populations may limit their ability to adapt successfully to future conditions.

What can be done?

The gradual pace of climate change allows industry and land managers the time to implement strategies that will ensure biocontrol continues as a mainstream pest management tool in the productive and environmental sectors. These could include:

- **Refuge habitats** - the provision of habitats that support a high abundance and diversity of predators and parasitoids should provide a buffer against extreme weather events.

- **Pre-emptive action against 'sleeper pests'** - biocontrol should be investigated for those that are likely to become serious pests under climate change, and for which effective biocontrol are available overseas.

- **A review of existing integrated pest management systems** to identify areas of most risk from climate change in each system and how to address them E.g. by introducing additional species of biocontrol agents for existing pests.

- **Increased genetic diversity** - risk assessment and regulatory approval for introductions of new genetic lines for introduced biocontrol agents founded by few individuals. This will lessen potential negative impacts of climate change through greater genetic variation and potential for adaptation.

- **Border biosecurity and surveillance** in 'at risk' localities, backed by rapid response, to defend against the increased risk that the frequent subtropical 'door knockers' become permanently established.

- **Predictive models** used to optimise the benefits of biocontrol, from the planning of long-term land uses and optimal timing and sequence of crops in a district to the augmentation of systems through the introduction of new natural enemies.

- **Grower awareness** - each of the actions suggested above relies on support, awareness and communication with and between farmers, growers and other land managers. Growers need to be aware of how climate change may affect the outcomes of their biocontrol so that they can plan, monitor and adjust their management practices appropriately. Growers may have an especially important role in early detection of problems, and in validating the predictions from models.

Further Information

The full technical report that this summary is based on is Possible impacts of climate change on biological systems in New Zealand MAF Technical paper No: 2011/21. Copies are freely available at: www.climatecloud.co.nz/CloudLibrary/2011-21-CC-biocontrol-systems.pdf