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National Action Plan for Pests of Broadacre Crops 2023-2033

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This project falls under Ethics Clearance 182/22. This study has been approved by CSIRO’s Social Science Human Research Ethics Committee in accordance with the National Statement on Ethical Conduct in Human Research 2007 (Updated 2018). If you have any questions concerning your participation in the study please contact the researchers via their contact details provided on the last page. Alternatively, any concerns or complaints about the conduct of this study can be raised with the Executive Manager of Social Responsibility and Ethics on +61 7 3833 5693 or by email at csshrec@csiro.au.

# Introduction

This project has been initiated to develop a nationally agreed approach to prevent, prepare for and respond to exotic pests of broadacre crops that represent a significant risk to farm livelihoods, food production, and our unique environments. We will deliver a *National Action Plan for Pests of Broadacre Crops* (the Plan) and its Implementation Schedule based on stakeholder consultation. National action plans are being developed to guide national preparedness for a suite of National Priority Plant Pests (NPPP 2019). This project aligns with the Priority Pest and Disease Planning and Response program’s outcome of strengthening the Australian biosecurity system and managing NPPPs.

There are many NPPPs relevant to broadacre cropping industries and the plan will guide the implementation of nationally agreed actions for a strategic and risk-based approach to prevent the entry of these pests and diseases, and to enhance our ability to detect and respond to an incursion of one of these pests. Without this planning, many broadacre cropping industries are at risk if an NPPP pest or disease is detected in Australia.

Australia’s Biosecurity System is based on shared responsibility and strong industry engagement to ensure that Australian agriculture is protected from exotic pest threats. The development of this plan reflects this shared responsibility and the resulting actions which will form the basis of an implementation plan will be carefully considered and discussed. To start this process, we have developed this issues paper to provide some context and background to stakeholders. We highlight the pests that are the focus of this plan and list potential actions stakeholders may consider. Through workshops and face-to-face discussions, we will identify and prioritize actions and clarify who needs to be involved in the implementation process. After our consultation process is complete, we aim to have a well-considered plan that is agreed upon by stakeholders, includes some ownership by industries over the actions identified, and is flexible enough to allow implementation by stakeholders with different levels of resourcing. Final endorsement will be provided through the Plant Health Committee.

## Australia’s Biosecurity System

Australia’s broadacre industries are protected to some degree from the arrival and establishment of exotic species through a diversity of activities that take place pre-border, at the border and post-border. The Biosecurity Act 2015 (the Biosecurity Act) is the current legislative framework used to reduce the risks to plant, animal, and human health in Australian territories. There is a continual need to strike a balance between reducing the risk of exotic pest arrival and maintaining our ability to trade effectively with other countries.

Australia’s geographic isolation and strong border quarantine system means we are in an ideal position to implement actions that reduce risks, and often have the benefit of knowledge about the pest species generated from other countries. Whilst both federal and state government departments provide systems and resources to implement our biosecurity system, industries, farmers, and the public are also tasked with undertaking activities to maintain biosecurity.

The cost of our biosecurity system is paid via both State and Federal government taxes, and industry support. The benefits accrue to Australia’s agricultural industries and to our environment and communities. An ABAREs report (in 2015) estimated that Australia’s biosecurity system improves the annual profits of typical mixed broadacre farms by $12,254-$12,626 per year (depending on degree of livestock integration) (Hafi *et al.* 2015). As an example, crop farming annual profits would be about 7% lower due to Karnal bunt (causing the downgrading of grain) if our biosecurity system was not present and thereby reducing incursion risk (Hafi *et al.* 2015).

The development of the [National Priority Plant Pests](https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/national-priority-plant-pests-2019) list was designed to focus investment and action on exotic pests and includes 42 species that could cause significant negative impacts to our agricultural sector, environments and communities. Several national action plans have [already been developed](https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/national-priority-plant-pests-2019) for Khapra beetle, Xylella and exotic vectors, exotic invasive ants, and hitchhiker (contaminating) plant pests.

## Broadacre Industries in Australia

Broadacre crops were grown across 26 million hectares of Australia in 2021 ([ABS 2020/21](https://www.abs.gov.au/statistics/industry/agriculture/agricultural-commodities-australia/latest-release), cereal and broadacre crops) by an estimated 32,200 farm businesses. This includes grains, rice, pulses, oilseeds, cotton, sugarcane, and some pasture cropping. These farm businesses, have through many years of innovation developed large-scale crop production in Australia to a point where we export large volumes of important food and fibre commodities each year. These crops also form the basis of the food chains for our livestock industries and the raw ingredients for many foods for Australian consumers.

Whilst broadacre farmers have seen increases in incomes and whole-farm profits over recent years, there are several risks faced by broadacre farmers we shouldn’t ignore. They collectively manage large areas of land and recently we have seen a trend towards larger farm sizes, enabled by the availability of technology. They have the capability to manage diverse land management problems from dryland salinity, soil erosion, droughts, floods, to the control of pests, weeds, and diseases (for both their crops and natural vegetation remnants on their property). However, many farmers are heavily reliant on the use of pesticides to control pests once an outbreak has occurred and may have irregular monitoring of crops for new pest or disease outbreaks (an exception may be cotton growers who tend to scout a minimum of twice a week). As we have seen with the recent establishment of Russian wheat aphid (Yazdani *et al.* 2018) and fall armyworm (Piggott *et al.* 2021) in Australia, managing new and exotic pests in broadacre production systems can be challenging in many ways.

There are four key changes or drivers that relate to the management of future exotic pest incursions that may impact broadacre farmers. These are:

1. Changing pest species complexes (due to many drivers including climate change) and changes to the traits of these pests.

Historically we know that the distribution and abundance of pests, and pest outbreaks, have changed over time due to changing climate conditions and management changes to crops and production landscapes (and the interactions between these two factors) (Macfadyen *et al.* 2018). Hoffmann *et al.* (2008) documented changing patterns in pest species that were problematic in grains from the 1980s to the early 2000s. Sometimes we observe pests that were previously not a problem for farmers reaching outbreak levels (e.g. Nash 2022, cabbage-centre grub). Furthermore, some species carry traits, like resistance to certain pesticides or host plant preferences, which alter the way they interact with the environment.

1. The shift towards more broadacre annual cropping in the Northern regions of Australia and into the High Rainfall Zones (HRZ) of Southern regions.

The expansion of cropping in the HRZ (>600mm of annual rainfall) of southern Australia, and methods for integrating cropping with grazing systems is an ongoing area of research (Nie *et al.* 2016). Increasing grain prices and declining wool prices, coupled with a greater potential yield for crops in the HRZ means that many farmers are moving their businesses towards annual crop production. With greater interest in irrigation development in Northern Australia we are also seeing moves away from traditional low-input beef grazing systems to including broadacre crops (e.g., cotton, sugarcane) in rotation or mixed farming situations, as well as growing other horticulture crops (mango, banana etc.) (Ash *et al.* 2017).

1. Trend towards larger farm sizes.

The average operating size of farms across Australia has increased since the 1980s. The impact of farm productivity and the make-up of farm units is continually under review (Sheng *et al.* 2015). A study from over 200 farms in WA from 2002-2011 showed that few farms in the study achieved productivity growth (Islam *et al.* 2018). Farms that did show the highest growth in total factor productivity typically increased their farm size and became more crop dominant. This general pattern means that operating units are larger, and potentially there are less farm staff per unit of land. This may or may not impact on their ability to detect and report suspected exotic pest threats.

1. Changes to biosecurity requirements for market access, especially for export markets.

Australia’s broadacre crops also face shifting requirements for market access that dictate the pest control actions that take place on the farm and in the export chain. In some cases, our ‘disease-free’ or ‘pest-free’ status is valued by export customers and enables us access to markets other countries may struggle to enter.

In the face of these drivers for change the industry groups that represent broadacre crops have increased their research, communications, and extension activities around biosecurity (Table 1). Many have evidence-based industry-level plans, surveillance strategies and farm-level plans and resources for growers. We are also aware that biosecurity plans for grains, cotton sugarcane and rice industries are currently being updated and will be released in 2023 or 2024. Our goal is not to repeat these documents, but to consider where the gaps lie and how nationally co-ordinated activities across the broadacre industries would provide added benefits to stakeholders. We would also like to highlight the “business as usual” activities that many industries already undertake in this area that could be enhanced, expanded, or continued in their current form as part of a National Plan.

**Table 1.** Summary of the biosecurity plans already developed by different broadacre industries.

|  |  |  |
| --- | --- | --- |
|  | Industry-level plans | Farm-level plans |
| Grains | National grain biosecurity surveillance strategy (2019-29)  https://www.planthealthaustralia.com.au/wp-content/uploads/2020/07/National-Grain-Biosecurity-Surveillance-Strategy.pdf  Industry Biosecurity Plan for the Grains industry | Grains farm biosecurity program (started 2007, with PHA)  <https://grainsbiosecurity.com.au/>  Checklists like: Farm Biosecurity Plan for Grain Producers, Grower-Consultant farm biosecurity agreement, Farm biosecurity practice checklist for agronomists and consultants  Biosecurity manual for grain producers  Farm biosecurity manual for organic grains industry |
| Cotton | Biosecurity plan for the cotton industry (2015)  <https://cottonaustralia.com.au/assets/general/Biosecurity/Biosecurity-Plan-2015.pdf> | Farm biosecurity manual for the cotton industry (2012)  <https://cottonaustralia.com.au/assets/general/Biosecurity/Farm-Biosecurity-manual.PDF>  Biosecurity plan for movement of cotton from NT and WA into south QLD for ginning (2022).  <https://cottonaustralia.com.au/assets/general/Biosecurity/CottonBRG_Ord_NT_BiosecurityManagementPlan-2022.pdf>  Come clean go clean fact sheet  <https://www.cottoninfo.com.au/node/129> |
| Sugarcane | Biosecurity plan for the sugarcane industry | Biosecurity manual for sugarcane producers (2017)  <https://www.planthealthaustralia.com.au/wp-content/uploads/2017/01/Biosecurity-Manual-for-Sugarcane-Producers.pdf> |
| Pastures, grazing | Focus mainly on the animal diseases (notifiable diseases):  <https://www.mla.com.au/research-and-development/biosecurity/industry-biosecurity/> | General guidelines on how to develop a farm biosecurity plan  <https://www.mla.com.au/research-and-development/biosecurity/farm-biosecurity/>  Information sheet developed by PHA  <https://www.farmbiosecurity.com.au/wp-content/uploads/2019/02/Farm-Biosecurity-for-Livestock-Producers.pdf> |
| Other crops | [Australian Industrial Hemp Strategic RD&E Plan (2022-2027), AgriFutures Australia](https://agrifutures.com.au/product/australian-industrial-hemp-strategic-rde-plan/)  [Pulse Australia - Biosecurity in the pulse industry](https://www.pulseaus.com.au/blog/post/biosecurity-pulse-industry)  <https://www.planthealthaustralia.com.au/strategies/> |  |

## The National Priority Plant Pests

The development of the [National Priority Plant Pests](https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/national-priority-plant-pests-2019) list has been used to focus investment and action on exotic pests and includes 42 groups of pest species, host-pathogen complexes, vectors and strains that could cause significant negative impacts to our environments and communities. For this plan the focal species have been revised and those directly relevant to broadacre industries highlighted. Table 2 lists the species that are the focus of this plan, but we acknowledge actions may address multiple exotic and endemic pest species beyond this list. Some species such as *Spodoptera frugiperda* (fall armyworm) have recently arrived in Australia but are still on list. Any emerging pests (not listed in Table 2) may also be considered and can be discussed during the workshop activities, and it may be this list changes throughout the life of the Plan.

**Table 2.** The National Priority Plant Pests that are the focus of this plan.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| NPPP number | Genus and species | Taxa group | Broadacre industry | Crop types impacted |
| NPPP#3 Karnal bunt | *Tilletia indica* | fungus | grains | *Triticum aestivum* L. and *Triticale* (Poaceae), wheat, durum, triticale |
| NPPP#15 Wheat stem rust | Ug99 *Puccinia graminis* f. sp*. tritici* (exotic strains) | fungus | grains | wheat, barley, oats and rye |
| NPPP#27 Barley stripe rust (exotic strains) | *Puccinia striiformis f. sp. hordei* (exotic strains) | fungus | grains | spring barley and barley grass |
| NPPP#21 Texas root rot | *Phymatotrichum omnivorum* | fungus | cotton | cotton, grape, nut, citrus and stone fruit industries |
| NPPP#23 Cyst nematodes of cereals (exotic species) | *Heterodera carotae* | nematode | grains | Oats, barley, rye, triticale, wheat, wild oats |
|  | *Heterodera filipjevi* | nematode |  | Wheat, barley |
|  | *Heterodera glycines* | nematode |  | Soybean |
|  | *Heterodera latipons* | nematode |  |  |
|  | *Heterodera sorghi* | nematode |  | Sorghum, maize |
|  | *Heterodera zeae* | nematode |  |  |
| NPPP#26 Wheat stem sawfly (exotic species) | *Cephus cinctus* | insect | grains | grains and grasses |
|  | *Cephus pygmeaus* | insect |  |  |
| NPPP#28 Hessian fly | *Mayetiola destructor* | insect | grains | Wheat, barley, triticale and rye |
|  | *Mayetiola hordei* | insect |  |  |
| NPPP#31 Armyworm (exotic species) | *Spodoptera eridania* | insect | cotton, grains, sugarcane | cassava, cotton, several members of the Brassicaceae, a wide range of legumes, maize and other Poaceae, potatoes, sweet potatoes, tobacco, tomatoes, yams, and many pot plants and vegetables |
|  | *Spodoptera frugiperda* (now established) | insect |  |  |
| NPPP#36 Exotic stem borers of sugarcane and cereals | *Chilo auricilius* | insect | sugarcane | Sugarcane, rice, sorghum, and corn |
|  | *Chilo infuscatellus* | insect | sugarcane |  |
|  | *Chilo orichalcociliella* | insect | sugarcane | Also maize, sorghum, millet |
|  | *Chilo partellus* | insect | sugarcane | Also sorghum, maize, Johnson grass, foxtail millet, finger millet, pearl millet, rice |
|  | *Chilo polychrysa* | insect | sugarcane |  |
|  | *Chilo sacchariphagus* | insect | sugarcane |  |
|  | *Chilo terrenellus* | insect | sugarcane |  |
|  | *Chilo tumidicostalis* | insect | sugarcane |  |
|  | *Eldana saccharina* | insect | sugarcane |  |
|  | *BMSSesamia grisescens* | insect | sugarcane |  |
|  | *Scirpophaga excerptalis* | insect | sugarcane |  |

## Summary for each taxa group

Below we provide a brief introduction to each taxa group listed on Table 2. with some notes about control options should they become established. Additional information is provided in the form of URLs for webpages with more in-depth descriptions about their biology, ecology, management, and impact.

**NPPP#3 Karnal bunt**  
Karnal bunt is a fungal disease of wheat, durum wheat and triticale (Tan *et al.* 2013). Yield loss directly caused by the Karnal bunt fungal pathogen *Tilletia indic*a is not the primary impact of this pest. Rather in countries like Mexico, where Karnal bunt has established the downgrading of up to a third of wheat produced is the biggest cost. If Karnal bunt is detected in more than 3% of seeds it is no longer suitable for human consumption and the grain must go into livestock feed. Furthermore, given this is a seed-borne disease Australia has a reputation for supplying ‘disease-free’ grain to export markets that is highly valued. A Karnal bunt incursion is classed as the highest level of risk by the Australian grains industry (overall risk extreme), in terms of the significant trade and quality impacts that would occur if established and the restriction to international markets would be a significant loss for Australia’s grain industry.

No chemical control options are available for Karnal bunt, but some foliar fungicides have shown some success. Growing resistant genotypes of wheat is an important form of control. Currently about 2% of the genotypes used in Australia show adequate levels of resistance (Emebiri *et al.* 2019).

Links to more information:

<https://www.padil.gov.au/pests-and-diseases/pest/136616>

<https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/karnal-bunt>

Fact sheet, contingency plan and diagnostic protocol can be found here:

<https://www.planthealthaustralia.com.au/pests/karnal-bunt/>



Karnal Bunt photo (from PaDIL image library). As seen in the photo parts of the seed blacken and crush easily also has a fishy like smell.

**NPPP#15 #27 Wheat and barley stem rust**  
Cereal rusts have been present in Australia for over a century and virulent strains of the fungus have arrived from overseas through multiple incursions. They have spores that move via wind and there is a strong relationship between weather conditions and outbreaks (rusts require rainfall or high humidity for spores to germinate and infect leaves). These endemic strains are managed using resistant varieties. Primary hosts of exotic wheat and barley stem rusts include wheat, barley and triticale and is considered a high risk to the grains industry due to potential yield impacts, grain rejection and international market losses. Newly emerged strains of the wheat stem rust pathogen, such as Ug99 (Addai *et al.* 2018), are a threat to Australian wheat production as they are more virulent than existing strains.

The University of Sydney has been conducting national surveys of cereal rusts in Australia since the 1920’s to characterise any new rust pathotypes that emerge and direct the breeding of effective rust resistance into new varieties. The use of tolerant or resistant varieties are important for reducing the risk of rust outbreaks, as well as the use of fungicides, and destruction of the green bridge and volunteer host plants. Practising hygiene, monitoring, and implementing biosecurity programs on farms is a valuable tool in checking for exotic rust strains.

Links to more information:

<https://www.agriculture.gov.au/abares/research-topics/biosecurity/biosecurity-economics/potential-impact-wheat-stem-rust>

<https://daff.ent.sirsidynix.net.au/client/en_AU/search/asset/1027089/0>

<https://www.agric.wa.gov.au/grains-research-development/managing-stripe-rust-and-leaf-rust-wheat-western-australia>

<https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/barley-stripe-rust>

<https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/ug99>

Annual survey maps:

<https://www.sydney.edu.au/science/our-research/research-areas/life-and-environmental-sciences/cereal-rust-research/rust-reports.html>

Biosecurity preparedness plan for Ug99:

<https://www.planthealthaustralia.com.au/wp-content/uploads/2013/03/Wheat-stem-rust-Ug99-Business-Continuity-Plan.pdf>



Sabine Werres BBA, Braunschweig, Germany, PaDIL image library

**NPPP#21 Texas root rot**  
Texas root rot (*Phymatotrichopsis omnivora* (Duggar) Hennebert, synonym *Phymatotrichum omnivorum* (Shear) Duggar, Uppalapati *et al.* 2010) is a disease caused by a soil-borne fungus that leads to dead, wilted plants. The potential plant host range of the fungus is incredibly large and includes cotton, alfalfa, citrus, and stone fruit. The movement of soil or infected roots on machinery and by other means can lead to long-distance spread of the fungus.

There are no known treatments for Texas root rot and once established in the soil the fungus can survive for more than five years without a host. Effective control options for this pest are not commonly reported and there is no evidence of genetic host plant resistance in any crop type studied so far. There is a fungicide that has shown some effectiveness in the USA on cotton, but it is very expensive. The fumigation of soil in large quantities is effective but cost prohibitive over large areas.



Photo by Chris Anderson, Department of Primary Industries, NSW

Links to more information:

<https://www.dpi.nsw.gov.au/biosecurity/plant/insect-pests-and-plant-diseases/texas-rootrot>

<https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/texas-root-rot>

**NPPP#23 Cyst nematodes of cereals (exotic species)**

Cereal cyst nematodes are parasites of plants that infest through the roots causing discoloration, yellowing, and stunting. *H. Latipons and H. filipjevi* are pathogen cereal cyst nematodes of wheat and barley., *H. zeae* is a major pathogen of maize and is restricted to tropical and sub-tropical regions. They are considered a medium risk to the grains industry due to yield impacts. Soybean cyst nematode is also medium risk, with primary host of soybean. Singh *et al.* (2022) modelled the potential distribution of *H. zeae* and showed that most of the grain producing areas of Australia had suitable climate. Only one strain of the *H. avenae* cereal cyst nematode is endemic in Australia and can cause up to 80% yield loss. The eggs can stay viable in the cysts in the soil for up to 4 years even in dry conditions.

Once a field has become infested with nematodes it is challenging to eradicate them again, so prevention of localized spread is important. A reduction in populations is achieved through changes to the rotation and introduction of non-host crops and resistant crops into the rotation sequence (Smiley *et al.* 2017). However, the shift to more than two years of broadleaf crops (non-hosts) or fallows in cereal systems can be economically challenging. There are some nematicides that can provide effective control of nematode populations, and biological suppression via fungal and bacterial natural enemies occurs but is not managed in an active way at this stage. For the endemic species *H. avenae* farmers can assess the population using the PreDicta B soil test service.

Links to more information:

<https://www.dpi.nsw.gov.au/biosecurity/plant/insect-pests-and-plant-diseases/cereal-cyst>

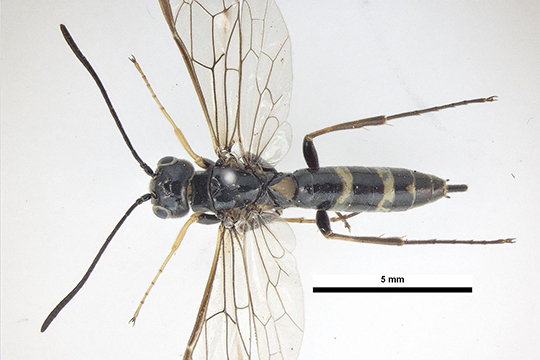
[Pest information / status (planthealthaustralia.com.au)](https://www.planthealthaustralia.com.au/wp-content/uploads/2014/06/Cereal-cyst-nematode-CP-2012.pdf) page 6

https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/cyst-nematodes-grains-vegetables

**NPPP#26 Wheat stem sawflies (exotic species)**

Wheat Stem Sawflies are a prolific pest in the grains industry. They are a wasp, and their larvae live within the stems of wheat, oats, barley, and rye and can cause significant damage to plants. They can be carried large distances inside straw that has been bailed for hay, but the adult wasps can move naturally via flying. Wheat stem sawflies are considered a high risk to the grains industry due to potential yield and trade impacts and the primary hosts include barley, triticale, rye, wheat, and wild grasses. *C. pygmeus* also uses wild oats, bromes grasses and timothies as hosts.

Solid-stemmed varieties of wheat are tolerant to infestation and are critical for *C. cinctus* management in North America (Beres *et al.* 2011). Insecticides (including seed dressings) have proved ineffective in the control of wheat stem sawflies (Beres *et al.* 2011). There are multiple braconid parasitoids that attack wheat stem sawflies in North America and biological control agents may be useful for reducing populations (Cavallini *et al.* 2023).



Pest and Disease image Library, Bugwood. org

Links to more information:

<https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/wheat-stem-sawfly>

<https://www.planthealthaustralia.com.au/wp-content/uploads/2021/01/Wheat-stem-sawflies-FS.pdf>

From the United States:

<https://agsci.colostate.edu/agbio/ipm-pests/wheat-stem-sawfly/>

**NPPP#28 Hessian fly**

Hessian flies are tiny mosquito like insects that are serious pests of cereal crops causing severe damage to crops across the world. Given wheat is the optimal host plant for the Hessian fly it is considered a high risk to the grains industry due to potential yield and trade impacts. However, Hessian fly can also persist on several grass species found in the cropping landscape. Yield loss occurs because of larval feeding on plants and seedlings, which leads to stunted growth, less grain, and reduced tillers (Schmid *et al.* 2018).

Resistant cultivars are the most important means of managing Hessian fly globally. There are well characterized resistance genes that can be transferred into wheat varieties. Hessian fly management across the midwestern United States includes delaying the planting of wheat until after winter aestivation of the fly (called the ‘fly-free date’, Eigendrode *et al.* 2017). Pheromone traps are available that capture low numbers of male flies, however the numbers in the traps are not correlated with the economically damaging infestations. Destruction of volunteer wheat is also important; however, insecticides have proved less effective due to their short duration (Schmid 2018).



*Mayetiola destructor* photo Scott Bauer, USDA Agricultural Research Service, Bugwood.org

Links to more information:

<https://www.padil.gov.au/pests-and-diseases/pest/136225>

<https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/hessian-flies>

<https://www.planthealthaustralia.com.au/pests/hessian-fly/>

From the United States:

<https://entomology.ca.uky.edu/ef155>

**NPPP#31 Armyworm (exotic species)**

Australia is already home to many *Spodoptera* species, some of which are pests on major crops like wheat, cotton, canola, and soybean. They are generally highly polyphagous and can grow and survive on many plant types. The two exotic species on the NPPP list include *S. frugiperda* (fall armyworm) and *S. eridania* (southern armyworm). Both species are spreading globally, and *S. frugiperda* was first recorded in Australia in 2020 and has been found in both the Northern Territory and Queensland (Piggott *et al.* 2021, Tay *et al.* 2022) but has since migrated to crop production areas in most states. Weinberg *et al.* (2022) modelled the potential geographic range of *S. eridania* and showed that areas across Northern Australia (multiple states and territories) and Northern parts of the WA wheat belt regions have climate suitable for your-round population growth.

In maize and sweet corn crops the use of conventional insecticides to control these species is challenging due to the larvae moving into the whorl which protects them from contact with the insecticide. Many countries are using or investigating the use of *Bt* crops, biopesticides and biological control from predators and parasitic wasps to improve management of these species. Control is further complicated through the presence of insecticide resistance being present in populations that may invade or have invaded Australia. In the recently invaded Australian populations of *S. frugiperda* mutations associated with resistance to carbamates and organophosphates has been detected (Nguyen *et al.* 2021), and decreased sensitivity to Group 1 insecticides and synthetic pyrethroids compared to another common moth *Helicoverpa armigera* (Bird *et al.* 2022). There may be wasp parasitoids, predators and pathogens that may help with control, that can be found in natural Australian farming systems.



Southern armyworm, *Spodoptera eridania* (Stoll), second and third instar larvae on tomato. Photograph by [Lyle J. Buss](mailto:ljbuss@ufl.edu), University of Florida.

Links to more information:

<https://www.padil.gov.au/pests-and-diseases/pest/143200>

<https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/exotic-armyworm>

From the United States:

<https://entnemdept.ufl.edu/creatures/veg/leaf/southern_armyworm.htm>

**NPPP#36 Exotic stem borers of sugarcane and cereals**

Australia has no significant exotic stem borer pest species present as sugarcane pests, with the native stem borer, *Bathytricha truncata*ae not causing significant damage (Lee *et al.* 2019). Spotted stalkborer/pink borer (*C. partellus*) are considered medium risk to the grains industry (although the sugarcane industry may rank this differently) due to yield impacts. They use sugarcane and sorghum, maize, Johnson grass, foxtail millet, finger millet, pearl millet, and rice as their primary hosts. Coastal stalk borer (*C. Orichalcociliellus)* is also medium risk to the grains industry. They cause damage when the larvae bore into the stalk causing a “dead heart” and reduced sugar quantity and quality.

There are some insecticides available to control some stem borer species in sugarcane, but not all are universally effective. Studies focussed on the parasitoids of stem borers (including egg parasitoids like *Trichogramma* sp.) have shown some success. Parasitic wasps such as *Trichogramma* and *Telenomus* are potential natural enemies as well as Tachinid fly parasitids. There has been some testing of Australian sugarcane clones in PNG to determine if tolerance exists to the borers not yet present in Australia. Australian commercial clones exhibited a range of susceptibilities to each borer species in the trials conducted in 2010-13, some were heavily attacked and some appearing relatively resistant (Samson *et al.* 2017).

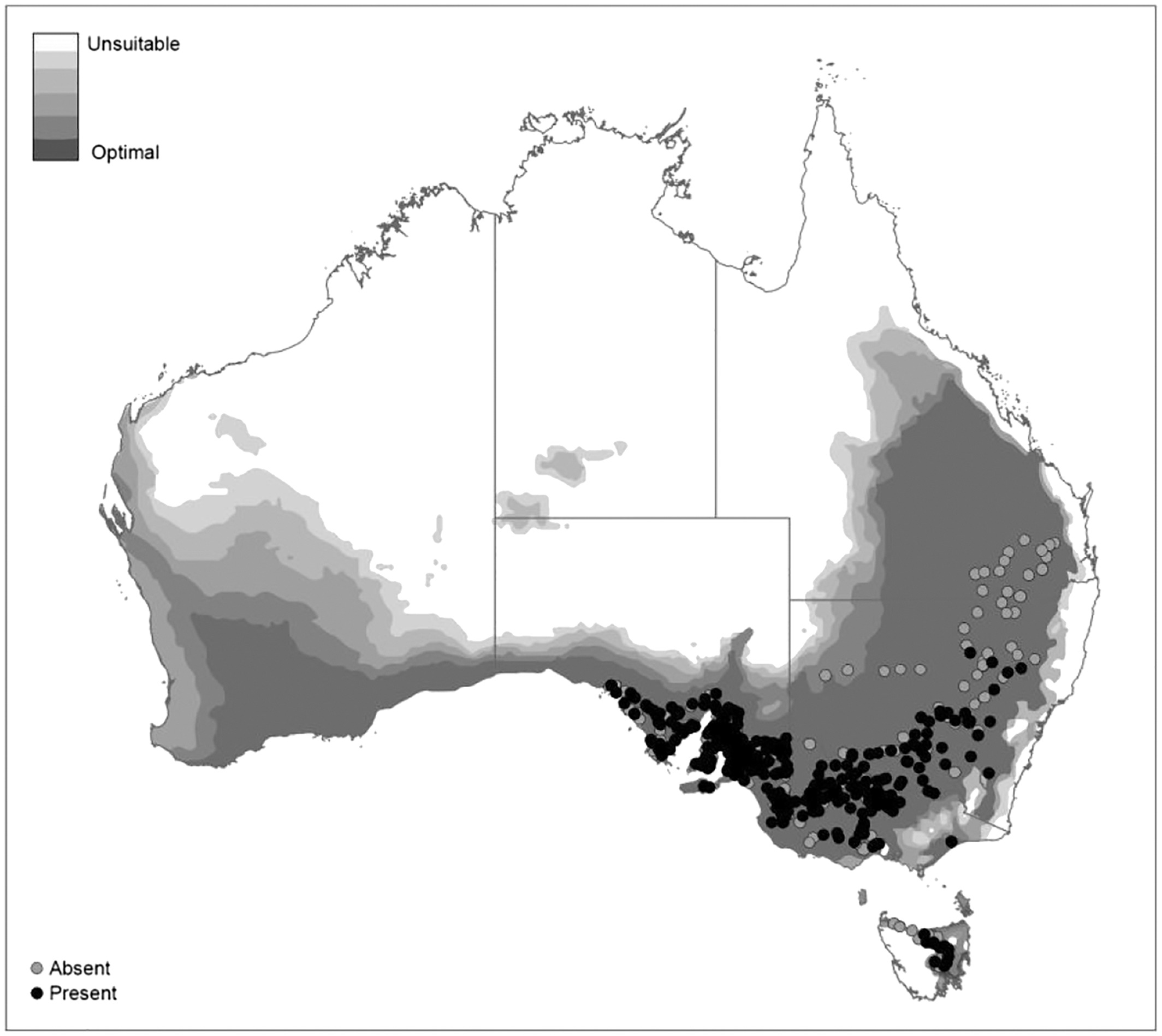
Links to more information:

<https://www.agriculture.gov.au/biosecurity-trade/policy/australia/naqs/naqs-target-lists/pests_of_plants_sugarcane_stem-borer>

<https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/stem-borers-sugarcane>

# Historical incursion, Russian wheat aphid case study

The Russian wheat aphid (*Diuraphis noxia*, [RWA](https://www.planthealthaustralia.com.au/pests/russian-wheat-aphid/)) is a global pest of wheat and barley and one of the few cereal aphid pests not found in Australian systems prior to 2016 (Yazadani *et al.* 2018). This pest damages plants by injecting enzymes from their saliva into plant tissues and thereby reducing the functioning of chloroplasts, but it does not cause much damage through vectoring diseases like other aphid pests. RWA can use a huge diversity of grass species as host plants throughout the year. During May 2016 aphid specimens were found in early sown wheat crops (volunteer wheat) around Tarlee in South Australia. The problem was initially raised by farm advisers and then morphologically identified as RWA by the Entomology Unit at SARDI. A molecular diagnosis on adults was also carried out (and an independent identification was completed by a different organisation).



**Figure 1.** Taken from Ward *et al.* (2000). Known distribution of *Diuraphis noxia* in Australia, overlaid with the Avila *et al.* (2019) model where darker colours indicate higher climate suitability. Black circles indicate areas where *D. noxia* has been identified between May 2016 and August 2019. Grey circles indicate areas where active surveillance has failed to locate *D. noxia* (source: E. Pirtle *et al.* unpubl. data).

Subsequent sampling of the infected paddock and adjacent paddocks by entomologists also occurred in late May and it was quickly determined that there was a large extent of infected area. This meant other personnel within the grains industry (agronomists, advisers, and farmers) were asked to collect samples and send in for diagnosis. It was soon concluded that attempts to eradicate RWA would be unsuccessful and by June 2016 it was decided that the pest could not be eradicated (Yazadani *et al.* 2018). By August 2016 a RWA national management plan (prepared by PHA) had been developed to enable actions over the next 12 months (with guidance on long-term R&D needs). By September 2016 RWA had been detected at sites in SA, Victoria, and New South Wales, by 2019 this pest also found in Tasmania (Figure 1, from Ward *et al.* 2020), and by 2020 had arrived in WA.

Initial responses to the RWA arrival, detection and outbreak were varied however good communication channels were established to let growers know about the pest arrival, mainly through the trained entomologists already working in the region. There was some uncertainty over the degree of impact these initial infestations would have, but by the end of the first season yield losses were not as dramatic as anticipated (perhaps due to intense rainfall events in 2016). Emergency use permits were established for insecticides to control RWA in the first year after incursion. There was strong interest from advisers to continue to monitor spread of populations and respond with insecticide applications to deal with the uncertainty. Since the establishment of RWA in Australia more growers have adopted prophylactic applications of insecticides on seeds prior to sowing, despite the development of a practical threshold calculator showing under what conditions insecticides are beneficial and economically justified (van Helden *et al.* 2022). After several years post-incursion, we can say that the relative yield impact from RWA infestations in Australia appears to be lower than reported in other countries. This could be due to several factors such as a shorter growing cycle, climatic conditions, and different varieties used here, and (van Helden *et al.* 2022).

Whilst some research on the potential impact of RWA on Australian grain production had taken place in the 1980s (e.g. Hughes & Maywald 1990), pre-emptive development of resistance cereal varieties had not consistently taken place and the germplasm used in earlier work was not conserved and available for use. Much of the work conducted post-incursion to establish the knowledge and tools needed for long-term management was financially supported by the grains industry (through GRDC-funded projects, and organisations like SARDI and cesar). Below we have outlined some of the actions that took place prior to the incursion and after the pest had established. These may give some insights into things that worked well and areas where we could have been better prepared. This is not designed to criticize the decisions made by individuals and organisations at the time, but to think about how we could improve our preparedness in the future.

Prior to incursion actions

* In the 1980s CSIRO compiled a detailed literature review (e.g. Hughes 1996) and conducted modelling of the likely areas of establishment within Australia (Hughes & Maywald 1990). As a pre-emptive strategy, potential parasitoids of RWA were studied for importation to be established on alternative endemic aphid species (Hughes *et al.* 1994).
* The grains industry had developed a preparedness plan specifically for this species (in about 2012). RWA was also listed under the Emergency Plant Pest Response Deed as a category 3 pest which provided a preliminary agreement to cost share the pest 50 % government and 50 % industry.
* Some preliminary pre-breeding for resistance in crop lines was conducted (Raman & Read 2000).
* Identification of the species and distinguishing this species from other cereal aphids was possible using morphological features (viewed under a microscope). Furthermore, damage symptoms (e.g. chlorotic streaking) in the field are unique and obvious in cereal crops. Therefore, diagnostic protocols were already available.

Post incursion actions

* A RWS national management plan was prepared by PHA soon after initial detection (July 2016).
* There was high demand from growers and advisors in the impacted area to seek advice directly from trained and experienced SARDI entomologists. At times this demand has higher than the number of staff available to respond.
* A summary of potential control options for RWA was published by GRDC in 2017 (Russian Wheat Aphid: Tactics for Future Control, Project Code: ACO00020-B).
* No pesticides were registered for control of RWA at the time of the incursion so trials for the application of emergency permits were conducted. These emergency use permits were active until June 2018.
* Whilst there are many identified sources of resistance to RWA in wheat lines around the globe, the deployment of those resistance traits in Australian plant breeding programmes had not taken place (Dong *et al.* 1997). Germplasm that had been the focus of research efforts in Australia many years earlier was no longer accessible. A screen of the commonly used varieties in Australia showed some differences in susceptibility to RWA, but not to the level of true resistance.
* Updated modelling on the potential distribution of RWA across Australia was conducted (Avila *et al.* 2019).
* Trials on the length of protection offered by a selection of insecticide seed-dressings currently registered in Australia for use in wheat against RWA were undertaken (Kirkland *et al.* 2018).
* The RWA biotype that entered Australia was identified and determined to be most like the biotypes found in the United States.
* A survey of the non-crop host plants for RWA over the summer months (from 2017-2020) in SA was undertaken (van Helden *et al.* 2021). This included surveillance of “green bridge” areas over summer where RWA populations might be found.
* Research into the parasitoid species that were attacking populations of RWA in Australia was undertaken (Ward *et al.* 2020).
* Development of a RWA action threshold calculator to help growers and agronomists determine if they need to use an insecticide to treat for RWA based on cost and potential yield loss (van Helden *et al.* 2022). https://www.pir.sa.gov.au/research/services/pest\_management/rwa\_action\_threshold\_calculator

Links to further information:  
<https://grdc.com.au/resources-and-publications/resources/russian-wheat-aphid>

<https://cesaraustralia.com/pestnotes/aphids/russian-wheat-aphid/#:~:text=Russian%20wheat%20aphid%20(RWA)%20is,New%20South%20Wales%20and%20Tasmania>.

<https://www.planthealthaustralia.com.au/pests/russian-wheat-aphid/>

# Actions to consider as part of The Plan

Below we list a diversity of different actions that stakeholders may consider as important for the development of The Plan. These actions have been suggested by authors of the papers cited here or other preparedness documents already published and some feedback from people in response to earlier versions of this report. The actions are not listed in any order, but grouped into the categories of prevention, detection, response, cross-cutting and cross-sectorial. Some of these may still be posed as vague ideas at this stage and require more clarity and discussion before turning into tractable actions. We expect many of these actions to be interconnected with each other and in some cases complex to implement across the 10 years of the plan. An opportunity will also be provided in the workshops for attendees to identify actions which have not been considered here or alter these actions to better suit their needs.

## Prevention

Preventative actions are any actions that minimize the likelihood of these pests entering Australia and spreading between enterprises, industries, and states within Australia. This includes research to better understand the biology, ecology, and potential impact of the species in different broadacre contexts. This research could be conducted in partnership with countries who already have the pest established and have analogous farming systems. Sometimes research is conducted in Australia on analogous endemic species.

Potential actions to explore

|  |  |
| --- | --- |
| Future ranking | Description |
|  | Risk mapping and risk assessments (e.g. Biosecurity Commons approaches) for each pest which includes the broadacre landscape context. |
|  | Up-to-date estimates of incursion probabilities for each pest, and an understanding of which factors reduce incursion potential. |
|  | Up-to-date time to eradication estimates and impact scenarios generated prior to incursion. |
|  | Research in native range to understand biology, ecology, host plant preferences, damage to crops and a diversity of control options (natural enemies). |
|  | Research on the routes and pathways for potential introduction to Australia (human assisted, trade, and natural movement). |
|  | Research on the routes and pathways for potential spread within broadacre landscapes in Australia (human assisted, trade, and natural movement). |
|  | Up-to-date knowledge about the pesticide resistance profile of likely invasive populations. Also include other problematic traits (at genetic level). |
|  | Pre-emptive development and release of resistant crop genotypes to delay spread. (e.g. for Karnal bunt and hessian fly). |
|  | Characterization of closely related species or strains already endemic to Australia (e.g. mapping and monitoring the existing rust strains, so we can say when a new one has arrived). |
|  | Your ideas can be added here. |
|  |  |

## Detection

Early detection of pests at the border or post-border is an important step in Australia’s Biosecurity system and can lead to the successful eradication of exotic pest species. Farmers and agribusiness advisors (on-farm, post-farm, and transport) undertake surveillance and monitoring activities and product testing as part of their day-to-day work. However, this is not co-ordinated and searching specifically for exotic pests (that have not yet arrived in Australia) would be infrequent. There is a national [hotline](https://www.planthealthaustralia.com.au/biosecurity/emergency-plant-pests/reporting-suspect-pests/) that people can call if they find something they think may be an exotic pest and they will be directed to the relevant state representative (also present on the [DAFF website](https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/report#:~:text=hotline%20on%201800%20798%20636,complete%20our%20online%20reporting%20form.)). The plant biosecurity surveillance systems that use general and specific surveillance have been summarised in Anderson *et al.* (2017). Some industries have developed specific surveillance strategies (e.g. National grain biosecurity surveillance strategies (2019-29)) that are at different stages of implementation, but there are also regular activities/projects to raise awareness and encourage people to report pests. For example, the “Spot Something Unusual Campaigns” were used to raise awareness around reporting species that may potentially be exotic. As a second example, the [Northern Australia Biosecurity](https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/biosecurity/australia/northern-biosecurity/northern-aus-biosecurity.pdf) team runs surveillance activities for the diversity of exotic threats (the NAQS target list includes sugarcane stem borers).

Whilst it is simple to consider if a diagnostic protocol exists for certain species, we also need to consider the other steps required for detection. We pose three questions to address this area:

1. Do we have an existing surveillance system that could detect exotic species, or the capacity to adjust existing surveillance system? At pre-border, border and post-border locations.
2. Do we have current diagnostic protocols for each species that can be run by people having first contact with a potential exotic pest (or are accessible to people having first contact)?
3. Do we understand the diversity of endemic species present, and could we say if something new has arrived?

Table 3 represents the data gathered to address these for each taxa group, but we don’t think this is the complete picture. During the workshops we will try to gather information to understand where we have gaps, which diagnostics are well developed, and which diagnostics have challenges associated with their implementation in a surveillance system (e.g. are costly, require specialist skills, or specialist containment facilities).

**Table 3.** The three components of an exotic pest detection system and known tools related to each component.

|  |  |  |  |
| --- | --- | --- | --- |
| Pest taxa group | Diagnostic | Surveillance systems | Endemic diversity understanding |
| NPPP#3 Karnal bunt | Protocol 2014 (PHA)  [NDP-19-Karnal-bunt-Tilletia-indica-V1.3.pdf (plantbiosecuritydiagnostics.net.au)](https://www.plantbiosecuritydiagnostics.net.au/app/uploads/2018/11/NDP-19-Karnal-bunt-Tilletia-indica-V1.3.pdf) | Draft national contingency plan in 2006  [Karnal-bunt-CP-draft-2006.pdf (planthealthaustralia.com.au)](https://www.planthealthaustralia.com.au/wp-content/uploads/2015/02/Karnal-bunt-CP-draft-2006.pdf)  Farm Biosecurity test (no report) [Karnal bunt scenario tests surveillance - Farm Biosecurity](https://www.farmbiosecurity.com.au/karnal-bunt-scenario-tests-surveillance/) |  |
| NPPP#15 Wheat stem rust | [PHYTO-09-16-0334-R (apsnet.org)](https://apsjournals.apsnet.org/doi/pdf/10.1094/PHYTO-09-16-0334-R) | National surveillance system already in place for endemic rust strains. 2009 |  |
| NPPP#27 Barley stripe rust (exotic strains)  NPPP#21 Texas root rot | National Diagnostic Protocol 2016 reviewed 2021 [NDP-38-Barley-stripe-rust-Puccinia-striiformis-f-sp-hordei-V1.pdf (plantbiosecuritydiagnostics.net.au)](https://www.plantbiosecuritydiagnostics.net.au/app/uploads/2018/11/NDP-38-Barley-stripe-rust-Puccinia-striiformis-f-sp-hordei-V1.pdf)    Currently one in development, Dr Karen Kirkby | Barley Strip Rust National Diagnostic protocol 2005 [A diagnostic protocol for the identification of Peronosclerospora philippinensis (Weston) Shaw, the cause of Philippine Downy Mildew in corn (planthealthaustralia.com.au)](https://www.planthealthaustralia.com.au/wp-content/uploads/2013/03/Barley-stripe-rust-DP-2005.pdf)  [A Plant-by-Plant Method to Identify and Treat Cotton Root Rot Based on UAV Remote Sensing (mdpi.com)](https://www.mdpi.com/2072-4292/12/15/2453)  Wang et al. (2020) |  |
| NPPP#23 Cyst nematodes of cereals (exotic species) | Some information on Potato Cyst that could be adapted perhaps. | PreDicta B test (SARDI) established for endemic species, could this be expanded to exotic species?  [Pest information / status (planthealthaustralia.com.au)](https://www.planthealthaustralia.com.au/wp-content/uploads/2014/06/Cereal-cyst-nematode-CP-2012.pdf) Threat specific contingency plan for cereal cyst nematodes |  |
| NPPP#26 Wheat stem sawfly (exotic species) |  | Industry Biosecurity plan for the grains Industry Threat specific CP 2008 [Pest information / status (planthealthaustralia.com.au)](https://www.planthealthaustralia.com.au/wp-content/uploads/2013/03/European-wheat-stem-sawfly-CP-2008.pdf) |  |
| NPPP#28 Hessian fly | National Diagnostic Protocol  [NDP-41-Hessian-fly-Mayetiola-destructor-V1.pdf (plantbiosecuritydiagnostics.net.au)](https://www.plantbiosecuritydiagnostics.net.au/app/uploads/2020/10/NDP-41-Hessian-fly-Mayetiola-destructor-V1.pdf) | Industry Biosecurity Plan Threat specific [GRAINS INDUSTRY BIOSECURITY PLAN (planthealthaustralia.com.au)](https://www.planthealthaustralia.com.au/wp-content/uploads/2013/03/Hessian-fly-CP-2005.pdf) |  |
| NPPP#31 Armyworm (exotic species) | Rapid PCR assay and LAMP assay, FAW good morphology  [s41598-022-04871-2.pdf](file:///C:/Users/sta285/Downloads/s41598-022-04871-2.pdf) | [Fall-Armworm-Continuity-Plan-2.pdf (planthealthaustralia.com.au)](https://www.planthealthaustralia.com.au/wp-content/uploads/2020/11/Fall-Armworm-Continuity-Plan-2.pdf) 2020  Fall Armyworm Surveillance Trapping Manual [Microsoft PowerPoint - DPIRD FAW Surveillance (agric.wa.gov.au)](https://www.agric.wa.gov.au/sites/gateway/files/DPIRD%20Fall%20armyworm%20surveillance-trapping%20training%20manual_1.pdf)  From Overseas:  [FAW-SURVEILANCE-AND-MANAGEMENT-PROTOCOL\_10272020.pdf (da.gov.ph)](https://bicol.da.gov.ph/wp-content/uploads/2021/04/FAW-SURVEILANCE-AND-MANAGEMENT-PROTOCOL_10272020.pdf) |  |
| NPPP#36 Exotic stem borers of sugarcane and cereals |  | [Industry\_Biosecurity\_Plan.pdf (sugarresearch.com.au)](https://sugarresearch.com.au/sugar_files/2017/02/Industry_Biosecurity_Plan.pdf)  Guideline for surveillance for plant pests in Asia and the Pacific [untitled (aciar.gov.au)](https://www.aciar.gov.au/sites/default/files/legacy/node/2311/mn119_guidelines_for_surveillance_for_plant_pests__16233.pdf) | Global DNA barcode library established (Lee *et al.* 2019) |

Potential actions to explore

|  |  |
| --- | --- |
| Future ranking | Description |
|  | Establish a nationally co-ordinated, post-border biosecurity surveillance system for early detection of broadacre pests (see action 2.2 of the grains plan). |
|  | Determine which diagnostics for which pests are ready to be integrated into a surveillance system versus those that need further research and development. Are they up-to-date? |
|  | Establish mechanisms to co-ordinate and share nationally agreed monitoring and surveillance data with a diversity of stakeholders. |
|  | Determine the optimal design of surveillance systems for each pest group, that are manageable given the large scale of broadacre crops and limited resources. |
|  | Develop techniques to improve the usefulness of on-farm monitoring and supply chain monitoring for detecting exotic pest species and maintaining proof of area freedom. |
|  | Encourage investment in the development of tools and technologies (including drone images and smart traps) to assist in scaling-out on-farm surveillance. |
|  | Develop the traditional on-farm surveillance protocols for the monitoring of pests that feed easily into digital farm record systems. |
|  | Determine if surveillance systems already in place for endemic species (e.g. rust system) could be expanded to include exotic pests. |
|  | Determine if additional training is required by on-farm staff and supply chain staff to adequately identify exotic species as part of their day-to-day functions. See Wright et al. 2016. |
|  | Your ideas can be added here. |
|  |  |

## Response

The response to the incursion of a pest species into Australia may involve a diversity of stakeholders, organisations, and processes. Determining if a species can be eradicated is a key activity, but there are several factors that will influence the success of eradication. For example, the eradication of Karnal bunt of wheat is considered extremely difficult and once there is detectable level of the disease it is likely that the pathogen has been present for several years (Tan *et al.* 2012). Even if eradication is not possible there may still be important reasons for delaying the spread of a pest between regions and states.

Potential actions to explore

|  |  |
| --- | --- |
| Future ranking | Description |
|  | Estimates of impact probabilities to agriculture and flow-on impacts to environment and communities. |
|  | Up-to-date time to eradication estimates and scenarios generated to inform decision-making. |
|  | Determine what proof of freedom credentials is required and the data gathering exercises needed to deliver. |
|  | Delivery of new surveillance systems to detect and monitor presence and absence in regions and states. Documenting the spread process. |
|  | Documentation around control options should the pest become established (what is missing from the tool box?). |
|  | Documentation of the risks around multi-species selection for pesticide resistance (due to changed practice in response to exotic pest arrival). |
|  | Pre-emptive registration of a selection of chemical pesticides and biopesticides prior to an incursion. |
|  | Pre-emptive development of resistant or tolerant varieties prior to an incursion. Ideally these are already deployed in the field prior to incursion. |
|  | Responding to the timing of pest population stages important for impact reduction (e.g. delaying sowing of wheat until after hessian fly aestivation date). |
|  | Determine the most important factors for prevention of localized spread (e.g. cyst nematodes), and long-distance spread. |
|  | Your ideas can be added here. |
|  |  |

## Cross-cutting

This group includes any actions that do not fit neatly into any of the above categories. This includes capacity building activities and communication, and extension needs. Specific activities on-farm to help landholders prepare and respond to pests.

Potential actions to explore

|  |  |
| --- | --- |
| Future ranking | Description |
|  | Build capacity to reduce biosecurity risks due to visitors to farms (agronomists, consultants, local council workers, fencing contractors, outsourcing bailing or spraying, school groups, scientists etc.). |
|  | For geographically dispersed holdings, the movement of people and machinery between management units carries a biosecurity risk. Developing plans to minimize this risk. |
|  | Grain storage on farm (or storage of other products on farm), what are the biosecurity risks that need to be considered and managed. |
|  | Outputs from farm, can the risks in the transportation and delivery steps be reduced? |
|  | Capacity development of staff in regions to identify and respond to new pest threats as they occur. Can capacity be improved and if so how? |
|  | Determine if seasonal forecasting for each pest species outbreak risk is ready to be deployed to help with decision-making. |
|  | Determine if the scale and location of surveillance data collection matches the scale and location of response (e.g. on-farm data but state -level response). |
|  | Your ideas could be added here. |
|  |  |

## 

## Cross-sectorial

This group includes any actions that do not fit neatly into any of the above categories but highlights issues that cross-industry or cross-sectorial in nature. There may be added benefits from developing actions at the national level, with support from multiple broadacre industry groups.

Potential actions to explore

|  |  |
| --- | --- |
| Future ranking | Description |
|  | Establish training opportunities for people pre-farm, on-farm and in the supply chain to build capacity to identify exotic pest species as part of their regular monitoring activities. See action 3.3 in grains plan. |
|  | Do we need to improve the digital tools available to communicate biosecurity risks and outbreaks in real-time? See Wright et al. 2018. |
|  | What capacity do we have in research organisations to study the pest species (before they arrive in Australia, but also if established). |
|  | Encourage regular reflection on the gaps in our surveillance system through enabling scientists and other stakeholders to review, analyse and interpret surveillance data. |
|  | Targeted advertising campaigns to communicate risk pathways with importers and travellers, focussing on the pest list relevant to broadacre crops. |
|  | Action to address the change in the NPPPs list and other priority lists across the 10 years of the plan. New pests will arrive, and some emerging pests may need to be added. |
|  | Consistency and communication around the way we label and describe exotic pest threats across different federal, state, industry lists. |
|  | Your ideas could be added here. |
|  |  |

# Prioritisation of actions

## Feedback from stakeholders

The next step is to prioritise the long list of potential actions highlighted above so that we can focus on the implementation of those that stakeholders consider higher priority. There may be some actions that are high priority for one industry but lower priority for another, and it is important that these inconsistencies are discussed and understood. Ultimately, we are not seeking consensus across all industries for every action, but an overall plan that each industry is collectively engaged with and can take ownership over.

We are planning two in-person workshops in May 2023 (in Perth and Brisbane) to further prioritise and discuss these potential actions. We will ask participants to rank those actions already identified (and suggest any additional actions to consider) and during the workshop break down the steps needed to respond to the highest priority actions. Through this process we will also draw out the barrier to these actions being implemented effectively and “business as usual” activities that are important to include. For people and representatives from industry groups who cannot attend the in-person workshops we will seek their feedback online via a simple survey.

By the end of the in-person workshops we would like to have agreement on the high priority actions, a more detailed understanding of what those actions entail, and who should be responsible for components and an appreciation of the timeframes around implementation (short, up to 3 years, medium 4-8 years, long up to 10 years). This will provide insights into the details required in the implementation plan.

References

Addai D, Hafi A, Randall L, et al (2018) Potential economic impacts of the wheat stem rust strain Ug99 in Australia. Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

Anderson C, Low-Choy S, Whittle P, et al (2017) Australian plant biosecurity surveillance systems. Crop Protection 100:8–20. <https://doi.org/10.1016/j.cropro.2017.05.023>

Ash A, Gleeson T, Hall M, et al (2017) Irrigated agricultural development in northern Australia: Value-chain challenges and opportunities. Agricultural Systems 155:116–125. <https://doi.org/10.1016/j.agsy.2017.04.010>

Avila GA, Davidson M, Helden M van, Fagan L (2019) The potential distribution of the Russian wheat aphid (*Diuraphis noxia*): an updated distribution model including irrigation improves model fit for predicting potential spread. Bulletin of Entomological Research 109:90–101. <https://doi.org/10.1017/S0007485318000226>

Beres BL, Dosdall LM, Weaver DK, et al (2011) Biology and integrated management of wheat stem sawfly and the need for continuing research. The Canadian Entomologist 143:105–125. <https://doi.org/10.4039/n10-056>

Bird L, Miles M, Quade A, Spafford H (2022) Insecticide resistance in Australian *Spodoptera frugiperda* (J.E. Smith) and development of testing procedures for resistance surveillance. PLOS ONE 17:e0263677. <https://doi.org/10.1371/journal.pone.0263677>

Cavallini L, Peterson RKD, Weaver DK (2023) Dietary sugars and amino acids increase longevity and enhance reproductive parameters of *Bracon cephi* and *B. lissogaster*, two parasitoids that specialise on wheat stem sawfly. Physiological Entomology 48:24–34. <https://doi.org/10.1111/phen.12399>

Dong H, Quick JS, Zhang Y (1997) Inheritance and allelism of Russian wheat aphid resistance in several wheat lines. Plant Breeding 116:449–453. <https://doi.org/10.1111/j.1439-0523.1997.tb01029.x>

University of Idaho, USA, Eigenbrode SD, Macfadyen S, CSIRO, Australia (2017) The impact of climate change on wheat insect pests: current knowledge and future trends. In: University of Adelaide, Australia, Langridge P (eds) Burleigh Dodds Series in Agricultural Science. Burleigh Dodds Science Publishing, pp 545–567.

Emebiri L, Singh PK, Tan MK, et al (2019) Reaction of Australian durum, common wheat and triticale genotypes to Karnal bunt (*Tilletia indica*) infection under artificial inoculation in the field. Crop Pasture Sci 70:107–112. <https://doi.org/10.1071/CP18235>

Hafi A, Addai D, Zhang K, Gray E (2015) The value of Australia’s biosecurity system at the farm gate: an analysis of avoided trade and on-farm impacts. ABARES, Canberra.

Hoffmann AA, Weeks AR, Nash MA, et al (2008) The changing status of invertebrate pests and the future of pest management in the Australian grains industry. Aust J Exp Agric 48:1481–1493. <https://doi.org/10.1071/EA08185>

Hughes RD (1996) A synopsis of information on the Russian wheat aphid, *Diuraphis noxia* (Mordwilko). (Revised edition). CSIRO Australia Division of Entomology Technical Paper

Hughes RD, Hughes MA, Aeschlimann J-P, et al (1994) An attempt to anticipate biological control of *Diuraphis noxia* (Hom., Aphididae). Entomophaga 39:211–223. <https://doi.org/10.1007/BF02372359>

Hughes RD, Maywald GF (1990) Forecasting the favourableness of the Australian environment for the Russian wheat aphid, *Diuraphis noxia* (Homoptera: Aphididae), and its potential impact on Australian wheat yields. Bulletin of Entomological Research 80:165–175. <https://doi.org/10.1017/S0007485300013389>

Islam N, Kingwell R, Xayavong V, et al (2018) Broadacre Farm Productivity Trajectories and Farm Characteristics. Australasian Agribusiness Review 26:82–103.

Kirkland LS, Pirtle EI, Umina PA (2018) Responses of the Russian wheat aphid (*Diuraphis noxia*) and bird cherry oat aphid (*Rhopalosiphum padi*) to insecticide seed treatments in wheat. Crop and Pasture Science 69:966–973. <https://doi.org/10.1071/CP18266>

Lee TRC, Anderson SJ, Tran-Nguyen LTT, et al (2019) Towards a global DNA barcode reference library for quarantine identifications of lepidopteran stemborers, with an emphasis on sugarcane pests. Scientific Reports 9:7039. <https://doi.org/10.1038/s41598-019-42995-0>

Macfadyen S, McDonald G, Hill MP (2018) From species distributions to climate change adaptation: Knowledge gaps in managing invertebrate pests in broad-acre grain crops. Agriculture, Ecosystems & Environment 253:208–219. <https://doi.org/10.1016/j.agee.2016.08.029>

Nash M (2022) Cabbage-centre grub (*Hellula hydralis* Guenée) (Lepidoptera: Pyralidae): a new pest challenge to long-season canola grown for forage and grain in southern Australia. Austral Entomology 61:236–246. <https://doi.org/10.1111/aen.12591>

Nguyen DT, Chen Y, Herron GA (2021) Preliminary characterisation of known pesticide resistance alleles in *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in its invasive Australian range. Austral Entomology 60:782–790. <https://doi.org/10.1111/aen.12570>

Nie Z, McLean T, Clough A, et al (2016) Benefits, challenges and opportunities of integrated crop-livestock systems and their potential application in the high rainfall zone of southern Australia: A review. Agriculture, Ecosystems & Environment 235:17–31. <https://doi.org/10.1016/j.agee.2016.10.002>

Piggott MP, Tadle FPJ, Patel S, et al (2021) Corn-strain or rice-strain? Detection of fall armyworm, *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae), in northern Australia. Int J Trop Insect Sci 41:2607–2615. <https://doi.org/10.1007/s42690-021-00441-7>

Raman H, Read BJ (2000) Utilisation of STS markers for selection of resistance against Russian wheat aphid in barley. Journal of Agricultural Genomics 5. <https://wheat.pw.usda.gov/jag/papers00/paper100/2000-P1.html>

Samson PR, Korowi K, Sallam N (2017) Resistance of Australian sugarcane clones to moth and weevil borers in Papua New Guinea. Crop Protection 96:14–21. <https://doi.org/10.1016/j.cropro.2017.01.001>

Schmid RB, Knutson A, Giles KL, McCornack BP (2018) Hessian Fly (Diptera: Cecidomyiidae) Biology and Management in Wheat. Journal of Integrated Pest Management 9:1, 14, 1-12. <https://doi.org/10.1093/jipm/pmy008>

Sheng Y, Zhao S, Nossal K, Zhang D (2015) Productivity and farm size in Australian agriculture: reinvestigating the returns to scale. Australian Journal of Agricultural and Resource Economics 59:16–38. <https://doi.org/10.1111/1467-8489.12063>

Singh SK, Kriticos DJ, Ota N, Hodda M (2022) Potential distribution and biosecurity risks from three economically important plant-parasitic nematodes. Annals of Applied Biology 180:371–382. <https://doi.org/10.1111/aab.12739>

Smiley RW, Dababat AA, Iqbal S, et al (2017) Cereal Cyst Nematodes: A complex and destructive group of *Heterodera* species. Plant Disease 101:1692–1720. <https://doi.org/10.1094/PDIS-03-17-0355-FE>

Tan M-K, Brennan JP, Wright D, Murray GM (2013) A review of the methodology to detect and identify Karnal bunt—a serious biosecurity threat. Australasian Plant Pathology 42:95–102. <https://doi.org/10.1007/s13313-012-0176-9>

Tay WT, Rane RV, Padovan A, et al (2022) Global population genomic signature of *Spodoptera frugiperda* (fall armyworm) supports complex introduction events across the Old World. Commun Biol 5:1–15. <https://doi.org/10.1038/s42003-022-03230-1>

Uppalapati SR, Young CA, Marek SM, Mysore KS (2010) Phymatotrichum (cotton) root rot caused by *Phymatotrichopsis omnivora*: retrospects and prospects. Molecular Plant Pathology 11:325–334. <https://doi.org/10.1111/j.1364-3703.2010.00616.x>

Van Helden M, Heddle T, Proctor C, et al (2021) Noncrop host plant associations for oversummering of *Diuraphis noxia* in the state of South Australia. Journal of Economic Entomology 114:2336–2345. <https://doi.org/10.1093/jee/toab191>

Van Helden M, Heddle T, Umina PA, Maino JL (2022) Economic injury levels and dynamic action thresholds for *Diuraphis noxia* (Hemiptera: Aphididae) in Australian cereal crops. Journal of Economic Entomology 115:592–601. <https://doi.org/10.1093/jee/toab272>

Wang T, Thomasson JA, Isakeit T, et al (2020) A Plant-by-Plant Method to Identify and Treat Cotton Root Rot Based on UAV Remote Sensing. Remote Sensing 12:2453. <https://doi.org/10.3390/rs12152453>

Ward S, van Helden M, Heddle T, et al (2020) Biology, ecology and management of *Diuraphis noxia* (Hemiptera: Aphididae) in Australia. Austral Entomology 59:238–252. <https://doi.org/10.1111/aen.12453>

Wright D, MacLeod B, Hammond N, Longnecker N (2016) Can grain growers and agronomists identify common leaf diseases and biosecurity threats in grain crops? An Australian example. Crop Protection 89:78–88. <https://doi.org/10.1016/j.cropro.2016.07.005>

Wright D, Hammond N, Thomas G, et al (2018) The provision of pest and disease information using Information Communication Tools (ICT); an Australian example. Crop Protection 103:20–29. <https://doi.org/10.1016/j.cropro.2017.08.023>

Weinberg J, Ota N, Goergen G, et al (2022) *Spodoptera eridania*: Current and emerging crop threats from another invasive, pesticide-resistant moth. Entomologia Generalis 42:701–712. <https://doi.org/10.1127/entomologia/2022/1397>

Yazdani M, Baker G, DeGraaf H, et al (2018) First detection of Russian wheat aphid *Diuraphis noxia* Kurdjumov (Hemiptera: Aphididae) in Australia: a major threat to cereal production. Austral Entomology 57:410–417. https://doi.org/10.1111/aen.12292

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