Cooperative Research Centre for National Plant Biosecurity

Final Report

CRC30009

Grains Surveillance Strategy

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1. Executive Summary

To ensure that the high plant health status of the Australian grains industry is maintained, activities that support biosecurity risk mitigation are essential. Within the grains industry, surveillance activities and preparation of contingency plans for key pest threats have been identified as critical components of biosecurity preparedness and prevention.

To fulfil these objectives, this project developed contingency plans for 18 key priority pest threats of plants and one weed species. In addition, the grains industry preparedness was strengthened with the revision and updating of five high risks pests to include recent research findings. Completion of these contingency plans ensures that all high risk pests of major grain crops will be covered by a contingency plan. These plans provide detailed information on pest life cycles, their potential for entry, establishment and spread, survival strategies and methods for surveillance and sampling. 'Contingency plans' will be used for development of 'response plans' in the event of detection of an exotic pest assessed current surveillance activities and phytosanitary requirements for export of grains from Australia.

Provision of an active biosecurity awareness program that delivered messages to growers, grain companies, and research and government agencies was a key part of this project with grains biosecurity officers employed by the Grains Farm Biosecurity Program to promote biosecurity awareness and improve on-farm biosecurity practices.

The third component of this project developed surveillance plans for Russian wheat aphid, Hessian fly and Sunn pest. Designing surveillance for early detection of exotic plant pests in grains is a complex task. This project assessed the use of general surveillance, comprising paddock monitoring from everyday on-farm activities to detect three different priority pests. While it was recognised general surveillance will have lower detectability, it is implemented with much broader coverage than is possible with targeted surveillance.

In developing these surveillance plans, statistical modelling provided both a qualitative and quantitative analysis of the effectiveness of a single snapshot of general surveillance for the early detection of these pests. A Bayesian hierarchical modelling framework was used. It is similar to Stochastic Scenario Trees (SSTs) and is one of the few approaches that permits examination of negative predictive values. It also allows several sampling strategies to be considered in combination, rather than one at a time and is able to reflect expert uncertainty or measurement uncertainty in all parameters. It can provide a basis to extend evaluation of a single snapshot to a more realistic evaluation of two or more snapshots, which often occurs in general surveillance of crops.

For Russian wheat aphid, general surveillance was effective when paddocks extended no further than 1 km from the road, and when visibility from vehicle scans was high (about 300 m was visible from the road). For deeper paddocks (5 km or 10 km from road), the number of potentially missed infested plants meant that early detection of the pest was unlikely. For Sunn pest, general surveillance didn't need to detect the pest at such low levels as a rapidly spreading pest like Russian wheat aphid. This led to a slightly greater potential to reveal the pest early. For Hessian fly both the field symptoms and the pest itself are difficult to detect, leading to lower chance of a single snapshot detecting this pest.

2. Aims and objectives

This project was undertaken to build on the outcomes achieved in the previous project including review of the Grains Industry Biosecurity Plan, ensuring that the level of biosecurity preparedness of the Australian grains industry was raised. In this project, the priority areas addressed included:

- development of contingency plans for high priority emergency plant pests of the grains industry,
- raising awareness of high priority pests and biosecurity in grains, and
- development of surveillance plans which identify minimum data required for early detection of, and area freedom from, “in-crop” exotic pests.

The development of specific contingency plans for high priority pest threats and weed species provides background information on the pest biology and control measures to assist with preparedness for an incursion of these pests and weed species into Australia. Each contingency plan provides guidelines and options for steps to be undertaken and considered when developing a Response plan for incursion of that pest. Use of these contingency plans in the event of an incursion will ensure the most rapid, cost effective and appropriate response is undertaken and will benefit the agencies undertaking emergency response and the grains industry as a whole.

Raising awareness of the Grains Industry Biosecurity Plan, the Emergency Plant Pest Response Deed (EPPRD), PLANTPLAN and grains biosecurity practices as a whole, is essential to ensure the industry understands the importance of biosecurity and the activities involved in preparedness, prevention and response. Improved biosecurity awareness benefits all stakeholders in the grains industry.

The development of surveillance plans for Russian wheat aphid, Hessian fly and Sunn pest that captured the minimum surveillance data required for early detection of each pest assists Australia’s biosecurity preparedness for the possible entry of such pests. To achieve this aim, this project addressed three main objectives:

1. Develop a conceptual model that can be implemented within a statistical modelling framework for examining performance of general surveillance, which is sufficiently flexible to address early detection of pests.
2. Utilise techniques that recognise measurement error to quantify the parameters within the statistical model, for the exemplar pests.
3. Implement the statistical models to assess general surveillance for these three case studies.

3. Key findings

The CRC30009 project (2010-2012) further extended the grain industry's biosecurity preparedness for incursion of exotic pests ensuring that all stakeholders within the supply chain from the grower right through to the end-users, are biosecurity prepared. The project was divided into three main components.

Development of contingency plans

- This project developed 14 pest-specific contingency plans for both high and medium priority threats for major and minor grain crops as well as one weed species. Updates of contingency plans for a further nine pests were completed. An audit of existing preparedness was also undertaken.

Biosecurity awareness

- This project raised biosecurity awareness using five grains biosecurity officers employed through the Grains Farm Biosecurity Program. These biosecurity officers promoted awareness of the EPPRD and grains industry biosecurity preparedness activities. They also provided information and material to growers and consultants improve on-farm biosecurity practices such as farm hygiene, use of biosecurity signage and surveillance for exotic pests.

General surveillance to detect Russian wheat aphid, Hessian fly or Sunn pest

The development of surveillance plans for Russian wheat aphid, Hessian fly and Sunn pest was based on information provided for situations in the Western Australian grain belt. Results indicated that general surveillance i.e. surveillance in the form of crop monitoring undertaken routinely by growers and consultants, has the potential to provide significant information on the absence of high priority pests in the grains industry.

For example, a single paddock surveillance snapshot for Hessian fly and Sunn pest estimated that no more than 12% of infested plants have been missed, at prevalence levels of interest. This applies for paddocks that extend 1 km or 5 km from the road, when 300 m of the depth of the paddock is visible from the road.

For Russian Wheat Aphid, a comparable level of pest freedom (no more than 10% of infested square metres missed), can be made if between 100 m of a 1 km paddock is visible from the road. However for this pest, this level of infestation is unlikely to be sufficient to detect the pest early enough where eradication may be technically feasible, since expert opinion suggested an initial single square metre infested could rapidly expand to levels that are not eradicable.

Further analysis is required to incorporate the knowledge that crop monitoring (surveillance) is often repeated throughout the season, thereby improving the likelihood of early detection.

3.1. Development of pest specific contingency plans

One of the key tools in industry preparedness for incursions of exotic pests is the development of contingency plans specific to each pest. The plans provide detailed information on the pest life cycles, pest entry, establishment and spread potentials, pest survival strategies and methods for surveillance and sampling. They also form the basis for development of Response Plans in the event of detection of an exotic pest.

Within this project, contingency plans were commissioned for 14 priority exotic plant pests and one weed species with an additional nine contingency plans updated during this project (Table 1). Completion of these contingency plans ensures that all high risk pests of major grain crops are covered by a contingency plan leaving 10 high risk pests for minor crops and 37 medium risk pests (from all crops) in the Industry Biosecurity Plan for the Grains Industry not covered by a contingency plan or pest risk review.

These pests were selected on the basis of their priority status provided in the Industry Biosecurity Plan Threat Summary Tables, as well as on the size of the area affected (host range and distribution) should an incursion occur. Contingency plans developed as part of this project can be found in Table 1.

An audit of all grain pest specific biosecurity reference material held electronically by Plant Health Australia including contingency plans, pest risk reviews and diagnostic protocols was undertaken. The content of each document has been given a preparedness rating based on the condition of the document in terms of completeness, length and content information (Table 2). The audit contains a summary of information for more than 80 different High and Medium priority grain pests or groups of pest species and includes documents produced prior to this project, for other plant industries or material that is more than seven years old (Table 3).

Table 1. Contingency plans developed as part of the CRC 30009 project

Common name	Scientific name
Black chaff, bacterial streak	*Xanthomonas translucens* pv. *translucens*
Cereal cyst nematodes	*Heterodera latipons; H. filipjevi;* *H. avenae* (exotic strains)
Corn earworm	*Heliocoverpa zea*
Crown rust of barley	*Puccinia coronata* f. sp. *hordei*
Fusarium wilt (of chickpea, lentil and lupin)	*Fusarium oxysporum* f. sp. *ciceris*, *Fusarium oxysporum* f. sp. *lentis*, *Fusarium oxysporum* f. sp. *lupini*
Leaf spot of field peas	*Alternaria humicola*
Leaf blight of wheat	*Alternaria triticina*
Leaf blotch of cereals	*Bipolaris spicifera* (formerly *Drechslera tetramera*)
Maize dwarf mosaic virus	*Maize dwarf mosaic virus (Potyvirus)*
Net form of net blotch	*Pyrenophora teres* f. sp. *teres*
Pea leaf weevil	*Sitona lineatus*
Philippine downy mildews of maize and Philippine mildew of sorghum	*Perenosclerospora philippinensis;* *P. sorghi*
Rape beetle	*Meligethes aeneus*
Rape stem weevil and Cabbage weevil	*Ceutorhynchus napi; C. pallidactylus*
Spotted stalk borer	*Chilo partellus*
Stem rust of wheat (Ug99)[1]	*Puccinia graminis* f. sp. *tritici* pathotype Ug99
Verticillium wilt of canola	*Verticillium longisporum*
Wheat aphid	*Sitibion avenae*
Wheat stem maggots	*Meromyza saltatrix* and *M. americana*
Witch weed	*Striga asiatica* and *S. hermonthica*

Contingency Plans for all grain pests can be found on the Plant Health Australia website (www.phau.com.au/pidd).

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[1] A review of the Australian grains industry's ability to respond to the arrival of stem rust of wheat (*Puccinia graminis* f. sp. *tritici*) pathotype Ug99

Table 2. Preparedness ratings based on the condition of the document in terms of completeness, length and information content

Preparedness rating	Comments
Good	Documents classified as being in good condition are complete, of an acceptable length and contain adequate information.
Fair - Good	Documents that are classified as being in fair-good condition are documents that are complete but either significantly shorter than comparable documents or have minor formatting issues, such as 'Draft' watermarks, highlighting or track changes. If the pest is a medium or high risk pest further work may be required but is not likely to be essential.
Fair	Documents that are classified as being in fair condition are documents that short or missing some information. If the pest is a medium or high risk pest further work may be required.
Poor - Fair	Documents that are classified as being fair – poor are documents that are that short or missing some information. If the pest is a medium or high risk pest further work is likely to be required.
Poor	Documents that are classified as being in poor condition are documents that are missing paragraphs or other important information. If the pest is a medium or high risk pest further work is likely to be required.

Table 3. Audit of grain pest specific reference material held electronically by Plant Health Australia

Pest	Scientific name	Overall risk	Hosts	Contingency plan[2]	Pest risk review[2]	Threat data sheets[2]	Diagnostic protocol[2]
American leaf miner (syn. Vegetable leaf miner)	*Liriomyza sativae*	High	Peanut		Fair-Good/2006		
American serpentine leaf miner	*Liriomyza trifolii*	High	Chickpea, faba bean, lentil, lupin, peanut, soybean	Good/2008[3]	Poor – Fair/2005	Good/2001	Fair-Good/2005
Annual ryegrass toxicity	*Rathayibacter toxicus*	High –in Australia	Ryegrass			Good/2002	
Bacterial leaf streak	*Xanthomonas translucens* pv. *translucens*	Low	Barley, wheat, oats	Fair-Good/2011[3]			
Barley mild mosaic virus	*Barley mild mosaic virus (Bymovirus)*	Unknown	Barley		Good/2005		
Barley stem gall midge	*Mayetiola hordei*	Very Low to High (depending on crop)	Barley, triticale, wheat	Good/2008[3]		Good/2005	
Barley stripe mosaic virus	*Barley stripe mosaic virus (Hordeivirus)*	Low in IBP Medium in Contingency Plan	Barley, oats, wheat	Good/2009[3]			
Barley stripe rust[4]	*Puccinia striiformis* f. sp. *hordei*	High	Barley	Good/2010[3]			Good/2005
Barley yellow mosaic virus	*Barley yellow mosaic virus (Bymovirus)*	Negligible	Barley		Good/2005		

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[2] Where pest specific reference material available, the preparedness rating (see Table 2) and year developed are listed

[3] Contingency plan created as part of Grains Surveillance Strategy (2009-12) CRC 30009

[4] A factsheet for this species is included in the Grains Farm Biosecurity Manual (FBM)

Pest	**Scientific name**	**Overall risk**	**Hosts**	**Contingency plan**[2]	**Pest risk review**[2]	**Threat data sheets**[2]	**Diagnostic protocol**[2]
Bean leaf roll virus	*Bean leaf roll virus (Luteovirus)*	Medium –in Australia	Pea, lentil, faba bean, chickpea			Fair/2001	
Bean yellow mosaic virus	*Bean yellow mosaic virus (Potyvirus)*	Low	Lupin		Good/2005		
Branched broomrape	*Orobanche ramosa*	Unknown	Broadleaf	Poor/2008			
Brassica pod midge	*Dasineura brassicae*	Medium	Canola	Good/2011	Good/2008		
Broad bean mottle virus	*Broad bean mottle virus (Bromovirus)*	Negligible	Chickpea, faba bean, field pea and lentil				Good/2006
Broad bean stain virus	*Broad bean stain virus (Comovirus)*	Low	Faba bean, lentil and field pea				Good/2005
Broad bean true mosaic comovirus	*Broad bean true mosaic virus (Comovirus)*	Low	Faba bean and field pea				Good/2005
Broomrape	*Orobanche aegyptica*	Unknown	Broadleaf		Fair/2006		
Cabbage lopper	*Trichoplusia ni*	Very low	Canola, chickpea, faba bean, field pea, lupin, peanut, soybean, sunflower		Good/2008		
Cabbage seedpod weevil	*Ceutorhynchus assimilis*	Medium	Canola	Good/2011	Good/2008	Fair-Good/2001	
Cereal cyst nematode	*Heterodera avenae* (exotic strains)	Medium	Barley, oats, wheat	Good/2011-12[3]			
Cereal cyst nematode	*Heterodera filipjevi*	Medium	Wheat	Good/2011-12[3]	Fair-good/2008		
Cereal cyst nematode	*Heterodera latipons*	Medium	Wheat	Good/2011-12[3]	Fair-Good/2008		
Cereal cyst nematode	*Heterodera ciceri*	Medium	Chickpea	Good/2011-12[3]	Fair-Good/2008		

Pest	**Scientific name**	**Overall risk**	**Hosts**	**Contingency plan**[2]	**Pest risk review**[2]	**Threat data sheets**[2]	**Diagnostic protocol**[2]
Cereal cyst nematode	*Heterodera glycines*	Medium	Soybean	Good/2011-12[3]	Fair-Good/2008		
Cereal cyst nematode	*Heterodera goettingiana*	Medium	Field pea	Good/2011-12[3]	Fair-Good/2008		
Cereal cyst nematode	*Heterodera zeae*	Medium	Maize, oats, wheat	Good/2011-12[3]	Fair-Good/2005		
Cereal leaf miners	*Agromyza ambigua*	Very Low	Barley, oats, maize, triticale, wheat	Good /2009[3]			
Cereal leaf miners	*Agromyza megalopsis*	Very Low	Barley, oats, maize, triticale, wheat	Good /2009[3]			
Cereal leaf miners	*Cerodontha denticornis*	Very Low	Barley, oats, maize, triticale and wheat	Good /2009[3]			
Cereal leaf miners	*Chromatomyia fuscula*	Very Low	Barley, oats, maize, triticale and wheat	Good /2009[3]			
Cereal leaf miners	*Chromatomyia nigra*	Very Low	Barley, oats, maize, triticale, wheat	Good /2009[3]			
Corn earworm	*Helicoverpa zea*	Medium to Very Low depending on crop affected	Chickpea, faba bean, lentil, maize, oat, peanut, sorghum, soybean, sunflower, triticale, wheat	Good/2009[3]			
Cowpea mild mottle virus	*Cowpea mild mottle virus (Carlavirus)*	Low	Peanut		Good/2005		
Crown rust of barley	*Puccinia coronata* f. sp. *Hordei*	High	Barley	Good/2011-12[3]			
Downy mildew of maize	*Perenosclerospora philippensis*	High	Maize, sorghum	Good/2009[3]			Poor-fair/2007
Downy mildew of maize	*Perenosclerospora sorghi*	High	Maize, sorghum	Good/2009[3]	Fair – Good/2005		

Pest	Scientific name	Overall risk	Hosts	Contingency plan[2]	Pest risk review[2]	Threat data sheets[2]	Diagnostic protocol[2]
Downy mildew of sunflower	*Plasmopara halstedii*	High	Sunflower		Fair-Good/2005		
Dwarf bunt of wheat	*Tilletia controversa*	Very Low	Barley, triticale, wheat	Good/2007[3]			Good/2006
European snails	*Cernuella virgata* (da Costa), *Theba pisana*, *Cochlicella acuta*, *Cochlicella barbara*	Medium Already in WA	Most crops			Poor/2002	
European wheat stem sawfly	*Cephus pygmeus*	Medium	Barley, oats, wheat and triticale	Good/2008[3]			
Field pea and lentil rust	*Uromyces vicae-fabae*	Medium	Field pea and lentil	Good/2009[3]	Good/2005		
Field pea and lentil rust	*Uromyces pisi*	Medium	Field pea	Good/2009[3]	Good/2005		
Fusarium head scab	*Fusarium graminearum*	Medium in WA	Wheat			Fair-Good/2004	
Fusarium wilt of canola	*Fusarium oxysporum* f. sp. *conglutinans*	Medium	Canola	Good/2007[3]			
Fusarium wilt of chickpeas	*Fusarium oxysporum* f. sp. *ciceris*	High	Chickpea	Good/2009[3]			Good/2007
Fusarium wilt of lentils	*Fusarium oxysporum* f. sp. *lentis*	Medium	Lentil	Good/2009[3]			
Fusarium wilt of lupins	*Fusarium oxysporum* f. sp. *lupini*	Medium (lupin) to low (faba bean)	Lupin and faba bean	Good/2009[3]		Fair-Good/2005	
Fusarium wilt of pea	*Fusarium oxysporum* f. sp. *pisi*	Medium in Australia	Field pea	Good/2009[3]		Fair-Good/2002	
Goss's wilt (Bacterial wilt and blight) of corn	*Clavibacter michiganensis* ssp. *nebraskensis*	Very low	Maize		Fair/2004		Good/2005

Pest	Scientific name	Overall risk	Hosts	Contingency plan[2]	Pest risk review[2]	Threat data sheets[2]	Diagnostic protocol[2]
Hessian fly[4]	*Mayetiola destructor*	Medium	Barley, oats, triticale, wheat	Good/2005 revised 2012	Good/2007		
Karnal bunt[4]	*Tilletia indica*	Extreme	Triticale wheat	Good/2006 revised 2011-12	Fair-Good/2005		Good/2004
Khapra beetle[4]	*Trogoderma granarium*	Low to High depending on crop affected	Barley, canola, chickpea, faba bean, field pea, lentil, lupin, maize, oat, peanut, soybean, sunflower, triticale, wheat	Good/2005 revised 2011-12	Good/2005		
Leaf blight of wheat	*Alternaria triticina*	High	Barley, triticale, wheat	Good/2009[3]	Poor/2005		
Leaf blotch of cereals	*Bipolaris spicifera*	Low	Field pea and lentil	Good/2009[3]			
Leaf rust of wheat	*Puccinia recondite*	High	Wheat	Poor/2008			
Leaf rust of wheat	*Puccinia triticina*	High	Wheat	Poor/2008			
Leaf spot of peas	*Alternaria humicola*	High	Field pea	Good/2009[3]			
Lentil anthracnose	*Colletotrichum truncatum*	High	Lentil	Good/2008[3]		Fair-Good/2001	Good/2005
Maize dwarf mosaic virus	*Maize dwarf mosaic virus (Potyvirus)*	Medium	Maize and sorghum	Good/2011[3]	Good/2005		Good/2004
Maize leaf hopper	*Cicadulina mbila*	Very Low	Maize		Fair-Good./2005		
May beetle	*Phyllophaga* sp.	High	Maize, peanut, sorghum, soybean, sunflower	Good/2008[3]			
Net form of net blotch (exotic pathotypes)	*Pyrenophora teres* f. sp. *teres*	High in IBP. But given as Medium in CP.	Barley	Good/2009[3]			
Pea early browning	*Pea early browning virus (Tobravirus)*	Negligible	Field pea, faba bean, lupin				Good/2006

Pest	**Scientific name**	**Overall risk**	**Hosts**	**Contingency plan**[2]	**Pest risk review**[2]	**Threat data sheets**[2]	**Diagnostic protocol**[2]
Pea enation mosaic virus	*Pea enation mosaic virus (Enamovirus + Umbravirus)*	Low	Chickpea, faba bean, field pea, lentil				Good/2007
Pea leaf miner	*Liriomyza huidobrensis*	Very Low	Faba bean , field pea, lupin				Fair-Good/2005
Pea leaf weevil	*Sitona lineatus*	Medium	Chickpea, faba bean, field pea, lupin, peanut, soybean	Good/2005 revised 2011-12[3]			
Peanut stripe virus	*Bean common mosaic virus (Potyvirus), peanut stripe strain*	High to Very Low depending on the crop affected	Lupin, peanut		Good/2005		
Phomopsis stem canker	*Phomopsis helianthi*	High	Sunflower		Fair-Good/2005		
Pulse seed beetle	*Bruchus rufimanus*	Very Low	Chickpea, faba bean, field pea and lentil			Fair-Good/2005	
Rape beetle	*Meligethes aeneus*	Medium	Canola	Good/2011-12[3]			
Rape stem weevil	*Ceutorhynchus napi*	Medium	Canola	Good/2011-12[3]			
Cabbage weevil	*Ceutorhynchus pallidactylus*	Medium	Canola	Good/2011-12[3]			
Red clover vein mosaic virus	*Red clover vein mosaic virus (Carlavirus)*	Medium	Chickpea, faba bean, field pea	Good/2008[3]			Good/2007
Red spotted sap beetle	*Glischrochilus fasciatus*	Very Low	Maize		Good/2005		
Russian wheat aphid[4]	*Diuraphis noxia*	High	Barley, oat, wheat and triticale	Good/2005 revised 2011-12	Good/2008		
Silver leaf white fly	*Bemisia tabaci* Biotype Q	Low	Soybean. Also vector of viruses		Fair-Good/2005		

Pest	Scientific name	Overall risk	Hosts	Contingency plan[2]	Pest risk review[2]	Threat data sheets[2]	Diagnostic protocol[2]
Soil borne viruses of wheat	*Soil-borne wheat mosaic virus (SBWMV), Soil-borne cereal mosaic virus (SBCMV), Chinese wheat mosaic virus (CWMV); bymoviruses, wheat spindle streak mosaic virus (WSSMV), Wheat yellow mosaic virus (WYMV); pecluviruses, Indian peanut clump virus (IPCV), Peanut clump virus (PCLV)*	Negligible	Wheat		Good/2005		Good/2005
Sorghum mosaic virus	*Sorghum mosaic virus (Potyvirus)*	Unknown	Sorghum		Fair-Good/2005		
Sorghum shoot fly	*Atherigona soccata*	Medium	Sorghum	Good/2008[3]	Good/2005		
Soybean cyst nematode	*Heterodera glycines*	Medium	Soybean		Good/2005		
Spider mites	*Tetranychus spp.*	Low	Most crops				Good/2005
Spotted stalk borer	*Chilo partellus*	Medium	Maize sorghum	Good/2009[3]			
Stem canker of sunflower	*Diaporthe helianthi* Ana. *Phomopsis helianthi*	High	Sunflower		Fair /2005		
Stem rust of wheat[4]	*Puccinia graminis* f. sp. *tritici pathotype Ug99*	High	Wheat	Good/2009[3]			
Stewarts wilt of maize	Erwinsia stewartii sp. stewartii	Medium	Maize		Good/2004		Good/2004
Striga (witchweed)	*Striga asiatica*	High	wheat, barley, sorghum,	Good/2011-12[3]			

Pest	Scientific name	Overall risk	Hosts	Contingency plan[2]	Pest risk review[2]	Threat data sheets[2]	Diagnostic protocol[2]
	Striga hermonthica		maize				
Sudden death syndrome	*Fusarium solani* f. sp. *glycines*	Unknown	Soybean		Good./2005		
Sunflower bud moth	*Suleima helianthana*	Medium	Sunflower		Good/2005		
Sunflower moth	*Homoeosoma electellum*	Medium	Sunflower		Good/2005		
Sunn pest[4]	*Eurygaster integriceps*	Medium to Low depending on the crop affected	Barley, oat, sorghum, triticale, wheat	Good/2008 revised 2011-12[5]	Good/2005		
Thrips	*Thysanoptera* family	Low	Wide host range				Good/2002
Turnip moth	*Agrotis segetum*	Medium	Barley, canola, chickpea, faba bean, field pea, lentil, lupin, maize, oat, peanut, soybean, sunflower, triticale, wheat	Good/2011	Good/2006		
Verticillium wilt	*Verticillium dahliae var. longisporum (syn. V. longisporum)*	Medium	Canola	Good/2011[3]		Fair-Good/2001	
Wheat aphid	*Diuraphis frequens*	Medium	Maize, triticale, wheat	Good/2009[3]			
Wheat bug	*Nysius huttoni*	Medium to Low depending on crop affected	Barley, oats, triticale, wheat	Good/2008[3]			
Wheat spindle streak mosaic virus	*Wheat spindle streak mosaic virus (Bymovirus)*	Negligible	Wheat ,triticale				Good/2005

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[5] Contingency plan created as part of Grains Surveillance Strategy (2009-12) CRC 30009. Note this contingency plan was updated with new reference material

Pest	Scientific name	Overall risk	Hosts	Contingency plan[2]	Pest risk review[2]	Threat data sheets[2]	Diagnostic protocol[2]
Wheat stem maggot	*Meromyza saltatrix*	Medium to Very Low depending on the crop affected.	Oat, triticale, wheat	Good/2009[3]			
Wheat stem sawfly	*Cephus cinctus*	Medium	barley, oats, wheat and triticale			Fair-Good/2002	
Wheat streak mosaic virus	*Wheat streak mosaic virus (Tritimovirus)*	Unknown	Wheat, barley, oats, rye and maize		Fair-Good/2003		

The audit of grains biosecurity preparedness material identified the following:

1. contingency plans that were considered inadequate and lacking fundamental information
2. contingency plans where information was lacking but have since been updated to reflect new research
3. contingency plans that were extremely detailed and have been edited to align more closely with the contingency plan format that could then be readily used to develop a Response plan (Table 4).

Table 4. Contingency plans that have been modified as part of this project

Common name	Scientific name
Karnal bunt of wheat	*Tilletia indica*
Hessian fly	*Mayetiola destructor*
Sunn pest[6]	*Eurygaster integriceps*
Khapra beetle	*Trogoderma granarium*
Russian wheat aphid	*Diuraphis noxia*

3.2. Raising biosecurity awareness

The main delivery mechanism for raising awareness of biosecurity issues (including an understanding of exotic pest threats and good farm hygiene practice) has been the Grains Farm Biosecurity Program.

The Grains Farm Biosecurity Program (GFBP) is an initiative managed by Plant Health Australia (PHA) administered by Grain Producers Australia (GPA) and funded by grower levies, which improves the management of, and preparedness for, biosecurity risks in the grains industry at the farm gate and industry level.

To help Australian grain growers ensure biosecurity is appropriately practiced on their farms, the program employs Grains Biosecurity Officers (GBOs) in five states (Western Australia, South Australia, Victoria, New South Wales and Queensland). GBOs are a dedicated source of support to grain growers looking for information and assistance in improving biosecurity on-farm. They promote the importance of biosecurity across the grains industry for maintaining productivity, profitability, sustainability, market access and trade, and, ultimately, grower livelihoods. In the event of a detection of a serious pest threat to the grains industry the GBOs are on hand to provide expert support to industry and help with the design and implementation of response measures under the Emergency Plant Pest Response Deed that operates between governments and Australia's plant industries.

One way GBOs help grain growers and industry to improve biosecurity status is to encourage practice change on-farm. The GFBP program has undertaken and continues to deliver a range of activities to drive practice change that includes:

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[6] This contingency plan was update to include new reference material

- Development of awareness material outlining biosecurity issues (including fact sheets, a Grains Farm Biosecurity Manual and promotional collateral to promote the GFBP).

- Raising awareness of the importance of biosecurity through consistent and ongoing releases of articles within the rural media. In addition to articles in the rural media, PHA has provided the content for a biosecurity page in GRDCs Groundcover. The biosecurity page highlights an article from a leading grain grower who demonstrates good biosecurity practices with a separate articles summarising biosecurity research. The biosecurity page has been feature of Groundcover for the past two years. Biosecurity was also the focus of the Groundcover supplement for January-February 2011 with four articles (six pages) prepared by the PHA team.

- Whilst the distribution of information in the form of manuals, pamphlets and fact sheets alone will not demonstrate practice change, when coupled with consistent and ongoing messages within the rural press, these mechanisms will assist with raising awareness of the importance of biosecurity.

- Other methods for delivery of biosecurity messages and to raise the profile of biosecurity to the grains industry is the identification of industry advocates, presentations to growers and researchers and provision of biosecurity support for field days, tours, workshops etc.

3.3. Surveillance plans for exotic pests

Three exemplar pests were selected to provide a basis for development of a conceptual model, and its subsequent parameterization: Russian wheat aphid, Sunn pest and Hessian fly. All three pests are high or medium pests of the grains industry. Russian wheat aphid is one of the top priority pests, due to its devastating impacts world-wide. Indicative of its high pest status is substantial research investment into preventative and contingency measures for controlling its spread in Australia.

The three pests were chosen to highlight different aspects of general surveillance. Russian wheat aphid (RWA) is small (up to 1.8 mm long), spreads easily and can be difficult to distinguish from other aphids (endemic pests). However with its distinctive symptoms, RWA provides a useful case study for examining the potential of general surveillance to detect a rapacious pest, early enough during establishment to make eradication possible. Symptoms of RWA infestation cause the leaves to roll up and white, purple or yellowish streaks to form, often awns are trapped by the rolled flag leaf, and grain heads be bleached in appearance. It was noted that these symptoms can also be caused by other diseases and disorders such as herbicide and virus damage, nutrient deficiencies and frost.

Sunn pest is a larger pest (10-13 mm long) that can be differentiated from other sap sucking shield bugs by colouration of the shield. Symptoms of Sunn pest infestation and crop damage include yellowing and dieback of the stem and leaves, stunting of the growth of tips and bud and whitening of the seed heads. This pest was considered a more likely candidate for successful general surveillance.

Hessian fly is small (2-4 mm) and feeding damage can cause leaf discolouration, from a darker green to bluish green or yellowing of new growth in seedlings. Plants are often stunted and tillers can become weakened causing plants to lodge. Infestation can be confused with frost damage

The project proceeded via a series of workshops.

1. The first workshop used Russian wheat aphid as the example to refine the conceptual model.
    - A semi-structured approach to eliciting expert knowledge was used, which was flexible to the conceptual model (refined through expert consultation), but provided a consistent framework for quantifying model parameters.
    - An ‘outside-in’ approach to elicitation was used based on ‘modellers’ experience in eliciting expert knowledge in terrestrial ecology and marine taxonomy.
    - Brief training was provided in the elicitation method at the outset of the workshop.
2. A second set of meetings addressed Sunn pest and Hessian fly, and also refined description of the aspects of general surveillance that differed from Russian wheat aphid.
    - The same semi-structured approach to elicitation of expert knowledge was used for most model parameters, which could be expressed as probabilities (e.g. detectability) or rates (levels of infestation of interest).
    - In addition, a scenario-based elicitation approach was used to elicit more complex relationships, such as the chance of detection in the field based on the level of damage.
    - More extensive training to remind experts of elicitation concepts and the overarching approach.
    - Given the more fully specified conceptual model on relevant general surveillance strategies, a protocol was developed and implemented to guide elicitation of expert knowledge to parameterize the model.

In the context of distilling the main components of surveillance modelling from these workshops, an overarching conceptual model was proposed, as depicted in Figure 1.

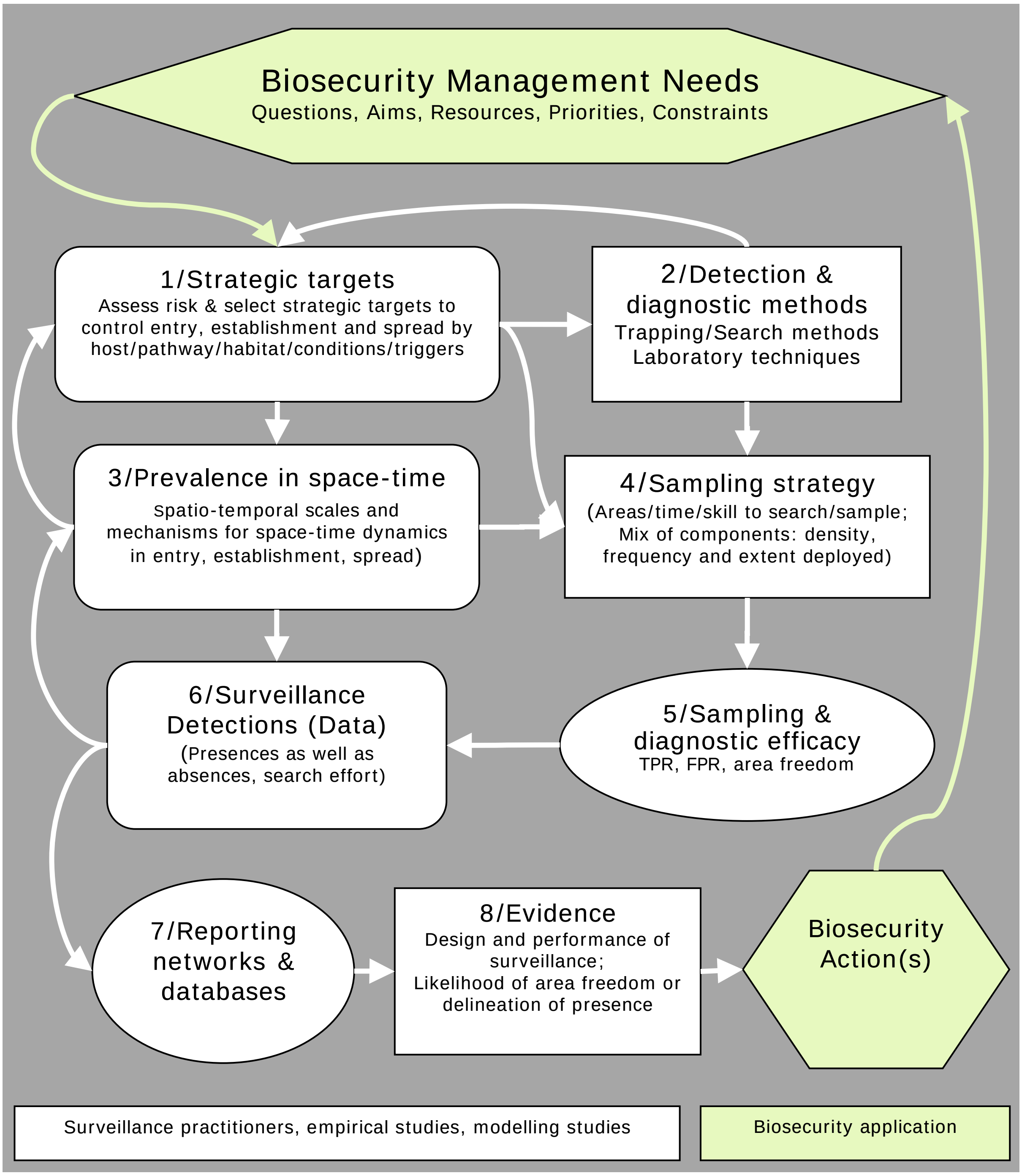


Figure 1: Conceptual model for developing design of surveillance for plant pests. Colours (legend shown) indicate potential source of information, which depend on the pest. Arrows indicate the flow of information between surveillance modelling components.

The underlying stages in surveillance to meet biosecurity management needs are:

1. Strategic target(s) for surveillance
2. Detection & diagnostic methods in the field and in the laboratory
3. Prevalence in space and time – dynamics and factors
4. Sampling strategy
5. Efficacy of sampling and diagnostic methods
6. Detections (raw data) obtained from surveillance
7. Reporting, including networks and databases
8. expression of these results in the form of evidence to inform and support

The outcomes from the model (stage 8) then inform Biosecurity Action(s). The biosecurity context provides the initial impetus for instigating the activities and analysis to produce the evidence, and ultimately this informs their actions.

This overall conceptual model extends the one proposed in the context of a multiple-species surveillance framework for detecting a wide range of pests on Barrow Island.

In summary, for general surveillance, these model components can be interpreted as follows.

1/ Target. A wide variety of plant pests may be exemplified by the three case studies. Pests may multiply rapidly (like Russian wheat aphid) or more slowly (like Hessian fly). Rapid development means that the pest must be detected at lower levels, which are more difficult to detect. Pests may be more or less symptomatic in the field or under a microscope. Russian wheat aphid produces highly distinctive symptoms whereas field symptoms from Hessian fly may be easily confused with frost or other common crop health problems. Sunn pest (as an insect rather than a symptom) is more easily discriminated whereas Hessian fly is difficult to identify.

2/ Detection. Detection is considered within the existing cascade of detection mechanisms that were originally designed to minimise false positives arising from general surveillance. The advantage of this cascade is that it makes the best use of plentiful resources with low detection ability and scarcer resources with higher detection ability. The detection occurs at three scales: in the field at the scales of *patches* in paddocks; upon closer field inspection of *plants* within patches; and finally in the laboratory based on *samples* of plants or pests. Empirical information on detection methods is not yet available in the Australian setting, so experts are pivotal to interpreting and transferring the little empirical evidence available to this setting.

3/ Prevalence. Given the lack of information on exotic plant pests that have never before entered the country, we consider a snapshot of surveillance, which requires no knowledge of the prior history of how the pest reached a given level of prevalence. However, instead of assuming that the level of prevalence is known, we examine performance of surveillance when prevalence is uncertain (facilitated by a Bayesian approach).

4/ Sampling strategy. A combination of search strategies were examined which reflect current farming practices that may reveal these pests, without directly targeting plant pests, but assumed instead to be focussed on examining plant health through crop monitoring. We focussed on more widespread general surveillance phases for crop health:

Phase I.	Vehicle scanning of paddocks for patches of suspicious symptoms, which are consistent with exotic plant pests (but not necessarily identified in the field as being an exotic rather than endemic plant pest).
Phase II.	Close-up inspection of plants within paddocks, to examine the worst symptoms of a suspicious patch; usually triggered by a Phase I vehicle scan.

Phase III.	Incidental inspection of plants within paddocks, via a walk-through, for example by a visiting agronomist, researcher.
Phase IV.	Confirmation by a taxonomic diagnostician, based on a physical sample of the pest.

In some cases it is possible to assume that detection in one phase will automatically trigger escalation to the next. For example, detection of distinctive crop symptoms in Phase I may be assumed to nearly always trigger close-up inspection in phase II, for pests with highly distinctive field symptoms such as Russian wheat aphid. For other less symptomatic pests (e.g. Sunn pest) there was some suggestion that escalation as a form of internal trigger from the same consultant from Phase I to Phase II. Alternatively external reporting may provide escalation between phases involving different people; for example escalation from Phases II or III to Phase IV, may be less certain. This introduced the need to explicitly model these ‘triggering’ or ‘reporting’ mechanisms.

For this project we examine potential to detect a pest within a paddock. Comprehensive sampling frames, describing the distribution of paddock sizes amongst farms within a region, would be required to quantify potential to detect a pest on a farm or in a region.

5/ Efficacy of detectability. Detectability at Phase I depends on whether moderately skilled farm workers would detect suspicious symptoms in a patch of plants, which is consistent with the exemplar pest. Detectability at Phase II depends on whether a follow-up inspection would reveal plant damage and/or pests that would raise suspicions sufficiently (in conjunction with patch-level evidence) to consider that the pest was not endemic. Confirmation by the taxonomist depends on the life-stage of the organism presented and whether sufficient accompanying information was supplied about the organism**.**

In many surveillance contexts, false positive rates are ameliorated by the cascade of detection mechanisms, and modelling focuses on quantifying true positive rates (or sensitivity) of each mode of detection. However, in general surveillance, false positives take on a different and important role. The more reports are triggered (between phases), the more true positives as well as false positives may arise. Thus a high false positive rate is expected from general surveillance, and indeed may not be a poor reflection of its ability to generate some true positives.

In most cases, empirical information on efficacy is not yet available, so we rely on expert assessments. By utilizing a structured approach to elicitation we aimed to minimize many biases that arise when asking experts to quantify their knowledge on a new topic. In particular we chose an ‘outside-in’ approach that elicits realistic bounds, a level of plausibility, before eliciting a best estimate. This helps avoid classic problems with logical reasoning and heuristics, such as anchoring and adjustment, representativeness bias, ambiguous baseline, and clarifies what the best estimate means to the expert.

6/ Detection data. For general surveillance, there already exists a well-structured system based on the cascade of detection and confirmation by increasingly more specialised inspectors. This system provides a strong system for dealing with potential positives. However it provides no support for negatives.

In this project, we demonstrate interpretation of surveillance when it returns all negatives, based on evaluating the negative or zero predictive value: *if nothing is detected, then how likely is it that the pest is absent? Or how many missed infested plants might there be?*. In this project we therefore concentrate on the predictive value of zeros: *If farm workers report no suspicious symptoms in a paddock, then how many exotic pests may have in fact been present?* Hence zero data is currently collated by inference rather than explicitly using standard databases and reporting mechanisms.

The Zero Predictive Value is related to the odds of: the chance of missing the pest, when it is indeed present at low, medium or high levels; compared to the chance of no false alarms with the pest is absent.

$$ZPV = 1 \Big/ \left\{ 1 + odds\left(\frac{\text{Missed when present, at LMH levels}}{\text{No false alarms when absent}} \right) \right\}$$

The numerator is related to the false negative rate (or equivalently the true positive rate) at low, medium or high levels of pest presence. It is weighted by the *a priori* hazard of pest presence in each of these situations. The denominator is related to the true negative rate (or equivalently the false positive rate) when the pest is absent, and is weighted by the *a priori* hazard of pest absence.

This provides an important basis for evaluating area freedom, not just in the context of early detection, but also for delimitation in areas adjoining an emergency outbreak, and post-treatment to establish that the pest has been eradicated.

7/ Reporting. Here we demonstrate the information requirements for evaluating whether current status of farms having 'no evidence of pest presence' can be upgraded to claims of 'evidence for pest absence' (Component 6). For a specific set of targets (Component 1), this requires constructing a conceptual model and matching statistical model that describe existing methods of detection (Component 2) and corresponding crop surveillance strategies that may detect exotic plant pests (Component 4), then quantify detectability for exemplar pests (Component 5).

8/ Evidence. We emphasize that this project has focussed on methodologies. The larger task of communicating results is part of a wider spectrum of activities beyond this project. These include activities within CRC90143 on designing surveillance in general. Concurrent representation and tasks on federal committees: until recently the Surveillance Reference Group (SRG), and more recently the Sub-Committee for National Plant Health Surveillance (SNPHS). These bodies oversee plant pest surveillance nationwide, provide guidelines for reporting from such methodologies, including the ones put forward here.

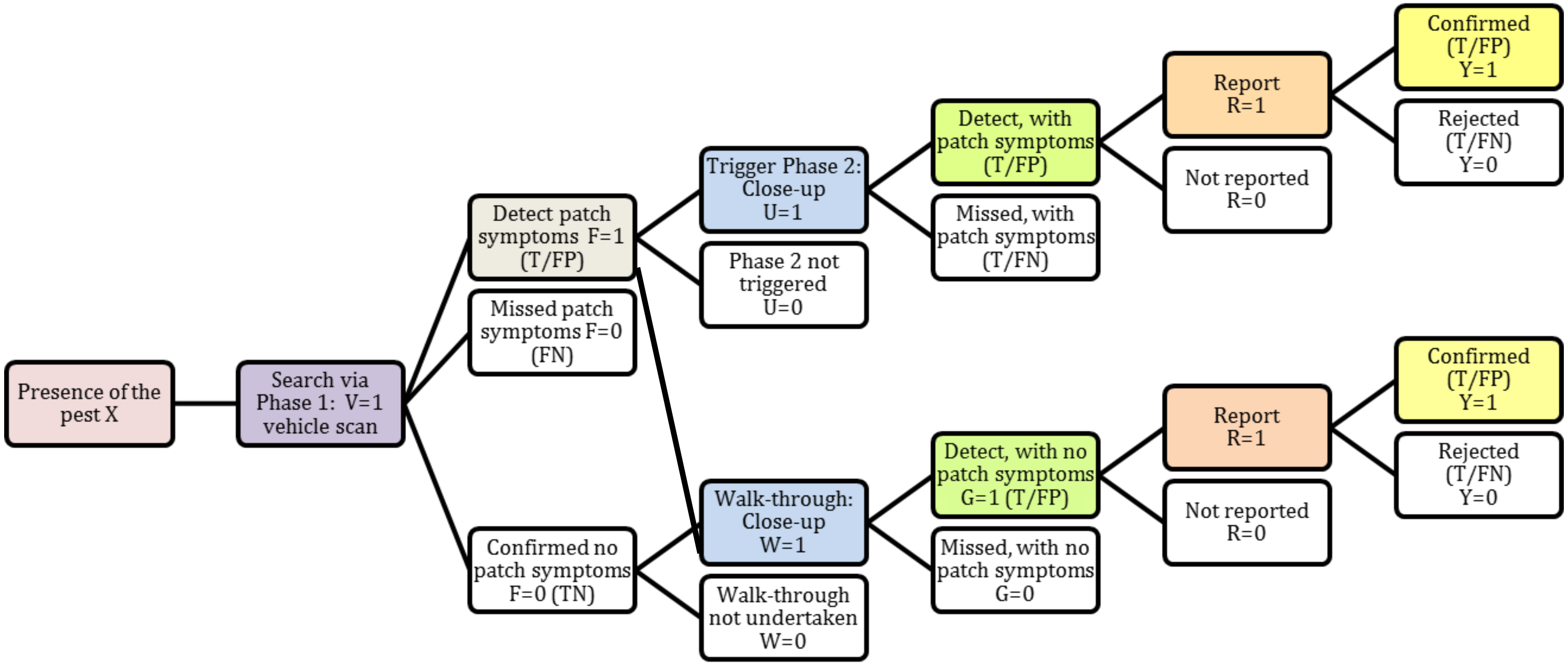


Figure 2: A process view of the conceptual model of general surveillance strategies. This emphasizes that pest prevalence (pink) is treated as a single snapshot, whilst observation is treated as a process (purple through yellow), and follows a classical separation of observational from latent presence process. The classical cascade of confirmation for positive detections is highlighted with colour, as searches progress from broader scales of patches in paddock (grey) through plant in patch scale (green) to laboratory samples of plants (yellow). Searches are triggered at each scale: patch (purple), plant (blue) and sample (red).

Table 5: Elements of the conceptual model expressed as random variables underlying a process view, and of the statistical model.

Detection	Phase	Description	Dependencies
X		Prevalence of the pest	
	V	Phase I Vehicle scan undertaken	
F		Detection of patch in paddock symptoms	V, X
	U	Phase II close inspection triggered;	F or X
	W	Walk-through undertaken	X
G		Detection of plant in patch symptoms	U,W, X
	R	Report of detection at plant in patch scale	G
Y		Diagnosis by taxonomist	R, X

3.3.2 Quantitative representation of the conceptual model

A graphical representation of how the conceptual model can be viewed in terms of a process is presented in Figure 2. This highlights the dependencies among elements of the model. For instance detectability at any stage (such as F for field detections arising from vehicle scans) depends on whether that phase of surveillance was undertaken or not (here denoted V). Every element in the process view relates to presence, detection or whether a phase of surveillance was undertaken (first column, Table 5). The process view also helps clarify the dependencies between elements in the model (last column, Table 5). For instance, as stated earlier, field detections F depend on whether vehicle scans were undertaken, V, but also on whether the pest is present.

To implement the conceptual model we utilize a hierarchical Bayesian model. These details are in preparation for publication as an important output from this project (Low-Choy, Taylor et al, in prep). For modelling general surveillance, this is replaced by: the sequential sampling strategy of two-phase vehicle-based field surveillance (V-U); sometimes in parallel with walk-throughs (W); and acknowledgement of the discretionary nature of the reporting process (R). However, similar approaches and underlying assumptions were utilized for modelling prevalence (X), and the final surveillance record of presence or absence (Y given R).

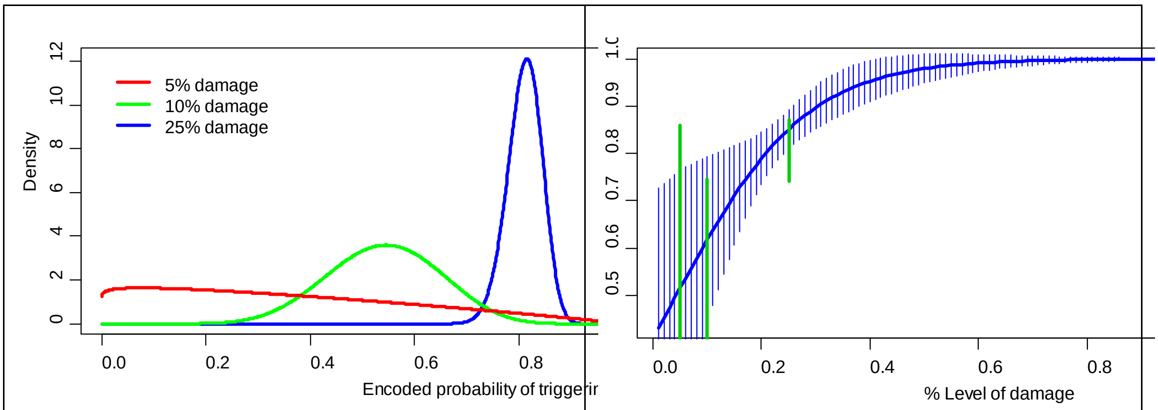
3.3.3 Detectability of different pests

Detection of the pest operates via a cascade of detection and reporting, involving specialists with increasing levels of skill in detecting the pest, but with ever-decreasing extent of search:

1. Patch in paddock: Field detection via a vehicle scan
2. Plant in patch: Close-up inspection of plants, either triggered by phase 1 or via a walk-through inspection for other purposes
3. Sample of a pest: ideally with a sample of the plant

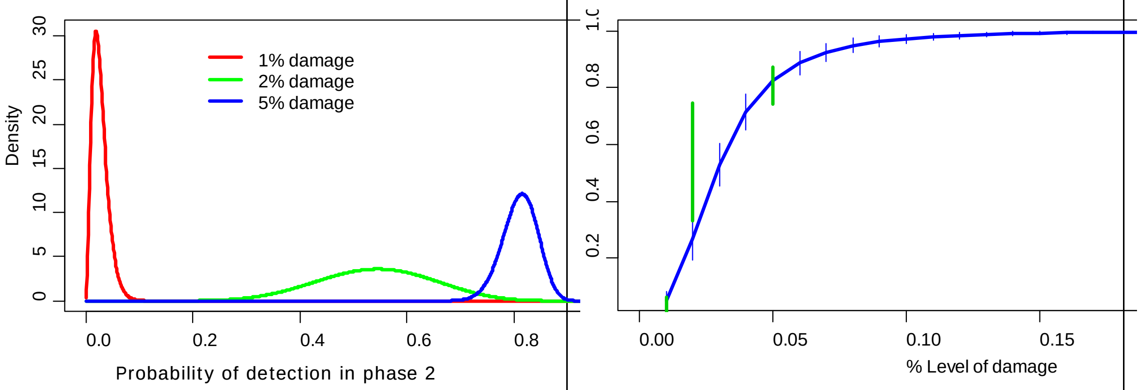
Detectability of each pest varies considerably due to the differences in the conceptual model reflecting the different ways that general surveillance can reveal the pest. Here we provide a summary. The easiest comparisons can be made at the diagnostic stage.

Diagnostic methods for confirming presence of the pests vastly differs in terms of detectability (Figure 3, attached separately). Younger life forms are not easily discerned for RWA (Sensitivity~50%) whereas adults are, both for Sunn Pest and RWA, and so are pupae for Hessian flies. The problem with detecting Hessian flies is that the adults are extremely small, so that detection requires pupae or late instar larvae. The false positive rate is markedly higher for late instar larvae of Hessian flies, so it is important to rely on identification via pupae. For the purposes of modelling, we considered scenarios where the more easily detected life stages were supplied for each pest; this was considered realistic since it was considered relatively common for these life stages to be presented for assessment.



Plausible levels (y-axis) for probability of triggering phase 2 on detecting patch-level symptoms from a vehicle (x-axis), encoded for discrete scenarios of level of damage (colour).

Probability of triggering phase 2 (y-axis) and 95% point wise prediction intervals, smoothed over level of damage (x-axis). Green vertical bars reflect elicited scenarios (shown at left) and their uncertainty.



As above, except that x-axis depicts the probability of detection in phase II.

As above, except that y-axis depicts Probability of detection in phase II.

Figure 4: Detectability for Hessian fly: Phase I triggering Phase II; and Sensitivity of Phase II

For Hessian fly, experts provided the probability of triggering a Phase II close-up inspection (row 1, Figure 4), and the sensitivity of phase II (row 2, Figure 4). For the latter, experts believed that 1% damage (red line) was difficult to detect even close-up, with high probability (height of y-axis) that detection was well below 1% (x-axis).

They were also certain that 5% damage (blue line) would be detectable since the probability of detection was between 70-90% (y-axis). The flatter blue curve arises because the experts' 'votes' are distributed over a wider range than for the 1% damage scenario, where their 'votes' are concentrated. We can compare the plausible levels of triggering or detecting in phase II, for different scenarios of damage (column 1, Figure 4). From these graphs it is evident that experts hold a fixed vision of scenarios with moderate or high probability, and that these are then assigned to different levels of damage, depending on the target of elicitation. Experts provided only moderate and high scenarios for triggering Phase II, so a relatively vague allocation of plausibility was provided for low probability scenario (red line, top left, Figure 4).

Smooth curves extrapolate the expert knowledge from specific scenarios to the full range of potential levels of damage, which provides more stable basis for modelling (right column, Figure 4). Here we see that a phase II inspection will almost certainly occur when the damage reaches 60% and has a high chance of occurring (over 80%) when damage exceeds 20% (top right, Figure 4). Similarly, we can be fairly certain that a close inspection will provide evidence of a pest when damage is 15% or more. At 2.5% damage, there is at least a 50-50 chance of detecting a pest.

The chance of reporting exotic pests increases with experience and the level of evidence, as depicted left to right in Figure 5. In the worst case scenario, with an inexperienced observer and little evidence, there is very little chance of reporting. It was considered 50-50 plausible that the chance of reporting would be less than 1%, 80% plausible that the chance of reporting would be less than 5%, and 100% plausible that reporting in this scenario could not exceed 20%. If the evidence became more substantial, then at most an inexperienced observer may plausibly report 40% of the time. A more realistic estimate is that reporting would occur in this situation between 10-20% of the time, with a best estimate of 15%. There is a much larger gap in reporting rates between the inexperienced and trained observers, than the impact of additional evidence.

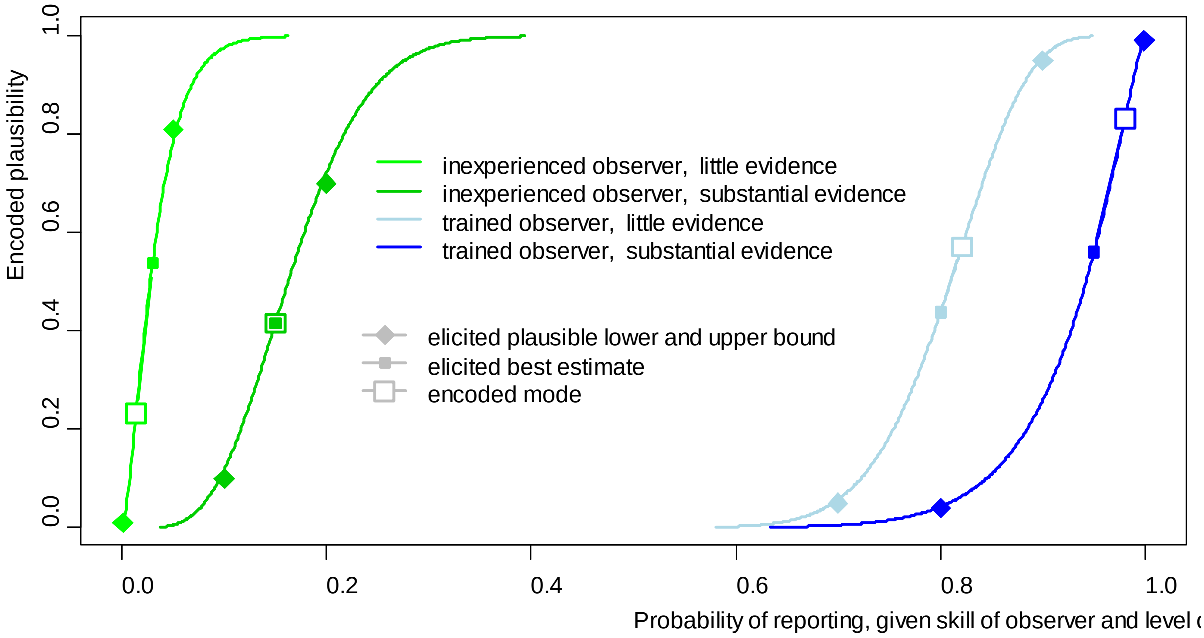
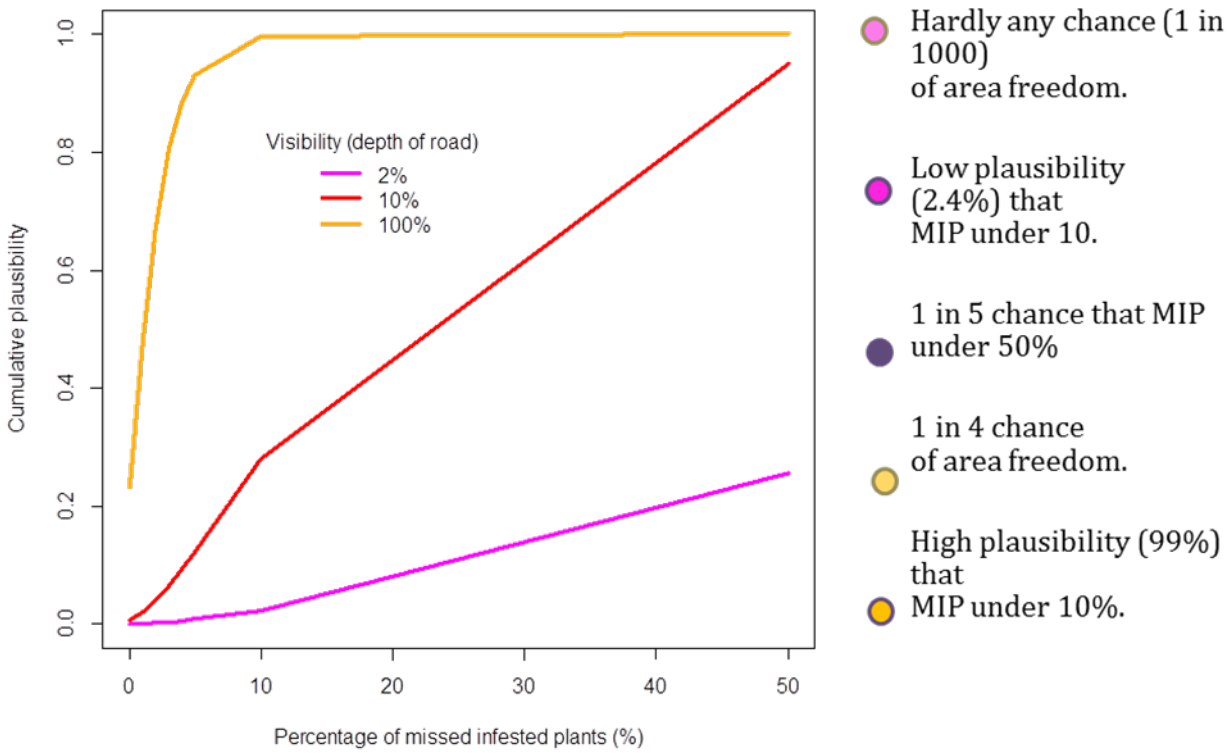


Figure 5: Reporting exotic pests

3.3.4 Potential for Confirming Area freedom

Russian wheat aphid

For Russian wheat aphid, when the visible portion of the paddock comprises just 2% of its depth, then there is hardly any chance (0.1%) of area freedom. There is low plausibility (2.4%) that at most 10% of the paddock is infested, however there is a 20% chance that at most 50% of the paddock is infested.



Hardly any chance (1 in 1000)
of area freedom.

Low plausibility (2.4%) that
MIP under 10.

1 in 5 chance that MIP under 50%

1 in 4 chance
of area freedom.

High plausibility (99%) that
MIP under 10%.

Figure 6: Cumulative plausibility (y-axis) of the proportion of missed infested plants (MIP) (x-axis). Three scenarios are considered, where visibility comprises just 2%, 10% to 100% of the depth of the paddock.

When only 10% of the paddock is visible from the road, there is also virtually no chance of area freedom. There is a 25% chance that 10% of the paddock is infested, or a very high chance (95%) that at most, 50% of the paddock is infested.

Consider the best case scenario, where the whole paddock is visible from the road. Then even if nothing is detected, there is a 25% chance of area freedom. There is a very high plausibility (99%) that only 10% of the paddock is infested, and nearly 100% plausibility that, at most, 50% of the paddock is infested.

For Russian wheat aphid, we consider a level of incursion of interest equivalent to a ‘suitcase’, or approximately a single square metre. We assess this square metre in the context of a kilometre of paddock, so prevalence level of interest is 1 in 1000 m^2, or 0.1%.

Sunn pest and Hessian fly

Despite their different levels of detectability at different scales, these two pests have similar levels of detectability overall, if we standardize to the levels of incursion of interest (that ensures each pest is still eradicable).

We compare the number of missed infested square metres of plants, assuming that 300 m of the paddock is visible from the road, for paddocks that extend 1000 m or 5000 m from the road (Figure 7).

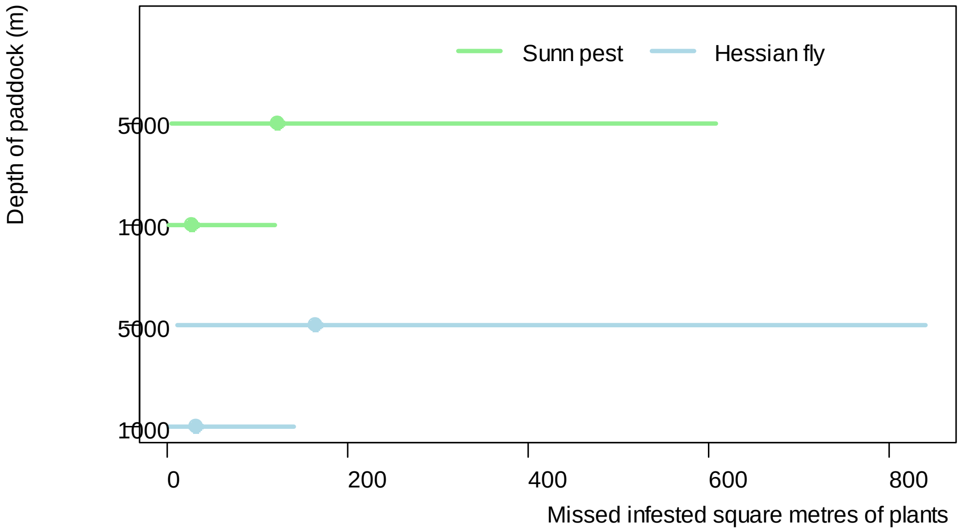


Figure 7: The median number of infested square metres of plants that are not detected, according to pest and depth of paddock. The lines show the lower 2.5th and upper 97.5th number in each scenario. Assume visible depth of paddock is 300 m. Note that detectability is assessed for a level of incursion of interest of 1 in 300 m^2 for Sunn pest, and 1 in 100 m^2 for Hessian fly; these correspond to detectable but still eradicable levels.

For Sunn pest an incursion of interest amounts to 1 affected square metre in 300, whereas for Hessian fly an incursion of interest is one third the size at 1 affected square metre in 100. Modelling examined the potential to detect each pest at their respective levels of interest, in the field via vehicular scan, potentially triggering a closer inspection, with the occasional walk-through. By standardizing on the incursion level of interest, we obtain comparable levels of missed infested plants, since Sunn pest is less likely to be missed in a single snapshot compared to Hessian fly.

This is most evident in larger paddocks (that extend 5 km from the road), where missed infestations could at worst amount to 600 m^2 (or 12% of the paddock) for Sunn pest, or 850m^2 (or 17% of the paddock). By ‘at worst’ we mean that there is only a 2.5% chance of exceeding this density of missed infested plants. In smaller paddocks (that extend 1 km from the road), missed infestations could at worst amount to 12% or 14% for Sunn pest or Hessian fly, respectively.

4. Implications for stakeholders

The development of contingency plans for key pest threats, biosecurity awareness and the development of surveillance plans for exotic pests form an important part of biosecurity preparedness and prevention activities for the grains industry.

As the development of Contingency Plans will provide information that will form the basis of Response Plans, these documents will have implications for agencies and industry personnel managing and participating in pest incursion responses. The provision of information within the Contingency Plans will assist with more rapid eradication, containment or management mechanisms being put in place, helping both deliverers and beneficiaries of the response.

Raising the profile and the ongoing promotion of biosecurity awareness using a coordinated approach through the Grains Farm Biosecurity Program, using grains biosecurity officers in the five major grain producing states has successfully promoted biosecurity to vast majority of grain growers.

With an increased need to provide data for area freedom from emergency plant pests or data for a level of detection that will maximise the chance of containment, eradication or implementation of rapid management the development of surveillance plans for Russian wheat aphid, Hessian fly and Sunn pest is highly valuable. The surveillance plans provide a valuable framework for collection and capture of data for both early detection of new pests and market access requirements.

Case study: a timely enquiry from a worried producer

In the week following the Surveillance plan workshop held with DAFWA staff in December 2012, a worried producer sent ‘bug’ specimens into DAFWA for identification.

These ‘bugs’ were prolific in numbers the grower noticed them flying off his lupin crop in front of the harvester. As the producer was concerned what the ‘bugs’ were, he emailed a photograph of the insects to DAFWA for identification.

The Shield bug was identified by DAFWA experts as *Coleotichus costatus*, a seed feeder of Acacia species (especially *A. cyclops*).

On first inspection, this Shield bug can be confused with Sunn pest and this case study provided a first hand example of how general surveillance by a grower led to reporting. Subsequent follow-up confirmed it wasn't a priority exotic pest.

Image of Shield bugs submitted by grower during harvest

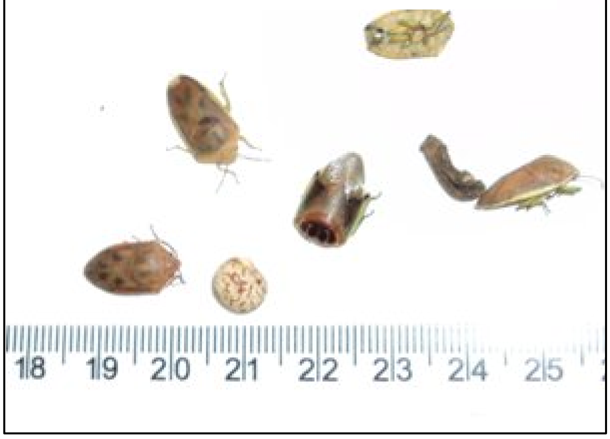


Image of Sunn pest

5. Recommendations

This project provided information on biosecurity preparedness activities for key pests of the grains industry. Further work was identified in the following areas:

- Developing generic contingency framework for groupings of high priority pests will ensure the industry is prepared for incursions of exotic pests that are not already covered by a pest specific contingency plan.

- Regular review of the Grains IBP and the ongoing implementation of the EPPRD and PLANTPLAN, together with the need for ongoing awareness within the grains industry remains a priority for the industry. With the large number of summer and winter grain crops and the enormous number of pests in the crop specific threat summary tables, regular reviews are essential.

- Continued improvement in promotion and delivery of on-farm biosecurity best practice information to the grains industry.

- Further enhancements to the Surveillance model. These include:

    - Testing the assumptions in the surveillance model with growers and consultants. Existing information was based on the Western Australian grain belt and requires expansion of the surveillance model to other areas of Australia.

    - Testing if the surveillance model can be used to assess general surveillance for exemplar groups of field symptoms rather than for specific HPPs.

    - Undertake sensitivity analyses to determine what parts of the model have the most impact on improving our confidence in detecting pests using general surveillance. This will inform whether different components of surveillance can be targeted to improve confidence of detection.

    - How does the information on general surveillance inform freedom from pests in different regions or across Australia.

        - Understanding how sampling frames (e.g. surveillance at a patch, paddock and farm regional level) can be extrapolated to wider regions.

6. Abbreviations/glossary

ABBREVIATION	FULL TITLE
CRCNPB	Cooperative Research Centre for National Plant Biosecurity
EPPRD	Emergency Plant Pest Response Deed
GBO	Grains Biosecurity Officers
GFBP	Grains Farm Biosecurity Program

GPA	Grain Producers Australia
GRDC	Grains Research and Development Corporation
IBP	Industry Biosecurity Plan
Pest	Any invertebrate, pathogen or disease injurious to plant health
PHA	Plant Health Australia
PLANTPLAN	Nationally endorsed operational guidelines for response to plant pest incursions

7. Attachments

Attachment 1

Low-Choy S, Slattery J, Falk M, Taylor S (2012) Eliciting expert knowledge on general surveillance. Paramaterizing design and evaluation of general surveillance for early detection of exemplar pests.

8. Plain English website summary

CRC project no:	CRC30009
Project title:	Grains Surveillance Strategy
Project leader:	Dr Sharyn Taylor
Project team:	Jo Slattery (PHA), Rohan Burgess (PHA), Sama Low Choy QUT
Research outcomes:	- Twenty two contingency plans for key high and medium priority pest threats to the Australian grains industry were prepared. These plans provide information on pest life cycles, potential distribution, survival strategies and methods for surveillance and sampling to assist with biosecurity preparedness. - Audit of grain pest specific reference material held electronically by PHA was undertaken. - Biosecurity awareness information was provided to researchers, growers, grains bulk handlers and agribusiness in the form of media articles and seminars. - Development of surveillance plans for Russian wheat aphid, Hessian fly and Sunn pest to assist capture of data for both early detection of new pests and market access requirements.
Research implications:	The development or update of contingency plans for key pest threats and surveillance plans for Russian wheat aphid, Hessian fly and Sunn pest, together with the delivery of biosecurity messages, form an important part of biosecurity preparedness and prevention activities for the grains industry. The development of contingency plans will provide information that will form the basis of response plans to pest incursions. The provision of information within the contingency plans will assist with more rapid eradication, containment or management mechanisms being put in place, helping both deliverers and beneficiaries of the emergency response. Provision of awareness training and information is an important part of industry preparedness, assisting to increase the understanding of the importance of biosecurity and the response mechanisms Australia puts in place in the event of an incursion. The surveillance plans for Russian wheat aphid, Hessian fly and Sunn pest provides a framework for a coordinated national approach to collection and capture of data for both early detection of new pests and market access requirements.

	The surveillance plans assessed the probability of detection of each of these pests using routine crop monitoring. This framework has implications for all stakeholders in the grains supply chain that will be impacted by pests of market access concern or potential pest incursions.
Research publications:	Low-Choy S, Taylor S, et al (in prep) Evaluating general surveillance for early detection of exemplar exotic plant pests: A Bayesian hierarchical modelling framework implemented in WinBUGS. Low-Choy S, Hammond N, Penrose L, Stanaway M, Taylor S (in prep) 600 samples and beyond: Statistical sampling strategies for surveillance in plant biosecurity. Taylor S, Low-Choy S, Slattery J et al (in prep) Can we detect exotic plant pests using general surveillance? Integrating the current state of knowledge in Russian wheat aphid, Sunn pest and Hessian fly. Low-Choy S, Hammond N, Penrose L, Anderson C, Taylor S (2011) Dispersal in a hurry: Bayesian learning from surveillance to establish area freedom from plant pests with early dispersal. In proceedings, 19th International Congress on Modelling and Simulation, http://mssanz.org.au/modsim2011, 2521-2527. Low-Choy S, Whittle P, Anderson C (2011) Quantitative approaches to designing plant biosecurity surveillance. In McKirdy S, editor, Biosecurity in Agriculture and the Environment, CABI, London.
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