

To help grain growers manage their crop pests, the National Invertebrate Pest Initiative has been set up with the support of the Grains Research and Development Corporation. NIPI pulls together scientists from state government departments, universities, farmer groups and CSIRO and its coordinator is Dr Gary Fitt from CSIRO Entomology. Australian Grain will be presenting articles reviewing the current knowledge of invertebrate pests – and their management in Australian grain systems.

Managing ecosystem services and pests in broadacre landscapes

By Louise Lawrence, CSIRO Entomology

Increasing demands are being made of Australia's agricultural landscapes and there are concerns that they may have reached a 'tipping point'. Farmers, scientists and conservationists are all now looking at ways that these landscapes can be made more sustainable by harnessing the ecosystem services, such as pest control and pollination, that native vegetation can offer.

The emphasis in considering these issues is at the landscape scale and not the farm or field scale. So all members of rural communities and other interest groups need to be involved in any solutions.

Since the first plantings by European settlers in 1788, the area being cropped in Australia has expanded to more than 25

million hectares and most of this is concentrated in areas with favourable rainfall. As a consequence, clearing and planting has dramatically changed these landscapes.

Native vegetation has all but disappeared in some places, cropping areas that now favour plague locusts and other pests are extensive and there is widespread use of pesticides. Added to this is an ever increasing area where crops are grown year-round, thus providing unbroken access to host plants for major insect pests such as Helicoverpa moths.

The end result is a rural landscape broken up into natural, semi-natural and highly modified patches of various sizes and degrees of isolation. Added to that is a reduction in the number of plant species

in various habitats and the development of cropping areas that favour pests, discourage natural enemies and pollinators and threaten biodiversity

A tipping point

In some cases, the cumulative effect of all these activities results in an abrupt change in the ecosystem. That is, the system reaches a 'tipping point' with a consequent deterioration in ecosystem services such as pest suppression and pollination.

For example, when only two or three different crops are grown in an area and all of these are attacked by the same pests, there may be a sudden, sustained increase in pest numbers.

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With these problems comes a growing awareness that insect pests are not constrained by crop boundaries and so managing them can't be either. It is also probable that the huge expanses of crops in some regions are more susceptible to pests than crops grown in isolated locations. The extensive production areas, which may themselves provide more favourable habitats for pests, also lack the non-crop habitats which probably play a crucial role in maintaining populations of natural enemies in agricultural landscapes.

Even small and isolated fragments of remnant vegetation are thought to be important as a source of natural enemies of pests, feral honey bees and native pollinators. They may also be refuges for species of conservation interest and in some instances – for example, with *Helicoverpa* resistant Bt cottons – they can be refuges for susceptible insects in strategies to maintain the efficacy of the GM crops.

The benefits of natural pest control are now widely recognised. Natural enemies suppress a wide range of insect herbivores so preventing many potential pest species from reaching outbreak levels in field crops. The value of the ecosystem service of pest control is estimated at more than US\$400 billion a year worldwide.

Area-wide management

If growers are trying to manage a highly mobile species that has several generations a year, then managing it over a larger area



Using insecticides (preferably soft spray options) to control *Helicoverpa* in low value crops such as sorghum may reduce pest pressure on high input crops later in the season. This appears to have been successful on the Darling Downs. (Photo by CSIRO Entomology)

would make sense – but would be challenging. For species such as *Helicoverpa* and diamond back moth (DBM) the main question is how large does a management unit have to be in order to be effective?

These pests need to be managed on an area-wide, season-long basis, which means that all growers in a region will need to cooperate if pest populations are to be reduced.

For *Helicoverpa*, a generalist herbivore, the use of insecticides (preferably soft spray

options such as a specific virus or bacteria) in low value crops such as sorghum may be needed to reduce pest pressure on high input crops later in the season. Such a program appears to have been successfully implemented on the Darling Downs of southern Queensland.

For a host specialist such as DBM, the effects of what is planted where and over what area is likely to have a significant impact on DBM population dynamics. Managing pest populations in crops that are a source of DBM such as canola or weedy Brassica has yet to be explored but minimising natural enemy mortality – by reducing broad-spectrum insecticide use – would be a good start.

If it works on a field/farm scale it will probably also have benefits over a larger area.

Natural enemies

In Australian agriculture, relatively little is known about natural enemies (parasites and predators) and the pests they control. Before serious efforts can be made to restore landscape features and thus increase the abundance and effectiveness of natural enemies, more information is needed on:

- Habitats that are sources of natural enemies and pests;
- The dispersal of beneficial organisms from these habitats into crops; and,
- The landscape scales at which they operate.

Efficient and sufficient pollination services are also important for several broadacre crops though their reliance on



Even small and isolated fragments of remnant vegetation are thought to be important as a source of natural enemies of pests, feral honey bees and native pollinators. (Photo by John Coppi, CSIRO Land & Water)

pollinators varies from high (clover 90 per cent, faba beans 50 per cent, field pea 50 per cent) to low (canola 15 per cent, lupin 10 per cent).

Australia has many native pollinators that may be good candidates for supplying agricultural pollination services and preliminary studies on native stingless bees suggest they could be useful low-maintenance pollinators.

American studies have shown that native bees could provide sufficient pollination on more than 90 per cent of the farms studied. But a lack of knowledge about the ecology and biology of native pollinators makes their management difficult for now.

Competing interests

Strategies that balance legitimate but seemingly competing interests need to be developed to reverse the negative consequences of some of the changes that come with Australian broadacre grain landscapes.

Before broadacre landscapes to suit multiple users can be designed, the very diverse group of users needs to acknowledge both the need for change and what needs to be fixed. This group includes natural resource managers, primary producers of all description, consumers and other land users such as residential and tourism.

That said, it will probably be the primary producers, with support from the other sectors, who will be charged with implementing landscape changes.

Another challenge is to design landscapes so they benefit a range of ecosystem services. For pest control and pollination the prospects look good. Some insects, such as hoverflies which are predators, provide both pest suppression and pollination services and important pollinator groups such as bees and many natural enemies of pest species depend on similar non-crop habitat.

This suggests that aiming for a (yet to be determined) critical proportion of non-crop habitats in the landscape may be a promising way to enhance both pest control and pollination.

Using models

When it comes to gaining a clearer understanding of how changes in landscape composition impact on ecosystem services, the experimental manipulation of landscapes isn't really feasible. This is where mathematical models can be useful.

These models can help unravel and allow investigation of processes such as colonisation, reproduction, mortality and emigration that underlie the functioning of an ecosystem at appropriate scales.



Farmers, scientists and conservationists are investigating ways that agricultural landscapes can be made more sustainable by harnessing ecosystem services, such as pollination, that native vegetation can offer. (Photo by Denis Anderson, CSIRO Entomology)

Models have already been used to explore how the arrangement of non-crop habitats in the landscape can affect pest control in crops, how the timing of crop colonisation by pests affects predators and ultimately pest suppression and how landscape diversity affects one predatory group – spiders.

Ideally, modelling would generate a set of general rules for use in developing management strategies for ecosystem services. For example: 'the pest control function is likely to be reasonably good in landscapes that contain more than nine per cent of non-crop habitat'.

One thing is certain. Designing landscapes for multiple outcomes is a complex problem.

But available evidence suggests grain growers may benefit from area-wide management strategies on a landscape scale in collaboration with growers of other crops with the same pest problems. But there

is, as yet little direct evidence that similar area-wide initiatives targeted for natural enemies and pollinators will have a greater effect than managing them locally.

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This article is a summary of a paper by Nancy Schellhorn, Sarina Macfadyen, Felix Bianchi, David Williams and Myron Zalucki* on managing ecosystem services in broadacre landscapes: *What are the appropriate spatial scales?* which appeared in the *Australian Journal of Experimental Agriculture* 48 (12): 1549–1559. It is one of a suite of papers published in this special edition of the journal.

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NEW COLLABORATIVE PROJECT

The Grains Research and Development Corporation is funding a new collaborative project between CSIRO Entomology, Department of Primary Industries & Fisheries Queensland, Department of Agriculture & Food Western Australia and the University of Queensland.

In agricultural landscapes in north, south and west Australia, they are investigating how grain pests are affected by the composition of the landscape by:

- Identifying source habitats of pests and natural enemies;
- Assessing their movement between habitats such as native vegetation and crops; and,
- Working out how long it takes pests and their natural enemies to colonise crops and how this is influenced by the landscape in which the crops are grown.

The research will identify the features of landscapes that suppress pests and will align IPM guidelines for pest management at several scales – field, farm and landscape. It is hoped the results will help reduce farmers' reliance on broad-spectrum insecticides, and, at the same time consider the broader public benefits of biodiversity and conservation.

Some of the strategies involved in better landscape design in broadacre cropping regions may also result in improved environmental outcomes such as enhanced amenity and conservation of biodiversity.

Although farmers will probably be charged with implementing these landscape changes, the movement for change may come from a range of stakeholders.