Australian Government
Land & Water Australia

FINAL MILESTONE REPORTING TEMPLATE

Program:	Native Vegetation & Biodiversity		
Project Number:	COT 3		
Project Title:	Capturing the ecosystem service of pest control from native vegetation		
Research Organisation:	CSIRO		
Principal Investigator:	Dr. Felix Bianchi		
Project Start Date:	01/07/2006	**Project Completion Date:**	01/09/2009

Milestone Report Title:	Final Report		
Milestone Number:	6		
Milestone Due Date:	01/09/2009	**Date Submitted:**	31 August 2009

Please contact your Program Officer for a copy of the report template populated with key project information.

General Project Information

1. Project Objectives

To demonstrate the benefit of pest control in cotton/grain systems as it relates to native vegetation and native remnant communities. This will be done by understanding:
(i) the contribution that native vegetation and native plant communities are making to growing populations of key beneficial insects (predators and parasitoids) and pests;
(ii) whether a high native remnant : arable land ratio results in greater pest control; and
(iii) the spatial scale at which native remnants contribute to the ecosystem of pest control.

2. Location

The research has been conducted in the SE Queensland in the Darling Downs region near Dalby. The findings of this project apply to cotton/grain landscapes in the Darling Downs in which native vegetation is dominated by poplar box, acacia and saltbush.

3. Outcomes

The three main outcomes of this project is that (1) native vegetation supports consistently higher predator densities than crops throughout the year and produce relatively few pest as compared to crops, (2) there is evidence that fields near native vegetation can benefit from pest control services from whitefly parasitoids and flying predators of cotton boll worm eggs, but this phenomenon is not always consistent across the year and fields, and (3) fields adjacent to native vegetation do not have higher colonization of pests than fields 400 m from native vegetation. On the contrary, the landscape with a high proportion native vegetation had consistently lower colonization rate of aphids. A simulation study indicates that the spatial arrangement of patches of native vegetation - from which natural enemies colonize the surrounding landscape - is crucial for effective pest control in crops. These findings show that cotton/grain growers can benefit from maintaining and managing native vegetation by regulating the pest to natural enemy ratio in the landscape and that native vegetation management can potentially play a role in landscape scale IPM.

4. Target Audience(s) for the research

The prime target audience are landholders in grain/cotton landscapes and NMR groups.

Milestone Report Information

5. Milestone Requirements and Deliverables

Submission of final report including details of: 1. Information from the two seasons on early season colonisation and predation and parasitism quantified. 2. Results presented to stakeholders. 3. Report on agreed K&A activities against the project K&A plan.
Achievement Criteria: 1. Acceptance of final report by Land & Water 2. K&A activities as agreed in the project K&A plan completed.

6. Project Progress & Milestone Achievements (up to 5 pages)

The problem

Cotton and grain production is often concentrated in intensive production landscapes with little native vegetation left. With an increasing recognition that pest problems need to be considered beyond the crop boundary, agricultural landholders often ask questions regarding the role of native vegetation as source habitats of pest insects and natural enemies. Three frequently asked questions are:
(i) what is the contribution of native vegetation to growing populations of natural enemies and pests?
(ii) does a high native remnant : arable land ratio result in greater pest control?
(iii) at what spatial scale does native remnants contribute to the ecosystem of pest control?
This project addresses these three questions in cotton/grain systems in the Darling Downs, SE Queensland. The project focuses on the early colonization of cotton fields by pests and natural enemies as an early arrival of natural enemies - when pest densities are still low - is likely to result in much better pest suppression than when pest densities are already high.

Scientific approaches

- Literature review of the appropriate spatial scales at which ecosystem services provided by insects (natural pest control and pollination) can be managed.

- Habitat assessment using beat sheet sampling for immature and adult stages of pests and predators in 6 crop types (including sorghum, wheat and cotton) and native vegetation (*Eucalyptus populnea, Acacia salicina* and the saltbush spp. *Enchylaena tomentosa*, *Atriplex muelleri*, *Sclerolaena muricata*, *Rhagodia nutans* and *Maireana microphylla*). The sampling was conducted in two landscapes (10 km diameter) with 6 and 13% native vegetation in 4 seasonal sampling periods during 2007 and 2008. The two landscapes were chosen to link with project Cotton Catchment Communities CRC project 2.04.09 "Healthy cotton catchments: integrating biodiversity, ecosystem services & landscape pattern for sustainable production" and because they both contained similar native vegetation communities, thus controlling for variation in plant species.

- Two large scale field experiments conducted at the time of cotton planting in October 2007 and 2008 in the two above mentioned landscapes. Colonization rates of cotton pest species, white fly parasitoids and *Helicoverpa* egg predators were assesses using transparent sticky traps and cotton seedlings. Sentinel cotton seedlings contained whitefly nymphs, *Helicoverpa* egg cards (accessible to ground dwelling predators), *Helicoverpa* egg cards where ground dwelling predators were excluded and uninfested cotton seedlings. The sticky traps provide information about flying colonizing adults and the cotton seedling sentinel plants provide information about the oviposition by colonizing adults. The experimental design was as follows: 2 years (2007 and 2008) x 2 landscapes (6 and 13 % native vegetation) x 3 native vegetation treatments (in, adjacent and >400 m from native vegetation) x 3 replications in time. In each year, nearly 4000 sentinel cotton plants were placed in rectangular grids in native vegetation, adjacent to native vegetation, and far from native vegetation. The plants were placed on bare soil to mimic early seedling emergence. Habitat assessment for pests and natural enemies was conducted during these experiments as a means to identify sources of colonizing pests and natural enemies.

- Simulation of the control of pest populations in crops by predators that colonize the landscape from predator patches. Natural pest control provided by predators is evaluated in 1000 computer landscapes with different spatial arrangement of crops and predator patches.

The key research findings

The literature review revealed that:

- Although there is limited information to draw firm conclusions, there are indications that clearing of native vegetation and pest management practices undertaken on individual farms can impact population dynamics of pests, natural enemies and pollinators at the field, farm and landscape scale. The culmination of these actions can potentially lead to changes in ecosystem service provision.

- Australian grain growers may benefit by implementing area-wide management strategies on a landscape scale in collaboration with growers of cotton and other crops that host the similar pest species. However, although positive effects of native vegetation on natural enemies have been reported in Europe and North America, for the Australian situation there is still little direct evidence that area-wide initiatives targeted for natural enemies and pollinators will have a greater effect than management strategies implemented at the field and farm level.

Sampling of pests and predators in crops and native vegetation showed that:

- Native plant communities support a significantly different insect community than crops. Leafhoppers, Rutherglen bugs, spiders and mirids were the major arthropod groups in crops, whereas spiders, ants and leafhoppers were dominant on native plants. The majority of the leafhopper species in native vegetation have no agricultural pest status. However, native plant communities support several species of predators that are important in agricultural pest control, such as ladybird beetles and lacewings.

- Native plants have a higher predator density than crops throughout the year. Even though poplar box and the saltbush spp. all had a positive predator to pest ratio, this was most pronounced for Acacia. Crops generally support much higher pest densities than native plants. Crops generally also have higher densities of immature pests, indicating that crops are major source habitats in which pest populations build up. Densities of immature predators were low and not significantly different between native plants and crops in any time of the year.

- The landscape with 13% native vegetation had a higher predator density and lower pest density than the landscape with 6% native vegetation. This information shows that native vegetation can contribute to a higher predator to pest ratio at the landscape scale and can potentially enhance natural pest suppression in crops.

The field experiments showed that:

- The overall percentage of whitefly parasitism was low (0.5% in 2007 and 0.2% in 2008), which is to be expected early in the season as summer crops are just emerging. However, whitefly parasitism is virtually limited to cotton near native vegetation and quickly declined at distances further than 50 m from native vegetation. Surprisingly, the parasitism levels were the highest in patches of native vegetation in the landscape with the lowest percentage native vegetation. The variability of whitefly parasitism between native remnant patches was high, with many patches where parasitism was absent, suggesting that there may be particular features of native vegetation that are important for supporting whitefly parasitoids. This high patch-to-patch variability also suggests a metapopulation structure.

- When ground dwelling predators (notably ants) had access to *Helicoverpa* eggs on cotton seedlings in non-irrigated, no- or low-till systems, the overall percentage daily predation in plots was 21% and ranged from 5% to 42%. Generally, egg predation was not influenced by the distance from native vegetation or by the percentage native vegetation in the landscape. This finding is in line with observations of ants taking eggs from the cotton seedlings in native vegetation, fields far and adjacent to native vegetation. Ants are therefore ubiquitous predators in low-disturbance cotton/grain systems, which can remove *Helicoverpa* eggs before the larvae can cause feeding damage to the crop.

- When ground dwelling predators were excluded from cotton seedlings and only flying predators could access *Helicoverpa* eggs, the overall percentage daily predation in plots was reduced to 12% and ranged from 0% to 29%. In 2 out of 3 trials, predation was higher in native vegetation than in fields 400 m from native vegetation. Predation was found to be higher in fields adjacent to native vegetation than in fields 400 m from native vegetation in one out of three trials.

- Pest colonization was measured using uninfested cotton seedlings and sticky traps. The overall colonization rate on these sentinel cotton seedlings across all years and landscapes was 0.37 pests per plant per day, and included *Helicoverpa* larvae, whiteflies, jassids, Rutherglen bugs, thrips and weevils. In 2007, the colonization of cotton seedlings by pests was not influenced by the distance from native vegetation. In 2008, after the drought has been broken, there was a tendency towards higher pest colonization in remnants, but pest colonization in fields adjacent to native vegetation and fields at 400 m were similar. The percentage native vegetation in the landscape did not affect pest colonization rates in 2007 or 2008.

- Pest colonization rates assessed on transparent sticky traps revealed that thrips, aphids and jassids were the dominant pest groups. Colonization rates of thrips were generally lower in native vegetation as compared to fields adjacent and far from native vegetation. In 2007, there was no clear landscape effect, but in 2008 thrips colonization was lower in the 13% than in the 6% native vegetation landscape. Colonization rates of aphids were consistently lower in the landscape with 13% native vegetation than in the landscape with 6% native vegetation, but there was generally no significant difference between colonization rates in native vegetation, fields adjacent to native vegetation and fields at 400 m from native vegetation. Thus, aphids respond to native vegetation at the landscape scale, confirming that they are good dispersers. Leafhoppers showed a variable response in 2007 and 2008. In 2007, when leafhopper densities were high, their colonization rates were lower in native vegetation than in fields adjacent and far from native vegetation. In 2008, however, when leafhopper densities were much lower, fields adjacent to native vegetation had higher colonization rates than native vegetation or fields far from native vegetation.

- Predator colonization was also assessed on uninfested sentinel cotton seedlings and sticky traps. The overall colonization rate on cotton seedlings across all years and landscapes was 0.011 natural enemies per plant per day, which included spiders, ants, pirate bugs and ladybeetles. In 2007, the colonization of cotton seedlings by predators was higher in the landscape with 13% native vegetation than in the landscape with 6% native vegetation. However, fields adjacent to native vegetation had similar colonization rates than field at 400 m distance from native vegetation, suggesting that natural enemies are quite mobile. In 2008, there was a tendency for higher natural enemy colonization in native vegetation than in fields adjacent and far from native vegetation. However, this pattern differed for the two landscapes and replications in time.

- On sticky traps, ladybeetles and lacewings were the dominant predators. These aphid predators did not show responses to distance from native vegetation or percentage native vegetation at the landscape scale, indicating that these species are highly mobile and habitat generalists.

- Comparison of the pest and predator colonization rates generated by sentinel cotton seedlings and sticky traps showed that these methods sampled partly different insect assemblages. Sticky traps (reflecting the airborne insect assemblage near the plants at any time during the sampling period, i.e. the potential colonizers) showed that there were less pests around cotton seedlings in native vegetation than in fields adjacent or far from native vegetation. Sentinel cotton plants (reflecting the insect assemblage present at the plants at the moment the plants were recollected from the plots, i.e. the actual colonizers and/or their progeny) did not reveal effects of distance from native vegetation on pest colonization rates. This indicates that a suite of methods is needed to fully grasp the full complexity of colonization processes.

- There were no apparent correlations between pest and natural enemy colonization rates on cotton seedlings and the crop and non-crop types present in landscape sectors with radia of 100, 500, 1000, 1500 and 2000 m.

The simulation study showed that:

- The distance between crops infested with pests and patches from which predators colonize the surrounding landscape has a major effect on the natural pest control provided by these predators. Natural pest control in crops declines with increasing distance of predator patches. This distance effect is stronger for poor dispersing predators than for mobile predators.

- Small-scale landscapes with patches of native vegetation intermingled with crops have the highest potential for natural pest control, provided that native vegetation provides predators that colonize the surrounding landscape.

Outputs

The findings of this project have been communicated to a wide audience via workshops for land owners in the study area (October 2008 and September 2009), participation on a field day, a workshop at the 14th cotton conference, 15 presentations (including NMR groups, universities, CSIRO, LWA and Cotton Catchment Communities CRC meetings), and 3 international conferences held in Sydney, Brisbane and Reno (USA). In addition, a presentation will be held at the Entomological Society of America (Indianapolis, USA) in December 2009. The broader community has been informed by 6 newspaper articles, 2 radio interviews and 5 popular press articles. The project has further generated a conference proceeding and 4 scientific papers (1 published, 2 submitted and 1 in preparation).

Synthesis and Conclusions

This study has revealed several independent lines of evidence that native vegetation is a reservoir of natural enemies, which have the potential to colonize and suppress pest populations in crops.

For instance, predator densities in native vegetation are consistently higher throughout the year in native vegetation than in crops, the landscape with 13% native vegetation had a higher predator density than the landscape with 6 % native vegetation, and whitefly parasitoids and flying predators of *Helicoverpa* eggs inflicted higher pest mortality in and near native vegetation than in fields far from native vegetation. On the other hand, there were also predators, such as ants, ladybeetles and lacewings that were not confined to native vegetation and provided pest control serviced throughout the landscape.

Crops are source habitats for pests where the far majority of pest reproduction takes place. Although potential pest species, such as aphids and leafhoppers, occur in native vegetation, there is no evidence that pest colonization rates are higher in fields near native vegetation than far away. Moreover, in the case of leafhoppers, more than 50% of the leafhopper population found in native vegetation are species which are not found in crops, i.e. are not agricultural pests. Native vegetation is associated with reduced colonization rates of thrips and aphids, and has a neutral effect on colonization rate of *Helicoverpa* species, leafhoppers and whiteflies. Thus, native vegetation is not a source for cotton pests and, depending on the species, can result in reduced pest colonization in fields.

Although native vegetation is associated with whitefly parasitoids, there was large variation in whitefly parasitism levels between patches of native vegetation and in time. The attained level of pest control provided by a patch of native vegetation is therefore difficult to predict and is not something that a grower can rely on. Monitoring pest and natural enemy populations in crops remains therefore essential. Another limitation of pest control services provided by native vegetation is the limited distance at which whitefly parasitoids penetrate the field. The crop area with enhanced natural enemy activity can in this case be limited.

The combination of empirical findings from crop and native vegetation sampling, field experiments and simulation models allows the design of pest suppressive landscapes. Using this novel approach, spatial arrangements of crops and native vegetation can be identified in which growers can achieve maximal benefit from pest control services associated with native vegetation. By managing native vegetation and/or revegetation they may reduce their dependency of broad-spectrum pesticides, potentially reducing pesticide load. In addition, management of native vegetation or revegetation programs with the aim to stimulate natural enemy populations can also contribute to other functions such as carbon sequestration and biodiversity conservation.

Recommendations
The key recommendations to integrate native vegetation in Integrated Pest Management strategies are:

- Native vegetation does not lead to increased pest problems.
- The spatial and temporal variation in pest suppression among patches of native vegetation can be considerable but is poorly understood. A better understanding of which patches of native vegetation are likely to provide pest control services is needed before landowners are likely to adopt native vegetation management as part of their IPM strategy.
- There is a need to assess the generality of pest control services provided a range of native vegetation types. This study focussed on poplar box/acacia/saltbush system, but for a further spatial up scaling pest control services provided by different native vegetation types need to be assessed as well.

7. Linkages with other research (up to ½ page)

The project is tightly linked with the Cotton Catchment Communities CRC project 2.04.09 "Healthy cotton catchments: integrating biodiversity, ecosystem services & landscape pattern for sustainable production" led by Dr. Alan House. Both projects have been conducted in the same study sites whereby the current project focussed on the ecosystem service of pest control associated with native vegetation and Alan House's project focuses on vegetation condition, ant and beetle diversity and native vegetation connectivity issues. The results of both projects will jointly be presented at a workshop for stakeholders (date to be determined). We have established collaboration with Dr. Yvonne Buckley (CSIRO/ University of Queensland) and Prof. Hugh Possingham (University of Queensland) who are co-author on a paper "Spatial variability in ecosystem services: simple rules for predator mediated pest suppression", which has been submitted to Ecological Applications. The project is further linked with PhD studies of Dr. Ingrid Rencken "An investigation of the importance of native and non-crop vegetation to beneficial generalist predators in Australian cotton " and Mr. David Perovic "Ecologically-based pest management for Macquarie region cotton production" (both funded by Cotton Catchment Communities CRC) by giving joint presentations at field days and informal exchange of ideas. Further, this project links with other activities in the CSIRO Spatial Ecology team including the contribution to a Grains Research and Development Corporation (GRDC) and National Invertebrate Pest Initiative (NIPI) special feature in *Australian Journal of Experimental Agriculture* where FJJA Bianchi co–authored the article 'Managing ecosystem services in broadacre landscapes: what are the appropriate spatial scales?'. Also, the project is linked via planning and research findings with the Spatial Ecology teams work (lead by NA Schellhorn) funded by Horticulture Australia Ltd on integrating native vegetation with vegetable production.

8. Issues of Concern / Risks (up to ½ page)

There have been no difficulties in reaching milestones, except for the shift of the milestone for the final report from 30 September 2009 to 1 September 2009 (agreed upon on 16 July 2009). By prioritizing this project above other projects we have been able to reach this milestone in time. Another concern is the low participation of landholders to workshops. We have tried to attract landowners by organize informal meetings with a BBQ at times outside working hours, but the turn out was in both cases disappointing (approximately 20% of the invitees showed up). Finally, we conducted our experiments in the Condamine region in which there is little native vegetation left. As a consequence, our experimental landscapes contained 6 and 13% native vegetation, respectively, which is a relative small contrast. In the ideal case we would have selected landscapes with approximately 5 and 20% native vegetation. However, by conducting our project in the Condamine region we were able to link with project 2.04.09 "Healthy cotton catchments: integrating biodiversity, ecosystem services & landscape pattern for sustainable production" and work in a Condamine priority area.

9. Opportunities (up to ½ page)

The finding that native vegetation can provide public (e.g. natural resource management, biodiversity conservation, carbon sequestration) and private benefits (e.g. ecosystem services of pest control) may offer incentives for landholders to value, manage and restore native vegetation for private benefits, and deliver public benefits at the same time. Hence, highlighting the potential benefits of native vegetation for agricultural production (natural pest control, pollination) may arouse the interest of land owners in native vegetation management, a group traditionally not interested or has even negative values about native vegetation. Further underpinning of the role of native vegetation for ecosystem service provision and initiating/extend a dialogue between primary industry and NMR groups may lead to an improved integration of agricultural production and natural resource management. A new opportunity arising from this work is a 3 year GRDC national project "Pest suppressive landscapes: linking IPM and natural resource management", which will be conducted in SE Queensland, Southern New South Wales and Western Australia.

10. Impact data for knowledge, adoption and promotional activities undertaken (up to 2 pages)

1. **Journal paper, conference contribution, book and book chapters, technical brochures, and other print media arising from project during the reporting period**

Author, Title, Journal/book/conference	Status	Copy attached
House, A.P.N., Schellhorn, N.A., Brown, S.D. and Bianchi, F.J.J.A. 2007. Landscape configuration, vegetation condition and ecosystem services in cotton agro-ecosystems in southern Queensland, Australia. In: R.G.H. Bunce, R.H.G. Jongman, L. Hojas & S. Weel (eds) '25 years of Landscape Ecology: Scientific Principles in Practice', pp. 86-87. *Proceedings of 7th International Association of Landscape Ecology World Congress, Wageningen, The Netherlands, 8-12 July 2007.*	published	N
Schellhorn, N.A., Pearce, S., Bianchi, F.J.J.A., Williams, D.G. and Zalucki, M. 2008. Managing ecosystem services in broad-acre landscapes: what are the appropriate spatial scales? *Australian Journal of Experimental Agriculture* 48, 1549-1559.	published	Y
Bianchi, F.J.J.A., Schellhorn, N.A., Buckley, Y and Possingham, H.P. Spatial variability in ecosystem services: simple rules for predator mediated pest suppression. (*submitted to Ecological Applications)*	submitted	N
Bianchi, F.J.J.A., Schellhorn, N.A. and Cunningham, S.A. Landscape functionality for ecosystem services: identification of source and sink habitats for pests and natural enemies (*submitted to Agriculture, Ecosystems and Environment*)	submitted	N

2. **Articles, information or other products disseminated through media (newsletters, newspapers, magazines, radio, digital media, web etc)**

Title of article or Nature of information	Name of media or name of recipient organisation	Copy attached (Y/N)	Follow-up actions?
Natural pest control: does native vegetation help?	Spotlight Magazine	N	Not yet
CSIRO focus on pests	Rural weekly	Y	Not yet
Seeking a native pest solution	Country leader	Y	Not yet
Plants play role in pest control	Western Magazine	Y	Not yet
Native vegetation helping pest control	Border news	Y	Not yet
Native vegetation assisting control of cotton pests	North west magazine	Y	Not yet
Northern pest researchers gathered in Toowoomba	North west magazine	Y	Not yet
Understanding the role of native vegetation for pest control: report of field work in Dalby, Qld	Gnatter	N	Not yet
Radio interview	2VM (Moree)	N	Not yet
Radio interview	4WK (Toowoomba)	N	Not yet
Capturing the ecosystem service of pest control from native vegetation: Let the bush work for you	Gnatter	N	Not yet
The landscape context of the ecosystem service of pest control	Bulletin of the Entomological Society of Queensland	N	Not yet
Capturing the ecosystem service of pest control from native vegetation	Thinking bush	N	Not yet

Managing ecosystem services and pests in broadacre landscapes	Australian grain	Y	Not yet
Capturing the ecosystem service of pest control from native vegetation	QMDC newsletter	Y	Not yet

Engagement with stakeholders, and recorded responses, during the reporting period

Date and location	Participants	Purpose and nature of engagement	Outcomes and impressions	Formal eval?
30 March 2007	15 persons (students and university staff)	Presentation at the University of Queensland	Presentation well received	N
20 September 2007, Dalby	5 persons (landholders and managers)	Informal workshop	Aim of the workshop was to involve landowners in the experiment that has been conducted in October 2007. Even though the number of participants was lower than we hoped for, all participated agreed to participate in the experiment.	N
19 June 2007, Canberra	30 persons (scientists)	Presentation at the LWA Native veg R&D program meeting	Presentation well received	N
21 June 2007 , Canberra	30 persons (scientists)	Presentation at CSIRO Entomology	Presentation well received	N
24 July 2007, Toowoomba	50 persons (scientists and extension)	Presentation at the IPM Researchers Forum	Presentation well received	N
8 August 2007, Narrabri	40 persons (landholders, scientists and ext)	Presentation at the CCC CRC Annual Science Meeting	Presentation well received	N
11-14 February 2008, Sydney	100 persons (scientists and extension)	Presentation at the IOBC meeting	Presentation well received	N
15 February 2008, Sydney	15 persons (scientists)	Presentation at the CCC CRC Ecosystems review	Presentation well received	N
6 May 2008, Canberra	30 persons (scientists)	Presentation at CSIRO Entomology	Presentation well received	N
20 June 2008, Dalby	15 persons (landholders and extension)	presentation at field day	Presentation well received	N
14 Aug 2008, Gold coast	7 persons (landholders and extension)	Hands-on-research session at the 14th Australian Cotton Conference	Presentation well received	N
15 Oct 2008, Narrabri	20 persons (landholders, scientists and extension)	Presentation at the CCC CRC Annual Science Meeting	Presentation well received	N
15 Oct 2008, Dalby	4 persons (landholders and managers)	Informal workshop	Aim of the workshop was present the results of 2007 experiment to the landowners on who's property it was conducted. The landowners were very interested and were eager to participate in the 2008 experiment.	N

Date and location	Participants	Purpose and nature of engagement	Outcomes and impressions	Formal eval?
21 October 2008, Toowoomba	30 persons (scientists and extension)	Presentation at the LWA Veg futures conference	Presentation well received	N
10 Nov 2008, Brisbane	20 persons (scientists and amateur entomologists)	Presentation for the Entomological Society of Queensland	Presentation well received	N
29 October 2008, Moree	15 persons (bankers, growers and CMA staff)	CMA Moree	Presentation well received	N
31 October 2008, Narrabri	10 persons (growers and CMA staff)	CMA Namoi	Presentation well received	N
13 November 2008, Reno, USA	30 persons (scientists)	Annual Meeting of the Entomological Society of America. Special symposium “Linking insects, ecosystem function and ecosystem services”	Presentation well received	N
15 January 2009, Canberra	15 persons (scientists)	Centre for Crop Systems Analysis, Wageningen University, The Netherlands	Presentation well received	N
25 February 2009, Canberra	30 persons (scientists)	CSIRO Postdoc Forum	Presentation well received	N
26 March 2009, Canberra	20 persons (scientists)	Divisional seminar	Presentation well received	N
18 August 2009, Brisbane	70 persons (scientists)	Intecol conference	Presentation well received	N

Spatial data generated:
Spatial data of pest and natural enemy colonization, egg removal rates by predators and whitefly parasitism were collected in a total of 18 plots composed of 12 or 20 sentinel cotton seedlings in a grid design. The distance between grid points was 15 m. The experiment was repeated 3 times in 2007 and 3 times in 2008. In addition, GIS maps have been created of two 10 km radius landscapes near Dalby, SE Queensland, with the native vegetation and crop types present in October 2007 and 2008.

11. IP Register

N/A