National Environment and Community Biosecurity Research, Development and Extension Strategy 2016 to 2019

National Biosecurity Research, Development and Extension Framework

Intergovernmental Agreement on Biosecurity



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Summary

Pests, weeds and diseases (which involve either alien or native organisms that adversely affect the environments they invade and impair their functionality) are well known to cause significant negative impacts on the Australian natural environment and community. They can adversely affect threatened and endangered native organisms and ecological communities, ecosystem services, cultural and spiritual values, social amenities, infrastructure, transport, utilities, human lifestyles and wellbeing. While their impacts on the environment and community can be very high, broad and diverse, these are not always readily quantifiable in economic terms.

The National Environment and Community Biosecurity Research, Development and Extension (RD&E) Strategy (the strategy) has been developed under Schedule 8 (National Biosecurity RD&E Framework) of the Intergovernmental Agreement on Biosecurity (IGAB). It aims to establish a national, coordinated and strategic approach to biosecurity RD&E for the environment and community, which is urgently required to maximise benefits from past and future RD&E investments. Current national approaches and investments in RD&E are highly fragmented and irregular, and are a major impediment to generating cost-effective RD&E that deliver major national outcomes.

Environment and community biosecurity is defined very broadly in the context of this strategy without distinction between threats from alien or native organisms. This strategy brings together the disparate and diverse biosecurity RD&E needs not covered by the Animal Biosecurity RD&E Strategy and National Plant Biosecurity RD&E Strategy, which focus on issues that affect primary production, including trade and human health. It was developed by a national steering committee with stakeholder consultation. Its audience extends from investors to RD&E providers and a wide range of end-users, with no single peak representative body.

Strategy vision

Australia's research, development and extension to reduce impacts of pests, weeds and diseases on the natural environment and community are well-coordinated nationally, directed at national priorities and effectively delivered through stakeholder collaboration.

Strategy goals and objectives

Goal 1 Efforts are focused on nationally agreed RD&E priority areas and build upon previous achievements as well as identifying opportunities to lead and support innovation.

Objectives

1.1 Coordinate national RD&E priority setting within groups of pests, weeds and diseases.

1.2 Collaboratively develop a framework to guide RD&E investment decisions to assist both proponents and decision-makers.

1.3 Identify gaps and vulnerabilities in RD&E capabilities and develop plans to address them.

1.4 Raise awareness in the community of the need for and benefits to be derived from targeted RD&E activities which improve management of pests, weeds and diseases.

Goal 2 The effectiveness of RD&E is enhanced to ensure maximum benefit is derived from stakeholder investments.

Objectives

2.1 Enhance coordination and collaboration in investing, undertaking and maintaining capabilities in RD&E within and across groups of pests, weeds and diseases.

2.2 Identify and take advantage of existing and potential new collaborations between biosecurity RD&E for the environment and community, and for primary industries.

2.3 Improve linkages between national research and development, and regional or local extension.

A series of strategic actions to achieve or progress each objective over the next three years will be developed during the implementation phase of this Strategy.

All pests, weeds and diseases of aquatic (freshwater and marine) and terrestrial habitats that affect the environment or the community are within the scope of this Strategy. For the purpose of this Strategy, they are grouped into the following sectors: 1) diseases of terrestrial wild animals, 2) diseases of marine and freshwater wild animals, 3) diseases of captive animals, 4) human disease animal vectors, 5) vertebrate pests, 6) invertebrate pests with impacts on social amenity or natural values, 7) environmental weeds, 8) marine pests, and 9) pests and diseases of plants in natural ecosystems and/or social amenities. RD&E priority areas for the sectors covered by this Strategy, which address the nationally agreed RD&E objectives under the IGAB, were identified by a cross-section of stakeholders at a national workshop. The RD&E priority areas identified are grouped under four broad categories: risk analysis and decision making; detection, diagnosis and surveillance; management methods and strategies; and stakeholder engagement.

An inventory of RD&E capabilities relevant to biosecurity issues of the environment and community revealed that they are mostly found in universities and government departments and agencies, although there is a plethora of other contributors, especially in extension. Depending on emergency requirements or availability of external funding, some capabilities deployed to address primary industry biosecurity issues are often redirected to biosecurity needs of the environment and community, and vice versa. There is also potential to divert capabilities that traditionally focus on biodiversity and ecosystem services research to biosecurity issues of the environment and community if there are specific needs and funding opportunities.

Government recognition of the importance of this strategy and national leadership in its delivery under the IGAB, within the legislative and constitutional responsibilities of governments, is necessary to provide the long term stability, commitment and continuity required to implement this strategy and ensure outcomes are delivered. Strong linkages and coordination between government departments (environment and agriculture) will be crucial for implementation. The growing non-government sector also needs to be more effectively harnessed, as it could have an important role in the successful implementation of this Strategy. It is important to realise, though, that financial support from community stakeholders to implement this strategy is likely to be difficult to achieve and thus support from government will be required. Recommendations for implementation of this strategy include:

- Embracing the series of change management approaches proposed to guide the transition from the limited coordination to biosecurity RD&E for the environment and community to a more collaborative and cost-efficient model.
- Establishment of a National Implementation Committee, with well-defined terms of reference and sufficiently empowered to make national level recommendations on priorities and strategies that are in the national interest. The committee should be endorsed by and report to the National Biosecurity Committee (NBC) or an Australian Government agency with appropriate levels of legislative and constitutional authority for the coverage of this Strategy. The National Implementation Committee should comprise up to 12 representatives from key stakeholder groups that are strongly committed to this Strategy.
- An alternative to the National Implementation Committee would be a government organisation willing to 'champion' this strategy and invest and seek resources to oversee its implementation, in partnership with an advisory committee comprising a cross-section of stakeholders.
- As a starting point, the National Implementation Committee or champion organisation should promote examples of where a coordinated approach has worked well to demonstrate the potential effectiveness of this Strategy. Initially targeting the strategy implementation against one of the seven important cross-sectoral RD&E priority areas identified would be another avenue to demonstrate effectiveness.

Acronyms

	ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences		
	АНС	Animal Health Committee		
	Catchment Management Authority			
	CSIRO	Commonwealth Scientific and Industrial Research Organisation		
	CRC	Cooperative Research Centre		
	EBC	Environmental Biosecurity Committee		
	EPBC Act	Environment Protection and Biodiversity Conservation Act 1999		
	IGAB	Intergovernmental Agreement on Biosecurity		
	IPAC	Invasive Plants and Animals Committee		
	ISC	Invasive Species Council		
	IUCN	International Union for Conservation of Nature		
	MPSC	Marine Pest Sectoral Committee		
	NBC	National Biosecurity Committee		
	NEBRA	National Environmental Biosecurity Response Agreement		
	NGO	Non-government organisation		
	NPBS	National Plant Biosecurity Strategy		
	NRM	Natural Resource Management		
	PHA	Plant Health Australia		
	РНС	Plant Health Committee		
	PISC	Primary Industries Standing Committee		
	RDC	Research and Development Corporation		
	R&D	research and development		
	RD&E	research, development and extension		
	SCoPI	Standing Council on Primary Industries		

Department of Agriculture and Water Resources

1 Introduction

The National Environment and Community Biosecurity Research, Development and Extension (RD&E) Strategy (the strategy) has been developed under Schedule 8 (National Biosecurity RD&E Framework) of the Intergovernmental Agreement on Biosecurity (IGAB). It brings together the disparate and diverse biosecurity RD&E needs not covered by the Animal Biosecurity RD&E Strategy and National Plant Biosecurity RD&E Strategy, which focus on issues that primarily affect primary production, including trade and human health (Appendices 3, 4; see section 3). It was developed by a national steering committee with stakeholder consultation.

In an era of tightening government financial investments there will always be more RD&E activities possible than the number that can be supported. This fact applies to RD&E activities across most areas of scientific endeavour, including those that focus on biosecurity issues. This strategy aims to establish a national, coordinated and strategic approach to biosecurity RD&E for the environment and community, which is urgently required to maximise benefits from past and future RD&E investments on invertebrate and vertebrate pests , weeds and diseases. Current national approaches and investments in RD&E are highly fragmented and irregular, and are a major impediment to generating cost-effective RD&E that deliver major national outcomes. Environment and community is defined very broadly in the context of this strategy without distinction between threats from alien or native organisms.

This document first provides general background information and outlines the vision, goals, objectives, scope and audience of this Strategy, as well as critical success factors and possible high-level outcomes following its implementation. It then presents a situational analysis of the sectors covered by this Strategy. It identifies RD&E priority areas for investment and provides an initial inventory and analysis of existing capabilities. Finally, it presents a series of recommendations for implementation of this Strategy.

2 Background

2.1 Intergovernmental Agreement on Biosecurity

This strategy has been developed under Schedule 8 (National Biosecurity RD&E Framework) of the Intergovernmental Agreement on Biosecurity (IGAB), which is being implemented by the National Biosecurity Committee (NBC).

The IGAB is an agreement between the Australian, state and territory governments (except Tasmania at this stage), which came into effect in January 2012 (Council of Australian Governments 2012a). It was developed to improve the national biosecurity system in Australia by identifying the roles and responsibilities of governments and outlining priority areas for collaboration.

The overall goal of Australia's national biosecurity system is to minimise the impact of all biological threats (pests, weeds and diseases) on the economy, environment and the community. The system aims to assess and manage risks while enabling trade and movements of animals, plants, people, goods, vectors and vessels to, from and within Australia.

The objectives of the national biosecurity system, as defined under the IGAB, are to provide arrangements, structures and frameworks that:

- reduce the likelihood of alien pests and diseases, which have the potential to cause significant harm to the economy, the environment, and the community (including people, animals and plants) from entering, becoming established or spreading in Australia
- prepare and allow for effective responses to, and management of, alien and emerging pests and diseases that enter, establish or spread in Australia
- ensure that, where appropriate, significant pests and diseases already in Australia are contained, suppressed or otherwise managed.

The former Schedule 8 Working Group (oversight of activities subsumed by IGAB Implementation Taskforce) of the IGAB had developed an overarching strategic approach for focussing national biosecurity RD&E priorities with the aim to i) align resources and activities to address biosecurity priorities; ii) build and maintain scientific and technical capacity; and iii) contribute to the collaborative management of biosecurity risks. The following four national biosecurity R&D priorities have been identified as part of this work:

- minimise the risk of entry, establishment, or spread of pests and diseases
- eradicate, control or mitigate the impact of established pests and diseases
- understand and quantify the impacts of pests and diseases
- cost-effectively demonstrate the absence of significant pests and diseases.

Objectives under each of the priorities are based on the National Biosecurity Research and Development Capability Audit 2012 (Intergovernmental Agreement on Biosecurity–Research, development and Extension Working Group, 2012) and presented in `.

These R&D priorities, agreed to by a wide array of stakeholders, are considered important for enhancing Australia's biosecurity system, but are currently under-developed and under-resourced.

This strategy complements the Animal Biosecurity RD&E Strategy and National Plant Biosecurity RD&E Strategy developed under the National Primary Industries RD&E Framework (see 2.2).

These three strategies provide the frameworks for progressing the priorities under Schedule 8 of the IGAB.

In this strategy the following IGAB definitions are adopted:

Biosecurity: The management of the risks to the economy, the environment, and the community of pests and diseases entering, emerging, establishing or spreading.

Environment:

1) ecosystems and their constituent parts, including people and communities

- 2) natural and physical resources
- 3) the qualities and characteristics of locations, places and areas
- 4) freshwater, estuarine and marine environments.

Community: Human society and its activities, including human health and social amenity.

The IGAB does not have a definition of 'social amenity'. The National Environmental Biosecurity Response Agreement (NEBRA) developed by the IGAB defines 'social amenity' as any tangible or intangible resources developed or provided by humans or nature such as dwellings and parks, or views and outlooks.

2.2 National Primary Industries RD&E Framework

The National Primary Industries RD&E Framework (the framework) was instigated and endorsed in November 2009 by the former Primary Industries Ministerial Council), subsequently known as the Standing Council on Primary Industries (SCoPI), which has recently been replaced by the Agriculture Ministers' Forum. Development of the Framework involved the Australian, state and territory governments, rural R&D corporations, CSIRO and universities. The Framework aims to promote and facilitate greater collaboration and coordination between research providers and focus RD&E investments nationally to increase efficiency and effectiveness, and thus maximise benefits to Australia's primary industries (National Primary Industries Research, Development and Extension Framework, 2016a) The outcomes sought from the Framework are outlined in Appendix 6.

RD&E strategies have been developed to support the implementation of the Framework (National Primary Industries Research, Development and Extension Framework, 2016b). Fourteen strategies focus on specific primary industry sectors (beef, cotton, dairy, fishing and aquaculture, forest and wood products, grains, horticulture, pork, poultry, sheep meat, sugarcane, wine, wool, and new and emerging industries). Another eight strategies focus on cross-industry sectors (animal welfare, biofuels and bioenergy, climate change, food and nutrition, water use in agriculture, soils, animal biosecurity and plant biosecurity). The Animal Biosecurity RD&E Strategy and National Plant Biosecurity RD&E Strategy, which complement this Strategy, have been endorsed by the former SCoPI.

It is noteworthy that many of the non-biosecurity focused RD&E strategies developed for primary industries under the Framework include components relevant to biosecurity issues affecting the environment. For example, one of the strategic research themes of the National Fishing and Aquaculture RD&E Strategy (Fisheries Research and Development Corporation 2010) focuses on biosecurity and aquatic animal health and aims 'to develop methods and processes to protect fisheries, aquaculture sites and ecosystems from pests and diseases'. The RD&E Strategy for the Forest and Wood Products Sector (Forest & Wood Products Australia 2010) includes priority research areas that are relevant to the biosecurity of native forests, for example, 'analysis of the potential impacts of pests and disease threats on non-commercial values (biodiversity, recreation, water and other values) in forests'. Coordination during the implementation phase of this strategy with several of the sector and cross-sector RD&E strategies will be required to build a common understanding of issues and take a collaborative approach wherever possible.

3 Strategy foundations

3.1 Vision

The vision of this strategy is:

Australia's research, development and extension to reduce impacts of pests, weeds and diseases on the natural environment and community are well coordinated nationally, directed at national priorities and effectively delivered through stakeholder collaboration.

3.2 Goals

The goals of this strategy are that:

- 1) efforts are focused on nationally agreed RD&E priority areas and built upon previous achievements as well as identifying opportunities to lead and support innovation
- 2) the effectiveness of RD&E is enhanced to ensure maximum benefit is derived from stakeholder investments.

3.3 Objectives

This strategy includes seven objectives as presented in Table 1 and Table 2, addressing the two goals identified above. Expected outcomes have been identified for each objective. A series of strategic actions to achieve or progress each objective over the next three years will be developed during the implementation phase of this Strategy. Progress against each objective should be measured annually against identified outcomes.

Table 1 Objectives and expected outcomes to address Goal 1

Objective	Outcome		
1.1 Coordinate national RD&E priority setting within groups of pests, weeds and diseases.	Key RD&E priority areas collectively identified and agreed by stakeholders.		
1.2 Collaboratively develop a framework to guide RD&E investment decisions to assist both proponents and decision-makers.	Future investment decisions for RD&E projects based on transparent criteria and closely linked to agreed priority areas.		
	More cost-effective allocation of limited resources.		
1.3 Identify gaps and vulnerabilities in RD&E capabilities and develop plans to address them.	Increased RD&E preparedness to promptly respond to biosecurity incidents.		

Note: Goal 1 Efforts are focused on nationally agreed RD&E priority areas and built upon previous achievements as well as identifying opportunities to lead and support innovation.

Table 2 Objectives and expected outcomes to address Goal 2

Objective	Outcome
2.1 Enhance coordination and collaboration in investing,	Better utilisation of available RD&E funds,
undertaking and maintaining capabilities in RD&E within	capabilities and infrastructures, and reduced
and across groups of pests, weeds and diseases.	transaction costs across Australia.
2.2 Identify and take advantage of existing and potential	Increased RD&E capacity and efficiency to address
new collaborations between biosecurity RD&E for the	biosecurity issues shared between the environment,
environment and community, and for primary industries.	community and primary industry sectors.
2.3 Improve linkages between national R&D and regional or local extension.	More effective delivery and adoption of R&D by end- users.

3.4 Scope

This strategy addresses national biosecurity RD&E issues relating to the natural environment and the community (social amenities, infrastructure, transport, utilities, human lifestyles and wellbeing) (Table 3). Social amenities are defined as desirable or useful facilities that provide members of the community a pleasant working and living environment, including for social, cultural or spiritual experiences.

This strategy focuses on pests, weeds and diseases that involve either alien or native organisms that adversely affect the environments they invade and impair their functionality. All pests, weeds and diseases of aquatic (freshwater and marine) and terrestrial habitats that affect the environment or the community are within the scope of this strategy (Table 3). This includes outbreaks and incipient or slow spreading invasions of pests, weeds and diseases, in any way considered harmful to valued native organisms, natural ecosystems, community assets or human lifestyles and wellbeing. It is necessarily broad because it is defined by all aspects of biosecurity recognised as part of Schedule 8 (National Biosecurity RD&E Framework) of the IGAB, which are not covered by the Animal Biosecurity RD&E Strategy and National Plant Biosecurity RD&E Strategy (Appendices 3, 4). Nonetheless there will be commonalities between these three strategies and hence a coordinated approach will be essential during their implementation.

It is noteworthy that some of the pests, weeds and diseases covered by this strategy may currently impact on primary industries or will affect them in the future. Vertebrate pests, for example, which are only covered in this Strategy, have impacts that are not restricted to a particular land use (Appendix 7). Other notable examples that are covered by both this strategy and the Animal Biosecurity RD&E Strategy are aquatic wild animals that may be important components of ecosystems and form part of community recreational fisheries, but become part of commercial fisheries if or when captured, and animal vectors of human diseases, which are themselves human pests (for example, ticks). Diseases like myrtle rust that affect plants of natural ecosystems and social amenities, and weeds that invade natural ecosystems are covered by this Strategy, but are also covered by the National Plant Biosecurity RD&E Strategy if they affect primary production. Similarly, this strategy includes pests, weeds and diseases that may be the focus of biodiversity conservation activities or be important components in the management of livestock or zoonotic diseases. Zoonotic diseases are infectious diseases that can be transmitted from animals to humans.

Organisms that affect human health (viruses, bacteria, fungi, parasites), whether transmitted through other organisms or not, genetically modified organisms, animal welfare, chemical contamination, or residue issues are not covered by this Strategy.

The sectors referred to in this strategy correspond to the traditional groupings of pests, weeds and diseases that have been used in Australia (Table 4).

3.5 Stakeholders

The audience for this strategy includes an extensive range of stakeholders, from investors to RD&E providers and a wide range of end-users (Table 5), with no single peak representative body and in many sectors no representative body at all. The general public are major beneficiaries of biosecurity RD&E that aims to protect and reduce harmful impacts of pests,

weeds and diseases on the environment and community. Benefits also flow to industries and other sectors of the economy.

Improved connectivity, information sharing and feedback mechanisms between stakeholders will be crucial for agreeing on national priorities and achieving this Strategy's goals.

Habitat Category of organism		Examples		
Aquatic – marine and freshwater	Vertebrates	Pest fish (for example, tilapia), amphibians and aquatic reptiles (for example, red-eared slider turtle)		
	Invertebrates	Pest animals (for example, Pacific oysters, zebra mussel) Overabundant or displaced native animals adversely affecting aquatic ecosystems (for example, smooth marron, crown of thorns starfish) Parasites of wild animals and aquarium animals Vectors of animal and human diseases Pests of plants		
	Plants	Weeds (for example, salvinia, cabomba) Invasive seaweed and microscopic algae (for example, didymo)		
	Pathogens	Diseases of wild animals and aquarium animals Diseases of plants		
Terrestrial	Vertebrate	 Feral domestic animals (for example, camels, horses, cats, rabbits) Alien mammals (for example, foxes, hares), birds (for example, Indian myna), amphibians (for example, cane toad) and reptiles (for example, Asian house gecko) Overabundant or displaced native animals adversely affecting natural ecosystems (for example, kangaroos) Vectors of animal diseases, including zoonotic and human diseases (for example, bat as vector of Hendra virus) 		
	Invertebrates	Parasites of wild animals Parasites of captive animals (zoo, companion animals, except horses) Pests of social amenities (for example, wasps, ants, red back spiders) Vectors of animal diseases, including zoonotic and human diseases (for example, mosquito, tick) Pests of plants in natural ecosystems and social amenities		
	Plants	Environmental weeds (for example, lantana, sweet pittosporum, gamba grass)		
	Pathogens	Diseases of wild animals Diseases of captive animals (zoo, companion animals, except horses) Diseases of plants in natural ecosystems and/or social amenities (for example, myrtle rust)		

Table 3 Scope of the National Environment and Community Biosecurity RD&E Strategy

Notes: Scope includes all aquatic (marine and freshwater) and terrestrial pests, weeds and diseases that affect the environment, social amenities, infrastructures, transport, utilities and/or human lifestyles and wellbeing, unless indicated otherwise. Pests and diseases of vertebrates that affect human health are covered by the Animal Biosecurity RD&E Strategy (Appendix 3). Native and feral animals. Pests and diseases of feral animals can pose a threat to native and companion animals. Throughout this document, the word 'invasive' denotes that the organism adversely affects the environments it invades and impairs their functionality. Horses are covered by the Animal Biosecurity RD&E Strategy.

Table 4 Sector	s referred	to in this	strategy
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Sector	Notes			
Diseases of terrestrial wild animals	Includes pathogens, parasites, potential animal vectors of diseases and invertebrate pests of animals.			
Diseases of marine and freshwater wild animals	Includes pathogens, parasites, potential animal vectors of diseases and invertebrate pests of animals.			
Diseases of captive animals	Zoo, aquarium, companion animals, except horses. Includes pathogens, parasites, potential animal vectors of diseases and invertebrate pests of animals.			
Human disease animal vectors	Includes mosquitoes and ticks that may vector human diseases or zoonotic diseases of human importance.			
Vertebrate pests	Alien and native mammals, birds, reptiles, amphibians, fish.			
Invertebrate pests with impacts of on social amenity or natural values and freshwater	For example, ants, wasps, spiders, leeches.			
Environmental weeds	Terrestrial and freshwater.			
Marine pests	Invertebrate, vertebrate and plant pests.			
Pests and diseases of plants in natural ecosystems and/or social amenities	Includes pests and diseases of native and non-native amenity plants.			

Note: Sectors correspond to the traditional groupings of pests, weeds and diseases that have been used in Australia The word 'pest' includes alien organisms as well as overabundant and displaced native organisms that adversely affect natural ecosystems.

Table 5 Exami	oles of stakeholders	of the National	Environment and	Community I	Biosecurity I	RD&E Strategy

End-users	RD&E providers	Principal investors
 Land managers of private land (for example, conservation covenants), crown land, public estates, protected areas, indigenous land including Indigenous Protected Areas National parks and reserves (terrestrial and marine) Natural Resource Management (NRM) Regions/Catchment Management Authority (CMA)/Local Land Services Local governments/Councils Local communities (for example, Landcare, bushcare and reefwatch groups) Primary producers Non-governmental organisations (NGOs) Private providers of environmental rehabilitation services Infrastructure companies Port authorities and port owners Water care and management authorities 	 Universities CSIRO CRCs State and territory governments (environment and primary industries departments) Botanical gardens Museums Private consultants NRM Regions /CMA /Local Land Services Zoos Conservation NGOs 	 Australian Government (AG) Department of the Environment AG Department of Agriculture and Water Resources State and territory governments (environment and primary industries departments) AG Department of Health AG Department of Prime Minister and Cabinet: Indigenous Affairs Australian Research Council Cooperative Research Centres (CRCs) RD&E providers generally contribute major resources as co-investment to projects financially supported by external investors

En	d-users	RD&E providers	Principal investors
٠	Resource exploitation companies		
•	Managers of crown land – Department of Defence		
٠	Forestry companies		
•	Wildlife rescue/rehabilitation organisations		
٠	Pest control companies		
•	Pet and aquarium industries		
•	Nursery industry		

3.6 Critical success factors

The critical success factors of this strategy, that is, elements that are vital to achieve the goals of this strategy are:

- Agreement on key RD&E priority areas in each sector by stakeholders, that build on previous achievements.
- Strong engagement and commitment to the establishment of a more effective RD&E model by stakeholders.
- A vibrant representative national committee or organisation to champion, lead and coordinate the implementation of this Strategy, with support (financial or otherwise) from stakeholders.
- Strong support of this strategy through regular evaluations of progress against objectives and on-going adjustments to address new challenges and changing circumstances.

3.7 High-level outcomes

The critical success factors of this Strategy, that is, elements that are vital to achieve the goals of this strategy are:

- The goals, objectives and recommended implementation arrangements of this strategy will contribute to the achievement of the following high-level outcomes:
- Australia meets its international obligations to conserve biodiversity
- Increased national profile of biosecurity issues that affect the environment and community in Australia
- Increased knowledge, benefits and on-ground impact from investments in environment and community biosecurity RD&E
- Greater national coordination of environment and community biosecurity RD&E through improved linkages between stakeholders, including primary industries
- More collaboration between and amongst environment and community biosecurity RD&E providers and investors, and more efficient utilisation of facilities across Australia
- More effective environment and community RD&E by engaging early with stakeholders and encouraging participation across all scales (local, regional and national)

- Effective coordination between this strategy and those for animal and plant biosecurity RD&E.
- Improved opportunities to align environmental, primary industry and invasive organisms policy, planning and research efforts nationally.

4 Situational analysis

4.1 Overview

Pests, weeds and diseases not only cause loss to primary production or restrict ability to trade, but also negatively impact upon the Australian natural environment, social amenities, infrastructure, transport, utilities, human lifestyles and wellbeing (Box 1). Pests, weeds and diseases that negatively affect the environment and community are found across a wide range of habitats; from aquatic to terrestrial, urban to rural, and natural to human-modified.

With one of the most advanced biosecurity systems in the world and major efforts from a wide range of stakeholders over many years, Australia has been able to retain relative freedom from many harmful pests, weeds and diseases. However, the increasing movement of goods and people around the world has enhanced the threat of introduction of new high risk organisms. Nonetheless, many troublesome pests, weeds and diseases are already well-established, spreading and causing major damage to the environment—threatening biodiversity and ecosystem services, which include Supporting, provisioning, regulating and cultural services that the environment provides—as well as being a nuisance and inconvenience to communities around Australia. As a result of the serious negative impacts caused by pests, weeds and diseases, major investments have been made into their control or to minimise their impacts.

Biosecurity RD&E initiatives are essential to generate the knowledge, tools, capacity and outcomes that are critical to:

- prevent entry and establishment of new, potentially invasive alien pests, weeds and diseases (pre-border and border)
- implement evidence-based adaptive management and control of invasive alien organisms already established and/or widespread, and native organisms that have become harmful (post-border; containment, impact mitigation and asset-protection) (Figure 1).

Research activities also include assessment and documentation of damage and impacts caused by pests, weeds and diseases on the environment and community, and benefit-cost analyses of future investments to provide quantitative data to justify expenditure on their management. RD&E on biosecurity issues that affect the environment and community are funded and performed by a wide range of investors and providers, including Australian, state and territory governments, Cooperative Research Centres (CRC), CSIRO, universities and private organisations.

4.2 Biosecurity of the environment and community

The importance of a nationally coordinated, effective biosecurity system for the protection of the environment and the community is at least as great as it is for primary industries, trade and human health. While the impact of pests, weeds and diseases can be very high, broad and diverse on the environment and the community, these are not always readily quantifiable in economic terms, although impacts often cascade into other areas. Most impacts are primarily recognised in terms of documented or observed declines in biodiversity, quality and quantity of ecosystem services and quality of life for people (Australian Government Department of the Environment and Energy 2011). Invasive ants (tramp ants), for example, red imported fire ant and yellow

crazy ant, can have deleterious impacts on biodiversity as well as social amenities and human wellbeing. Similarly, invasive alien grasses (for examples, gamba grass or para grass) have direct negative effects on biodiversity, but also drastically change fire regimes making them more dangerous. Further, aquatic weeds, such as water hyacinth, reduce water quality, light penetration and oxygen levels and increase evapotranspiration. They also block irrigation systems and reduce the recreational use and aesthetic values of waterways.

Box 1 Examples of pests, weeds and diseases currently causing negative impacts on the environment and the community in Australia

Marine pest

European fan worm is believed to compete with native filter-feeding organisms for food and space and could be a major threat to benthic assemblages as well as the nutrient cycling processes.

Freshwater pest

Red-eared slider turtle is present in Australia and listed by the International Union for Conservation of Nature (IUCN) as one of the 100 world's worst invaders. It competes with native turtles, spreading diseases and parasites.

Vertebrate pest

Cane toads, introduced in north Queensland in the 1930s, have now spread across to north Western Australia. Impacts on biodiversity are reportedly high as the toxin produced by all stages of the cane toad causes deaths in animals (terrestrial or aquatic) which prey on the toad. Cane toads also pose a significant threat to household pets and children.

Disease of wild native animal

Devil facial tumour disease, a contagious cancer, spreads when Tasmanian devils bite or nip each other. It has major direct impacts on this endangered species, with death usually occurring within 6 months. The disease is untreatable at this time, so efforts are being made to establish a captive insurance population of healthy animals.

Disease of wild fish

An uncharacterised herpes virus caused extensive mortality in pilchard populations around the Australian coastline in the mid-1990s. Collateral adverse impacts were reported on populations of piscivorous species such as little penguins and Australasian gannets.

Tramp ant

On Christmas Island, yellow crazy ant swarms have killed more than 15 million native red land crabs. They also pose a threat to unique birds.

Environmental weed

The alien woody shrub mimosa infests over 80 000 hectares of coastal floodplain in the Northern Territory. It forms dense monocultures that exclude native fauna and flora.

Disease of native plants

Myrtle rust fungus causes a disease that affects trees and shrubs in the Myrtaceae family of plants. When severely infected, young plants and new growth become stunted and in the worst case may die. The Myrtaceae family includes many iconic Australian native plants such as bottle brush, tea tree and eucalypts.

Invertebrate vector of a human disease

Aedes aegypti, probably introduced to Australia in the mid-1800s, is a mosquito of human habitations that transmits the occasionally fatal dengue fever in North Queensland.

Note: Australian Biosecurity Group 2005, 'Invasive weeds, pests and diseases – solutions to secure Australia', available at nrmonline. (<u>nrm.gov.au/downloads/mql:2687/pdf</u>, accessed 20 January 2016) provides more examples.

Figure 1 Generalised invasion curve for pests, weeds and diseases



GENERALISED INVASION CURVE SHOWING ACTIONS APPROPRIATE TO EACH STAGE

Note: Shows actions appropriate at each stage and return on investment. Source: Department of Economic Development, Jobs, Transport and Resources (2015)

Many aspects of biosecurity relating to the environment overlap with biodiversity conservation. For example, the damage caused by some organisms, such as land degradation by European rabbits, dieback caused by the root-rot fungus Phytophthora cinnamomi, infection of amphibians by chytrid fungus and invasion of northern Australia by gamba grass, are officially recognised under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) as key threatening processes for the survival, abundance or evolutionary development of listed threatened native organisms or ecological communities (Australian Government Department of the Environment and Energy 2016a). Invasive organisms threaten more nationally listed native species than any other threat category apart from habitat loss (Evans et al. 2011). The Australia state of the environment 2011 reports that 'invasive species and pathogens represent one of the most potent, persistent and widespread threats to Australian biodiversity' and says that pressures from invasive organisms are major and have been growing worse over the past decade (Australian Government Department of the Environment and Energy 2011). The Australia's Biodiversity Conservation Strategy 2010-2030 has the following target that focuses on invasive organisms: 'By 2015, reduce by at least 10% the impacts of invasive species on threatened species and ecological communities in terrestrial, aquatic and marine environments (Australian Government Department of the Environment and Energy 2010).

To address listed key threatening processes, threat abatement plans are developed to guide the research, management, and any other actions necessary to reduce their impact and assist the long term survival in the wild of affected native organisms or ecological communities. Several research projects that address invasive organisms within the context of threat abatement plans have been supported by the Australia Government Department of the Environment and other funding bodies (Australian Government Department of the Environment and Energy 2016b).

The Invasive Species Council (ISC), an environmental non-governmental organisation (NGO) in Australia, proposed in 2012 the establishment of a separate body ('Environmental Health Australia') to complement existing industry-government biosecurity partnerships (Plant Health Australia [PHA] and Animal Health Australia [AHA]) (Invasive Species Council 2012a). The goal of this proposed national body was to 'foster ecological, coordinated and collaborative approaches to prevent and reduce environmental harm from invasive species'. In a more recent discussion paper (Invasive Species Council 2012b), the ISC outlined the following aspects which it believes distinguish primary industries and the environment with regards to biosecurity issues:

- While the impacts of pests, weeds and diseases on primary industries are often quantifiable in economic terms and can often be prevented with replacements (for example, using new breeds), the values at stake for the environment (thousands of organisms and their interactions that constitute ecosystems and ecosystem processes in terrestrial, freshwater and marine systems) are not readily quantified in economic terms or replaced
- Pests, weeds and diseases threatening the environment are far greater in number than those threatening primary industries
- Much less is known about native biota than cultivated organisms, and the impacts of pests, weeds and diseases that threaten them
- There are higher levels of uncertainty about the impacts of pests, weeds and diseases on the environment than on primary industries because of complex interactions, long timeframes and lack of knowledge
- There are many more management options available for pests, weeds and diseases of primary industries than for the environment
- Primary industries have commercial incentives to manage pests, weeds and diseases and prevent introduction of new organisms, whereas biosecurity issues affecting the environment rely on government and community public good investment.

4.3 Australia's biosecurity system overview

The Australian Government Department of Agriculture and Water Resources has primary responsibility for managing Australia's biosecurity system, with a particular focus offshore and at the border. In addition to its core priorities in managing biosecurity to protect food security and the economy, it is also committed to partner with other stakeholders to protect the environment from the impacts of pests, weeds and diseases. State and territory governments have responsibility to manage onshore biosecurity risks within their jurisdiction.

The National Biosecurity Committee (NBC), established in July 2008, provides strategic leadership in managing national approaches to emerging and ongoing biosecurity policy issues across jurisdictions and sectors, and provides advice to the Agriculture Ministers' Forum, via the Agriculture Senior Officials Committee. The Forum and Committee both include representatives from Australian, state and territory governments (Figure 2).



Figure 2 Schematic of Australia's current national biosecurity system

Note: the diagram was developed with assistance from the NBC secretariat. Emergency response agreements and plans are not shown.

The NBC is also responsible for implementing the IGAB and overseeing a number of sectoral committees (see 4.4). Biosecurity issues that relate to the environment and community are NBC responsibilities. PHA and AHA are not-for-profit companies that coordinate government-industry partnerships nationally for primary industry plant and animal biosecurity, respectively. Their activities however, have been generally limited in relation to weeds and vertebrate pests as these have not been included in industry-government cost-sharing deeds in relation to incursions threatening primary industries.

The National Environmental Biosecurity Response Agreement (NEBRA) (Council of Australian Governments 2012b), developed under the aegis of IGAB and involving the Australian, state and territory governments, outlines agreed emergency response and cost-sharing arrangements for responding to biosecurity incidents (outbreaks and new incursions) that primarily affect the environment and community. It specifically relates to situations where the response is for the public good. This is in contrast to other emergency response agreements that are specifically designed for responding to biosecurity incidents that affect primary industries – the Emergency Animal Disease Response Agreement and Emergency Plant Pest Response Deed, and their

associated response plans (that is, AUSVETPLAN, PLANTPLAN and AQUAVETPLAN). The NEBRA is also currently the relevant mechanism for responding to biosecurity incidents, including weeds and vertebrate pests, relevant to primary production but not covered under the existing primary industries' deeds with industry cost-sharing provisions.

4.4 Sectoral committees

Several sectoral committees currently sit under the NBC and focus on different biosecurity issues (Figure 2, Table 6). Their role is to develop and coordinate the implementation of harmonised, national arrangements to identify, minimise and address risks from pests, weeds and diseases. They also review and advise on biosecurity RD&E programs and activities to achieve optimal value from public investment.

It is noteworthy that an Environmental Biosecurity Committee (EBC) was established in September 2007 as another committee to report to the NBC (pending its official formation in 2008) to oversee the biosecurity threats of invertebrates and pathogens to the environment, which were seen as gaps not covered by the existing sectoral committees. The EBC was dissolved in early 2009 and its responsibility devolved to the NBC and the various sectoral committees.

The two key roles of the EBC as part of its terms of reference were to:

- coordinate, as appropriate, work under the NBC on biosecurity matters as they impact on the natural environment
- coordinate development of national biosecurity policy in relation to invertebrates and pathogens that impact on the natural environment.

The EBC contracted in 2008 the Bureau of Rural Sciences (now known as the Australian Bureau of Agricultural and Resource Economics and Sciences [ABARES]) to investigate the invasive capacity and likely impact of several alien invasive pathogens and invertebrates that affect the environment. The report proposed a methodology for use in future assessments and provided an interim list of 20 high risk pathogens and invertebrates, including information on their world distributions, potential pathways and impacts (Appendix 8).

The Australian Government Department of Agriculture and Water Resources has primary responsibility for managing Australia's biosecurity system, with a particular focus offshore and at the border. In addition to its core priorities in managing biosecurity to protect food security and the economy, it is also committed to partner with other stakeholders to protect the environment from the impacts of pests, weeds and diseases. State and territory governments have responsibility to manage onshore biosecurity risks within their jurisdiction.

4.5 RD&E in sectoral strategies

National strategies have been developed for some sectors—plant health, weeds, vertebrate pests, marine pests (currently in draft form), freshwater pest fish (2014–19)—to provide a framework to identify priorities for management of pests, weeds and diseases across the nation (Figure 2). These strategies set out guidelines as to how the Australian, state and territory governments will work with business, researchers, industry and the community to achieve strategic goals, with the ultimate aim of minimising impacts of pests, weeds and diseases. The marine pest sector has also established the National System for the Prevention and Management

of Marine Pest Incursions, which consists of a suite of measures aimed at prevention, emergency management and ongoing management and control of marine pests.

RD&E issues considered in the finalised strategies (and in the marine pest national system) are outlined in this strategy. Several of the sectoral committees have also started to develop RD&E strategies specific for their sectors; at this stage only the RD&E national priorities for introduced marine pests are available (see Figure 2).

Table 6 Pests, weeds and diseases that affect the environment, social amenities, infrastructures, transport, utilities and/or human lifestyles and wellbeing, mapped to the various NBC sectoral committees

Sectoral committee	Pests, weeds and diseases allocated to each committee
Animal Health Committee (AHC) Sub-committee on Aquatic Animal Health (SCAAH) National Animal Disease Surveillance and Diagnostics Strategy	Diseases (including parasites) of zoo and companion animals Animal/human health related vertebrate or invertebrate vectors Diseases (including parasites) of marine and freshwater fish and invertebrate organisms
Plant Health Committee (PHC) Subcommittee on Plant Health Diagnostics Subcommittee on National Plant Health Surveillance	Invertebrate pests and diseases of native plants in natural ecosystems and of native and non-native amenity plants Terrestrial invertebrate pests without host (but not vector of diseases) (for example, tramp ants) Pests of pollinators or those that impact upon pollinators
Marine Pest Sectoral Committee (MPSC)	Marine invertebrate and vertebrate pest organisms Marine biofouling Marine vascular/non-vascular invasive plants
Invasive Plants and Animals Committee (IPAC)	Terrestrial vertebrate pest organisms Freshwater vertebrate pest organisms Freshwater invertebrate pests Environmental and established agricultural terrestrial weeds Fresh water aquatic vascular (for example, salvinia) and non-vascular weeds (for example, didymo)

Note: Pests and diseases of vertebrates that affect human health are covered by the Animal Biosecurity RD&E Strategy (Appendix 3).

There is no general biosecurity strategy available for the animal health sector; however three relevant documents are available (Animal Biosecurity RD&E Strategy (Appendix 3), National Animal Health Laboratory Strategy, National Strategic Plan for Aquatic Animal Health – AQUAPLAN 2014–19)(Department of Agriculture and water Resources 2015) and a number of national programs also support the national animal health system (Animal Health Australia 2015).

4.5.1 National Plant Biosecurity Strategy

The development of the National Plant Biosecurity Strategy (NPBS), which focuses on primary production, was facilitated by PHA and the strategy was endorsed by the Australian, state and territory governments and industry in December 2010 (Plant Health Australia 2010).

One component of the NPBS recommends the development of a national framework for plant biosecurity research. This recommendation aims to address limitations of the current system in order to achieve the following by 2020:

- A national framework for biosecurity research that strengthens, prioritises and coordinates national research capabilities, and which efficiently and cost-effectively addresses plant biosecurity continuum and cross-sector plant production issues
- Agreed national strategies in place together with stable funding arrangements for research teams and entities across sectors
- Well-defined roles for all contributing parties
- The identification and prioritisation of key research and development areas in plant biosecurity
- Standardised, transparent prioritisation processes in place, conducted in a collaborative manner between government and industry and the use of risk and benefit-cost analyses to establish strong business cases for priority research.

Two key actions are included in the NPBS:

- Conduct a national plant industries research and development stocktake on a regular basis
- Identify and prioritise key research and development areas in plant biosecurity.

The biosecurity R&D priorities for plants listed in the NPBS are the same as the four national biosecurity R&D priorities developed under Schedule 8 (National Biosecurity RD&E Framework) of the IGAB (Appendix 6).

4.5.2 Australian Pest Animal Strategy

The Australian Pest Animal Strategy (APAS) (Australian Government Department of the Environment and Energy 2007) is a strategic framework developed by the former Vertebrate Pests Committee (VPC) and endorsed by the former Natural Resource Management Ministerial Council and Primary Industries Ministerial Council in 2007. It was revised under the leadership of the Invasive Plants and Animals Committee (IPAC) and released in September 2016 for consultation. While the APAS does not identify RD&E priorities, it does recognise the need to improve research coordination (Goal 1 – Provide leadership and coordination for management of pest animals; Objective 1.3), by specifically outlining the following: 'Produce a shared research and development plan to improve the development and adoption of best practice pest animal control methods, and facilitate adoption of this plan by all stakeholders.'

The APAS recognises that there is a need to both continually refine control techniques for vertebrate pests and to develop additional techniques. It also recommends that research programs should address the lack of ecological knowledge for some organisms and the poor understanding of the social components of vertebrate pest management. The development of a vertebrate pest animal R&D plan is also seen as critical to coordinate national research in high priority areas, identify current impediments to R&D and ways in which they could be overcome, and canvass approaches for more effective adoption of new, more effective control methods. Australian pest animal strategy is available at the Department of the Environment and Energy website (environment.gov.au/biodiversity/invasive-species/publications/australian-pest-animal-strategy).

The APAS identifies the following research challenges:

- better understanding the costs of environmental impacts
- addressing all pathways of introduction and spread
- understanding changes in risk posed by pest animals due to climate change
- continuing to provide improved methods and knowledge for optimising pest animal management.

It also articulates that the Australian Government has responsibilities to provide leadership, coordination and resources for research and evaluation of vertebrate pest issues of national significance, while state and territory governments have the responsibility to provide leadership, coordination and resources for research, evaluation and advisory services about pest animals affecting their jurisdiction. Community and industry organisations have responsibility to contribute to the funding of R&D of improved pest control methods.

The Invasive Animal CRC (Invasive Animals CRC 2010) is currently the most important and relevant entity to implement coordinated RD&E to deliver on the objectives of the APAS. For example, it recently supported a project to provide direction on how to advance development of national emergency response arrangements for freshwater fish incursions in Australia (Ayres, R & Clunie, P 2010). The project identified clear gaps in knowledge and outlined the following series of R&D needs:

- understanding key pathways of entry of alien freshwater fish this would enable those pathways to be targeted to minimise entry
- understanding social attitudes and understanding of alien freshwater fish issues
- understanding the ecology of high-priority organisms to maximise effective targeting of management approaches
- enhancing detection and surveillance capabilities through enhanced and targeted technologies
- expanding the suite of tools available for eradication, control and containment through trialling and implementation of new techniques.

4.5.3 Australian Weeds Strategy

The Australian Weeds Strategy (AWS) (Australian Weeds Committee 2007) was developed by the former Australian Weeds Committee and built upon the successes of the previous National Weeds Strategy launched in 1997. It was endorsed by the Natural Resource Management Ministerial Councils in 2006. It was revised under the leadership of IPAC and released for consultation in September 2016. The AWS recognises that there is an ongoing need to strengthen and improve Australia's collaborative R&D capabilities to address weed problems and threats into the future.

Similarly to the APAS, the AWS does not identify specific RD&E priorities. It does however, as part of its Goal 3 – Enhance Australia's capacity and commitment to solve weed problems – list the following strategic actions and outcomes that relate to research (Table 7).

Table 7 Australian Weeds Strategy—Goal 3

Strategic action	Outcome
Prioritise weed research needs and identify and facilitate programmes to develop new approaches (3.2.3)	Research on weeds is undertaken based on priority needs. Improved weed management is achieved through increased knowledge and new techniques.
Encourage funding of research that will provide the scientific basis to support weed management decisions (3.2.4)	Investment in weeds research increases.
Strengthen collaboration between research institutions, industry and government on weed research issues (3.2.5)	Collaborative and coordinated weed research is undertaken across Australia.

4.5.4 National System for the Prevention and Management of Marine Pest Incursions

The National System for the Prevention and Management of Marine Pest Incursions (Australian Government 2013) aims to prevent new marine pests arriving, guide responses when a new pest does arrive and minimise the spread and impact of pests already established in Australia. It also comprises four supporting components: monitoring, communication, R&D, and evaluation and review. The MPSC is responsible for implementing the measures and arrangements under the system.

R&D activities encouraged by the system are guided by a set of R&D priorities recently developed by the MPSC in the National Priorities for Introduced Marine Pest Research and Development 2013-2023 (Marine Pest Sectoral Committee 2013). This replaces the previous document 2006-2016 Research and Development Strategy produced by the former National Introduced Marine Pest Coordination Group.

The objective of the National Priorities for Introduced Marine Pest Research and Development 2013-2023 is to encourage coordinated and collaborative R&D efforts and investment in four priorities (Table 8).

Priority	Strategic objective
Vector management	Ensure potential and actual vectors of marine pests are managed to effectively minimise the risk of introduced marine pest incursions and translocations.
Species and ecological information for management	To prevent marine pests from entering Australian waters and effectively eradicate or manage established marine pest populations.
Monitoring, evaluation and review	Effective monitoring of Australian waters to detect and respond to marine pests. Evaluate marine pest management for continuous and adaptive improvement of the National System.
Information, communication and education	Inform governments, industry and the community of the importance of the elements of the National System and encourage or facilitate the uptake of voluntary and/or mandatory measures.

Table 8 Four priorities under the National Priorities for Introduced Marine Pest Researchand Development 2013-2023

4.6 D&E in state and territory biosecurity strategies

State-based biosecurity strategies exist for, Queensland (Department of Primary Industries and Fisheries 2009), Tasmania (Department of Primary Industries, Parks, Water and Environment 2013) and New South Wales (NSW) (NSW Government 2013). A pest animal management strategy (ACT Government 2012) and a state biosecurity policy document (Primary Industries & Regions SA 2013) have also been published by the Australian Capital Territory (ACT) and South Australian governments respectively. All of these strategies recognise the threats to biodiversity and/or the natural environment, and links to human wellbeing as being a focus in addition to primary industries. The strategy for Tasmania focuses on preparedness for new incursions (preborder risk assessment through to emergency response) rather than the management of existing widespread pests, weeds and diseases, while the other strategies focus on issues across the biosecurity continuum. In all cases, RD&E are considered of paramount importance to effective delivery of biosecurity systems. The strategies of NSW, Tasmania, Queensland and the ACT include a separate section on the importance of RD&E and a more detailed scoping out of RD&E needs and priorities.

A number of general RD&E priorities, either stated explicitly or implicitly, are common to all strategies. This includes a need to focus on prevention, risk analysis, risk-based decision making, surveillance, diagnostics, effective data management, embracing developments in information technologies and/or remote sensing, considering new threats like climate change, awareness communication and training. Other priorities have less consistent coverage. Focussing research to better understand and prioritise pathways of movement of pests, weeds and diseases is recognised by the South Australian policy and ACT strategies. The need for adaptive management approaches for biosecurity is recognised by South Australian policy and ACT strategy, while the need to understand the biology and ecology of the biological invader is explicitly recognised only by the Tasmanian and ACT strategies. Biological control research as an important component of managing widespread pests is recognised in the South Australian policy, the Queensland, NSW and ACT strategies. Vaccination options for animal disease management are a recognised need in the Queensland and NSW strategies. The multidisciplinary basis for biosecurity and the need to engage the social sciences is only recognised by the Queensland and NSW strategies. Similarly, the need for a system or landscape-based approach to biosecurity is only touched on in the Tasmanian, NSW and ACT strategies. All strategies recognise the imperative for national as well as state level coordination in capability development and investment to ensure strong capacity to address the necessary RD&E needs.

It needs to be acknowledged that initiatives may exist within jurisdictions outside state and or territory biosecurity strategies. For example, in Victoria, considerably RD&E capability and capacity exists with priorities articulated within the Victorian Invasive Plants and Animals Policy Framework.

4.7 Challenges and opportunities for biosecurity RD&E4.7.1 Cross-sectoral biosecurity RD&E

Many RD&E activities for biosecurity are relevant for both public and private benefits. These activities include risk analysis, prioritisation processes for threats, decision-making processes, new technologies for surveillance and detection, risk-return based decision making, diagnostics, eradication strategies, effective data management, analysis and information sharing platforms, e-research ,extension through technology transfer and adoption, and end-user training. (e-

research is Set of activities that harness the power of advanced information and communication technologies for research). Invasive organism management approaches, such as biological control, and adaptive integrated management strategies have relevance across sectors in terms of their development. Investment in biosecurity is driven by both the likelihood and consequence of an impact, so high risk threats, in terms of the scale of the impacts, attract the greatest concern and investment. Direct threats to human health are on top of the list, followed by threats to the large agricultural sectors of livestock and grains, and to a lesser degree to the smaller agricultural sectors and finally threats to the environment and communal infrastructures, transport, utilities and social amenities. While this drives uneven investment in biosecurity RD&E across sectors and issues, most investment can provide shared benefits across most, if not, all sectors. This demonstrates that biosecurity is a shared responsibility, although for investment in RD&E the need for cross-sectoral approaches is imperative as a basis for structuring sectoral RD&E investment priorities.

The 'Beale review' (Beale et al. 2008)—One Biosecurity: A working partnership —in 2008 is the most recent national review of economic imperatives and community attitudes towards biosecurity and how the government should respond. This review fully recognised the need for an approach to biosecurity across sectors and across the continuum from pre-border, border and post-border interventions, including RD&E investments. The report called for increased stakeholder engagement in RD&E; better understanding of the social, ecological and economic factors in biosecurity and disease prevention and control; and multidisciplinary and cross-sectoral approaches to managing biosecurity risks.

4.7.2 Changing biosecurity risks

The biosecurity risk profile for Australia is in constant change across all sectors as new threats emerge and incursions are detected. The main drivers of this in the context of this strategy are:

- Globalisation, including increasing trade and the massive increases in the movement of people and other organisms
- Population growth, expansion of urbanisation and a greater exposure of society to infectious diseases emerging from wildlife
- Changing land-use and inappropriate fire management leading to declining areas of pristine natural environment and greater mixing of native communities with alien organisms/genotypes
- Climate change—increasing temperatures most likely to adversely affect human health and result in more outbreaks of infectious diseases, and increase chances of biological invasions following environmental disturbance.

Movement of alien pests, weeds and diseases into new countries is on the rise globally and such increases appear exponential in developing countries. In Australia, with our existing efficient biosecurity system, these increases are more linear.

Increasing incidents of diseases transmitted from wild animals to humans (that is, zoonoses) and vector (for example, mosquito) borne diseases such as Chikungunya, dengue fever and Japanese encephalitis, are another key changing risk. Novel infectious diseases are also likely to emerge in the future. Note that diseases of vertebrates such as rabies, transmissible spongiform encephalopathies, Hendra virus and Nipah virus, Rift Valley fever, West Nile virus that also affect human health are covered by the Animal Biosecurity RD&E Strategy Land-use change, driven partly by the need to feed an expanding population, and associated habitat loss are the largest global drivers of biodiversity loss. This brings with it human activity and disturbance, and opportunities for alien and native organisms to move into new areas and become invasive, leading to the degradation of native flora and fauna communities. Examples of land-use change in Australia are the declining agricultural viability of inland arid farming systems leading to reduced management and the increasing interest in developing more intensive agricultural systems in northern Australia.

Climate change is another key driver of land-use change and its potential direct impacts on our environment are still being assessed. For example, if left unchecked, rising temperatures are expected to have a dramatic impact on native organisms. Their survival and distribution may be greatly affected in Australia's iconic marine environments and in many upland and arid ecosystems where they will have no opportunity to move to more suitable areas. Under climate change, impacts of pests, weeds and diseases are expected to increase as native communities become stressed and less resilient to biological invasions. Academic debate has already begun around the suggestion that pristine native communities are a 'thing of the past' and humans have to manage less resilient novel ecosystems made up of mixtures of native and alien organisms.

4.7.3 Community trends

Community awareness of the importance of biosecurity is on the rise as a result of the increasing number of biosecurity issues impacting on daily life. Clear examples of this are the red imported fire ant incursion in the greater Brisbane area and the rapid spread of myrtle rust in eastern Australia. While community recognition of the importance of biosecurity is increasing from a number of perspectives, public funds available to support biosecurity RD&E have been steadily decreasing.

Community awareness of biosecurity issues for the environment and community has increased for the following main reasons:

- Recognition of the role pests, weeds and diseases play in the declining state of Australian native biodiversity has increased concurrently with broader acceptance of ecosystem services and natural capital as being important for human wellbeing
- Increasing outbreaks in Australia of mosquito-borne diseases like dengue fever and a growing awareness that the risks originate from inadequate vector management
- Increased recognition of the impacts of feral animals (for examples, cats and foxes) and the risks posed by importing novel, live alien organisms into the country
- Increased threats to the urban environments from more incursions of invertebrate pests such as tramp ants
- Increased native and non-native wildlife-human interactions at urban and peri-urban interfaces
- Increasing awareness of the impacts of weeds in gardens and social amenities in urban and peri-urban areas, and in natural ecosystems
- Plant pest and disease incursions (for example, myrtle rust) impacting public and private gardens, urban street tree plantings and natural ecosystems.

Communities expect to see proven, coordinated, cost-effective approaches to managing biosecurity risks and impacts to the environment and community. They are quickly aware when outbreaks result from the inability of the different sectors alone to manage risks, and failure of all sectors to work together to minimise risks.

The public perception of lack of government leadership in environmental and community biosecurity has led to increase community actions. Community groups, which involve considerable numbers of volunteers, are increasingly lobbying local politicians and seeking public support to tackle environment and community biosecurity issues in their regions (for examples, through the Landcare, Bushcare, Coastcare networks). A consequence of this is the increasing role of the community in the form of citizen science providers and 'surveillance eyes' on the ground to respond to all aspects of environment and community biosecurity. This is an important trend that needs to be embraced as part of RD&E activities.

4.7.4 Government trends

The 'Beale review' proposed, based on a national economic benefit-cost analysis, that the Australian Government should increase investment to biosecurity agencies by \$260 million per annum and provide an additional one-off injection of \$225 million to upgrade their information technology and business systems. At this point in time, only the second component of this recommendation is happening. The review also argued strongly for an evidence-based approach focussing on a 'risk-return' approach to deciding where to direct resources across the biosecurity continuum. While the recommendation for increased national financial investment in biosecurity agencies has not been fully adopted by the Australian Government, the science-basis to biosecurity decision making has never been in doubt.

In the context of this Strategy, governments of all jurisdictions in Australia have the following regulatory responsibilities driving their need to respond to biosecurity issues:

- Responding through risk analysis to requests to import alien organisms into Australia for commercial or other purposes
- Meeting obligations under the EPBC Act and equivalent state and territory legislation for taking actions against biosecurity threats and impacts as key threatening processes to listed native threatened organisms and communities, through the implementation of threat abatement plans
- Limiting the impacts of alien pests and weeds to public amenities and urban environments (for examples, tramp ants, wasps, non-native plants that cause allergies, cane toads)
- Limiting local threats from vector (for example, mosquito) borne diseases
- Managing the impacts of major invasive animals affecting natural ecosystems (for examples, foxes, cats, rabbits, camels) while considering public concerns about animal welfare.

There is greater investment by governments in biosecurity RD&E for primary industries than for the environment and community, as evidenced by the National Biosecurity Research and Development Capability Audit. The National Biosecurity Research and Development Capability Audit 2012 is available at the Department of Agriculture and water Resources website (agriculture.gov.au/SiteCollectionDocuments/animal-plant-health/pihc/national-researchdevelopment-capability-audit.pdf). In early 2012 there were 70.3 government research full time equivalent (FTE) staff working on weeds, 47.8 on pest animals and 15.4 on marine pests. This compared to 362.2 and 287 FTE staff in plant health and animal health, respectively. In part, this is because of an ability to leverage industry for additional funding. There is no similar financial motivator on offer for environmental and community biosecurity.

There are constant efforts by governments to make their decision systems more efficient, effective and flexible by reducing the regulatory burden and making better use of information and communication technologies. Biosecurity, however, is like insurance in that investments will reduce the potential impacts of environmental and community harm caused by a biosecurity incursion or spread of invasive organisms, but does not generate a clear measurable benefit without such incursions. Belief in the need to invest will decline over periods of low impact or few incursions. In this context biosecurity regulation can also be viewed as 'green tape' for urban and industrial development and the science-based inputs to biosecurity policy need to recognise these perceptions and avoid accentuating them.

There is also a trend by governments to support pro-active industry and community groups to manage established pests, weeds and diseases by implementing new approaches based on outcomes from biosecurity RD&E investments. This trend needs to be supported through continued RD&E as community pressure and involvement increases. Governments also recognise the need for prevention through improving surveillance, innovation, and delivering effective emergency preparedness and response capability.

Furthermore, the Australian Government also has commitments under several international agreements (for example, Convention on Biological Diversity, COP 10 Decision X/2 Strategic Plan for Biodiversity 2011-2020, International Plant Protection Convention) around prioritisation and management of pathways and invasive organisms affecting biodiversity, ecosystem services and community values.

4.7.5 Non-government organisations trends

Increasing community awareness and concern around the impacts of pests, weeds and diseases on the environment and community has led to an increasing number of active non-government organisations (NGOs), with a science basis to their activities, and which play an advocacy role to government. These include bodies (or organisations) that are directly targeting the environmental impacts of invasive organisms, such as the ISC, and conservation agencies that are managing such impacts as part of overall conservation activities, including the management of weeds, the trapping of feral animals and the construction of predator proof fences. These include Australia Wildlife Conservancy, Australian Bush Heritage, Greening Australia, Conservation Volunteers Australia and the many smaller landcare, bushcare, reefwatch and 'friends of' groups.

NGOs have fostered enhanced community involvement and citizen science in environmental issues, which have led to increased community-led biodiversity surveys and monitoring that often include components relating to biosecurity. New tools are emerging to make this simpler including inexpensive motion-detection digital cameras and collaborative databases such as the national Atlas of Living Australia.

4.7.6 Governance and institutional arrangements around biosecurity RD&E

There are a range of areas that should be considered by stakeholders to improve the governance and institutional arrangements around biosecurity RD&E in Australia. Some of the key areas are:

- alignment of priorities and communication between policy makers and research providers
- improvement of processes for increasing adoption of research findings to inform policy and management decisions
- establishment of clear, efficient and effective processes for nationally prioritising research and allocating funding
- establishment of mechanisms to support cooperation and collaboration in investing in and undertaking biosecurity RD&E (including cross-sector)
- establishment of coordinated/collaborative information systems for biosecurity data and analysis
- reversing the decline in capabilities and capacity to undertake biosecurity R&D
- improving connection between research and extension delivery services.

5 RD&E priority areas

RD&E priority areas for the sectors covered by this Strategy, which address the nationally agreed RD&E objectives under the IGAB (Appendix 6), were identified by stakeholders representative of wide range of organisations, including government agencies and universities, at a national workshop (Appendix 1, Table 7).

The RD&E priority areas are grouped under four broad categories – Risk analysis and decision making; Detection, diagnosis and surveillance; Management methods and strategies; Stakeholder engagement. Cost-efficiency, robustness, reliability, social acceptability and suitability for end user uptake (adoption) are key guiding principles for all activities, processes and deliverables associated with the priority areas.

Category	Priority areas	Relevant national RD&E objectives
1. Risk analysis and decision making	1.1 Develop and apply risk analysis approaches to prioritise pests, weeds and diseases for management actions pre- and post- border, including ecological and socio-economic modelling of distribution, spread and impacts.	1A
-	1.2 Characterise and prioritise pathways of pest, weed and disease movement, including between land uses and between jurisdictions.	1A, 2A
_	1.3 Identify mechanisms (for example, genetic, ecological, epidemiological, evolutionary, social/human behaviours and interactions with the environment) that increase new pest, weed and disease risks.	1A, 2C, 2D
_	1.4 Identify criteria for understanding the status of biological invasions along the invasion continuum to assist decision making around feasible management interventions.	1D, 2D
_	1.5 Develop approaches to quantify cumulative effects of multiple pest, weed and disease invasion, and develop prioritisation and management decision-making processes for such scenarios.	2D, 3A

Table 9 RD&E priority areas for the sectors covered by this strategy
Category	Relevant national RD&E objectives	
-	1.6 Refine and further develop approaches to understand and quantify potential socio-economic and environmental direct and indirect beneficial and harmful impacts of pests, weeds and diseases, including cross-sectoral risks, and the cost effectiveness and benefits from policy and management options.	3A
_	1.7 Refine decision-making frameworks for eradication programs (for example, to assist the NEBRA process).	1E
2. Detection, diagnosis and surveillance	2.1 Refine or develop novel detection and surveillance techniques and best practice diagnostic procedures for pests, weeds and diseases not yet established or established at low levels, including probabilities of absence (for example, remote diagnostics, genetic identification techniques, automated approaches, social media).	1B, 1E, 4
-	2.2 Develop methods to assess the effectiveness of routine detection and surveillance systems currently undertaken by government, industries and communities.	1B, 1E, 4
3. Management methods and strategies	3.1 Review and improve eradication and containment tools and strategies for national and regional use against priority pests, weeds and diseases.	1D, 1E
-	3.2 Identify key biological vulnerabilities of pests, weeds and diseases to exploit for management (for example, behavioural, physiological, ecological).	2D
-	3.3 Refine and further develop management tools and integrated strategies for priority pests, weeds and diseases, including biological control.	2B
-	3.4 Incorporate integrated management strategies into whole- of-system management to ensure sustainable outcomes.	2B
_	3.5 Develop approaches to design landscapesB and townscapes to increase resilience to multiple pest, weed and disease invasions and their impacts.	2B

Category	Priority areas	Relevant national RD&E objectives
-	3.6 Review and improve effectiveness of existing policy instruments, management guidelines and techniques regarding the use and/or management of contentious invasive organisms (for example, invasive pastoral grasses, cats, wild dogs).	3B
4. Stakeholder engagement	4.1 Understand diverse community perceptions of risks and impacts of pests, weeds and diseases and the socioeconomic drivers and incentives that lead to response and action.	1C
-	4.2 Improve methods to increase public awareness of the impacts of pests, weeds and diseases, and influence behaviours in response to biosecurity issues.	-
-	4.3 Develop training for different stakeholders in decision making and implementation of biosecurity measures.	_
-	4.4 Develop approaches to optimise stakeholders' engagement in all stages of biosecurity RD&E (for example, citizen science).	_
-	4.5 Review existing frameworks and consultative processes to encourage greater co-governance across sectors for management of pests, weeds and diseases.	2B, 3B
-	4.6 Develop guidelines to encourage and facilitate strategic adaptive management of pests, weeds and diseases by stakeholders.	2B

Notes: relevant National R&D objectives are provided in Appendix 6. The identification number of the relevant national RD&E objective(s) under the IGAB (Appendix 6) for each priority area is indicated, where applicable. The terms 'land' and 'landscape' also include aquatic areas. Activities, processes and deliverables associated with the priority areas provided in the table should be cost-efficient, robust, reliable, socially acceptable and suitable for end user uptake that is adoptable.

Stakeholders (Appendix 2) with a range of expertise were approached to select the five most important RD&E priority areas for future focus and investment in the sector(s) that they know well (that is, areas that would make the most difference in advancing biosecurity issues faced by the sector) (Appendix 9).

The seven cross-sectoral RD&E priority areas most frequently selected during this expert elicitation exercise were:

• 1.1 Develop and apply risk analysis approaches to prioritise pests, weeds and diseases for management actions pre-and post-border, including ecological and socio-economic modelling of distribution, spread and impacts

- 1.2 Characterise and prioritise pathways of pest, weed and disease movement, including between land uses and between jurisdictions
- 1.6 Refine and further develop approaches to understand and quantify potential socioeconomic and environmental direct and indirect beneficial and harmful impacts of pests, weeds and diseases, including cross-sectoral risks, and the cost effectiveness and benefits from policy and management options
- 2.1 Refine or develop novel detection and surveillance techniques and best practice diagnostic procedures for pests, weeds and diseases not yet established or established at low levels, including probabilities of absence (for examples, remote diagnostics, genetic identification techniques, automated approaches, social media)
- 3.1 Review and improve eradication and containment tools and strategies for national and regional use against priority pests, weeds and diseases
- 3.3 Refine and further develop management tools and integrated strategies for priority pests, weeds and diseases, including biological control
- 4.2 Improve methods to increase public awareness of the impacts of pests, weeds and diseases, and influence behaviours in response to biosecurity issues.

The RD&E priority areas in each sector that were selected as most important by the stakeholders are listed in Table 10. It is important to emphasise that given the very broad coverage of this strategy these results are only indicative and a more in-depth prioritisation of RD&E areas is needed within each sector as part of the implementation of this Strategy.

Table 10 RD&E priority areas identified as most important in each sector by representative stakeholders

Sector	Number of stakeholders' assessments	Most important RD&E priority areas
Diseases of terrestrial wild animals	8	1.1, 1.6, 4.2
Diseases of marine and freshwater wild animals	9	1.1, 2.1, 4.2
Diseases of captive animals	5	4.1, 4.2
Human disease animal vectors	5	1.1, 1.2, 1.6
Vertebrate pests	13	2.1, 3.1, 3.2, 3.3, 4.2
Invertebrate pests with impacts of on social amenity or natural values and freshwater	8	1.4, 2.1
Environmental weeds	15	1.1, 1.5, 1.6, 2.1, 3.3, 3.4, 3.6, 4.1, 4.2
Marine pests	11	1.1, 1.6, 2.1, 3.1,
Pests and diseases of plants in natural ecosystems and/or social amenities	10	1.2, 1.3, 1.6, 3.1, 3.4, 4.2
Total	84	-

Notes: Numbers refer to RD&E priority areas listed in Table 7. There is no level of relative importance between the areas identified. Results presented in the table are indicative only and further, in-depth prioritisation is required within each sector. RD&E priority areas listed were identified by; i) at least 3 people in sectors with \leq 5 stakeholder's assessments, ii) at least 4 people in sectors with > 5 but \leq 10 stakeholder's assessments, and iii) at least 5 people in sectors with > 10 stakeholder's assessments (Appendix 9).

6 RD&E capabilities

The capabilities underpinning biosecurity RD&E for the environment and community in Australia encompass a wide range of disciplines and are widely dispersed across organisations. Some important capabilities are transient, such as post-graduate students and post-doctoral fellows who contribute to specific projects for a defined period of time. Core capabilities are mostly found in universities and government departments and agencies (for example, CSIRO), although there is a plethora of other contributors, especially in extension, for examples, NGOs, community groups, NRM Regions, CMA and Local Land Services, which have demonstrated track records in fostering adoption of R&D outputs by end users.

Other strategies under the National Primary Industries RD&E Framework (see section 3) have developed a responsibility matrix to identify organisations with i) a major national role (that is, undertake significant RD&E at the national scale), ii) a supporting role (that is, undertake some RD&E but with other organisations providing the major effort), and iii) a linking role (that is, undertake little or no RD&E and instead access information and resources from other organisations). Because of the broad nature of the sectors covered in this strategy and the spread of RD&E capabilities across a large number of organisations, including universities as major contributors, it was impractical to develop such a matrix in drafting this Strategy. The development of such a matrix should be considered during the implementation phase of this Strategy.

The large number of stakeholders involved in resourcing RD&E over the broad scope of this strategy further complicates the assignment of responsibilities to specific organisations to coordinate RD&E and maintain core capabilities. This is in contrast to RD&E areas relating to primary industries that are directly aligned to Research and Development Corporations (Rural R&D Corporations 2011).

6.1 Inventory of RD&E capabilities

6.1.1 National biosecurity R&D capability audit

A national audit, sponsored by the former IGAB Schedule 8 Working Group, was undertaken over the period January to July 2012 to gather information on current capability (infrastructure and personnel) and capacity (amount of capabilities available) and on investment in biosecurity R&D .The audit covered the biosecurity sectors of animal health, plant health, weeds, pest animals and marine pests, and did not separate between primary industry and the environment and community. Extension was not included in the scope of the audit. Further, the audit did not provide insight into the adequacy of the existing capabilities and upward or downward trend in capabilities. Limitations with the audit have been summarised in the two national primary industry (plant and animal) biosecurity RD&E strategies (Appendix 10).

The audit provided the following snapshot on capabilities:

• a total of 818.3 full time equivalent (FTE) staff employed in biosecurity R&D across all sectors nationally: animal health = 287, plant health = 362.2, weeds = 70.3, pest animals = 47.8, marine pests = 15.4, generic/cross sectoral = 35.6

- 58% of FTE were with state and territory governments; 42% with CSIRO and Australian Government Department of Agriculture and Water Resources. Note that capability can be found in other organisations that were not audited (for example, universities) or did not provide a response to the audit
- Distribution of research efforts against the nationally agreed RD&E priorities (Appendix 6):
 - Minimise risk of entry, establishment, spread of pests and diseases = 50%
 - Eradicate, control, or mitigate the impact of pests and diseases = 42%
 - Understand and quantify impacts of pests and diseases = 5%
 - Cost-effectively demonstrate the absence of significant pests and diseases = 3%
- Major infrastructure investments (> \$750M) have occurred between 2007–11, for examples, upgrades at the Australian Animal Health Laboratory (Victoria) and Elizabeth Macarthur Agricultural Institute (NSW) and new developments that include facilities for biosecurity R&D Centre for AgriBioscience (Victoria) and, Ecosciences Precinct and Health and Food Sciences Precinct (Queensland)
- Key vulnerabilities across the sectors identified:
 - limited capabilities in taxonomy and socio-economic sciences
 - ageing pool of expertise and lack of succession planning
 - major reliance on short-term competitive external funding that is uncertain and affects ability to retain capabilities
 - lack of a nationally coordinated approach to biosecurity R&D.

6.1.2 Additional capability information specific to this Strategy

Additional information on R&D capabilities in the various sectors covered by the breadth of this strategy was obtained in drafting this strategy (Table 9, Appendix 11). The initial inventory conducted revealed that relevant R&D is undertaken by a very wide range of organisations across Australia. Universities and the CSIRO are primarily involved in R&D, while state and territory government departments often have activities that span the entire spectrum of RD&E. Many organisations possess R&D capabilities across more than one sector, including capabilities on native organisms and ecosystems that are rarely recognised as contributing to direct biosecurity-related research. Some of the R&D performed falls under the umbrella of CRCs, such as the Invasive Animals CRC and the former CRC for Australian Weed Management. It is noteworthy that relevant R&D is also performed by other agencies such as zoos and botanical gardens, although this was not captured by this initial inventory.

6.2 Capability analysis

Capturing an accurate picture of the RD&E capabilities relevant to biosecurity issues of the environment and community that are currently available in Australia is, as already noted, a considerable challenge. No single organisation is uniquely specialised in these areas. Depending on emergency requirements or availability of external funding, some capabilities deployed to address primary industry biosecurity issues (for examples, plant and animal pathology, entomology, risk analysis, weed science) are often redirected to biosecurity needs of the environment and community, and vice versa. There is also potential to divert capabilities that traditionally focus on biodiversity and ecosystem services research to biosecurity issues of the environment and the community if there are specific needs and funding opportunities. On the other hand, generic capabilities, such as molecular biology and bioinformatics, can either be

accessed within organisations already involved in biosecurity research or through partnerships with other organisations that are not traditionally involved in biosecurity.

Biosecurity RD&E capabilities focusing on the environment and community have several strengths and weaknesses, as well as many threats and opportunities (Table 10).

The methodology used to ascertain capabilities specific to environment and community biosecurity RD&E in this document only considered expertise and did not address capacity or availability due to resources limitations in drafting this Strategy. A comprehensive analysis of relevant RD&E capacity across Australia should be undertaken in the future, especially considering that over commitment and dependence on a few key people were identified as threats in the SWOT analysis (Table 10).

Table 11 presents the Initial inventory of R&D capabilities in various organisations for each of the sectors covered by this strategy and in relevant general disciplines. Methodology is presented in Appendix 11. Capabilities were allocated to general disciplines when it was not possible, with the information obtained, to allocate them to specific sectors. Only capabilities for which names of people and their specialities were obtained are shown. Note that despite considerable efforts to produce this inventory, not all capabilities have been captured (within listed organisations and/or other organisations such as museums, botanical gardens and zoos) and thus further investigation will be required to identify all existing capabilities.

Institution	Diseases of animals (all habitats, wild and captive)	Human disease animal vectors	Vertebrate pests	Invertebrate pests	Environmental weeds	Marine pests	Pests and diseases of plants	Invasive organisms ecology	Economics, modelling, surveillance, risk analysis, social sciences
Universities									
Australian Catholic University	-	-	yes	-	-	-	-	-	-
Australian National University	-	-	-	-	-	-	-	-	yes
Central Queensland University	-	-	-	-	_	yes	-	-	-
Charles Darwin University	-	-	yes	-	yes	-	-	-	-
Charles Sturt University	-	-	-	-	yes	-	-	-	_
Curtin University	-	-	-	yes	_	-	-	-	-
Deakin University	-	-	-	-	-	-	yes	-	_
Flinders University	-	-	-	-	-	yes			
Griffith University	yes	-	-	-	-	_	-	-	-
James Cook University	yes	yes	yes	yes	-	yes	-	-	-
La Trobe University	-	-	-	yes	yes	-	yes	-	-
Macquarie University	-	-	-	-	yes	_	-	-	_

Table 11 Initial inventory of R&D capabilities in various organisations for each of the sectors covered by this strategy and in relevant general disciplines

Department of Agriculture and Water Resources

Institution	Diseases of animals (all habitats, wild and captive)	Human disease animal vectors	Vertebrate pests	Invertebrate pests	Environmental weeds	Marine pests	Pests and diseases of plants	Invasive organisms ecology	Economics, modelling, surveillance, risk analysis, social sciences
Monash University	yes	-	yes	-	yes	-	-	yes	yes
Murdoch University	yes	-	yes	-	-	-	yes	-	_
Queensland University of Technology	-	-	yes	-	yes	-	-	-	yes
RMIT University	yes	-	-	-	-	yes	-	-	-
The University of Melbourne	-	-	yes	-	yes	yes	-	-	yes
The University of Sydney	yes	-	yes	-	-	-	yes	-	-
University of Adelaide	-	-	yes	-	yes	-	-	yes	-
University of Canberra	-	-	yes	-	yes	-	-	-	yes
University of New England	-	-	yes	-	-	-	-	-	yes
University of New South Wales	-	-	-	-	yes	yes	-	-	-
University of Newcastle	-		yes	-	-	yes	-	-	-
University of Queensland	-	yes	yes	yes	Yes	yes	-	yes	yes
University of South Australia	-	yes	-	yes	-	-	-	-	-
University of Tasmania	-	-	yes	-	-	yes	-	-	-
University of Western Australia	-	-	yes	-	-	yes		yes	yes
University of Wollongong	-	-	-	-	yes	yes	-	-	-
Government agencies	-	-	-	-	-	-	-	-	-
ACT Environment and Sustainable Development Directorate	-	-	yes	-	-	-	-	-	-
ACT Territory and Municipal Services	-	-	-	-	yes	-	-	-	-
Australian Government Department of Agriculture and Water Resources, ABARES	-	-	-	-	-	yes	-	yes	yes
Australian Government Department of the Environment	yes	-	-	yes	yes	-	-	-	-
CSIRO	yes	yes	yes	yes	yes	yes	yes	-	yes
Defence Science and Technology Organisation, Australian Government Department of Defence	-	-	-	-	-	yes	-	-	-
Northern Territory Department of Land Resource Management	-	-	-	-	yes	-	-	-	-
Northern Territory Department of Primary Industry and Fisheries	yes	yes	_	yes	-	yes	yes	-	-
NSW Department of Primary Industries	yes	-	yes	yes	yes	-	yes	-	-
NSW Office of the Environment and Heritage	-	-	yes	-	yes	-	-	-	-
Parks Victoria	-	-	-	-	_	yes	-	-	_
Primary Industries and Regions South Australia, Biosecurity South Australia	-	-	yes	-	-	yes	-	-	_

Institution	Diseases of animals (all habitats, wild and captive)	Human disease animal vectors	Vertebrate pests	Invertebrate pests	Environmental weeds	Marine pests	Pests and diseases of plants	Invasive organisms ecology	Economics, modelling, surveillance, risk analysis, social sciences
Primary Industries and Regions South Australia, South Australian Research and Development Institute	-	-		yes	-	yes	yes	-	yes
QIMR Berghofer Medical Research Institute	-	yes	-	yes	-	-	-	-	-
Queensland Department of Agriculture, Fisheries and Forestry	yes	yes	yes	-	yes	-	yes	-	-
Tasmanian Department of Primary Industries, Parks, Water and Environment	yes	-	yes	yes	yes	-	yes	-	yes
Victorian Department of Economic Development, Jobs, Transport and Resources (DEDJTR)	yes	yes	yes	yes	yes	I	yes	yes	yes
Victorian Department of Environment and Primary Industries, Arthur Rylah Institute	yes	-	yes	yes	yes	-	I	Ι	-
Western Australia, Department of Agriculture and Food	-	-	yes	yes	yes	-	I	-	-
Western Australia, Department of Fisheries	yes	_	-	yes	-	yes	-	-	-
Western Australia, Department of Parks and Wildlife	_	-	yes	yes	-	-	yes	-	-

Notes: Invertebrate pests cover those that impact on social amenity or natural values.

Table 12 Strengths and weaknesses of current capabilities in RD&E biosecurity for the	
environment	

Strength		W	Weakness			
•	National distribution of capabilities, especially in universities and government departments, with	•	Lack of funding to maintain capabilities and support coordination framework			
	potential to achieve critical mass level if networked	•	Overcommitment of most staff			
•	Wide range of expertise	•	Overdependence on few key staff			
•	Access to adequate infrastructures	•	Aging workforce in some organisations and limited succession planning			
•	Excellent national reputation for delivering high quality research outcomes and solutions	•	High cost to maintain infrastructures (for example, quarantine facilities)			
•	Good linkages/engagement with end users and investors	•	Linkages/collaboration with other staff within and outside organisations not fully exploited			
•	Broad, flexible and adaptable staff	•	Investment gaps in several areas, including taxonomy			
•	Good track record in attracting external funding			and socio-economic research (Based on findings from		
•	Commitment to developing long term solutions to		the National biosecurity R&D capability audit)			
	biosecurity problems	•	Lack of continuity to enable delivery on long-term			
•	Excellent international reputation		often transient post-graduate students or post-			
٠	Existing national collaborative networks		doctoral fellows			
•	Existing research collaborative centre on invasive animals (CRC)	•	Loss of promising early-career researchers due to job insecurity and poor career prospects			
		•	Increased reliance on external funding to maintain capabilities			

Table 13 External threats and opportunities of current capabilities in RD&E biosecurity for
the environment and community

Threat	Opportunity
 Lack of coordination framework for better use of available capabilities. Future government investment in biosecurity RD&E likely to be lower than 2010 handle (Beard on Studiens from the National history price). 	 Utilise existing mechanisms, and develop new ones if necessary to underpin a national collaborative framework.
 than 2010 levels (Based on findings from the National biosecurity R&D capability audit). Uncertain future funding model for invasive organisms from Australian government. Biological sciences, including biosecurity research, less attractive to students nowadays Competitive funding schemes that do not encourage collaboration between researchers and often favour specific areas (for example, terrestrial pest animals or weeds) Research on alien organisms before entry to Australia, including biocontrol agents, requires expensive infrastructures for which costs 	 Organisations encouraging workforce to be more flexible and collaborative and to engage more fully with end-users. National recognition of the need to focus RD&E investments among identified priorities for each sector and develop collaborative arrangements between organisations. Growing interest by the general
 have to be shared between all parties. Increasing costing structure for RD&E projects across organisations. 	public to participate in scientific research (citizen science).
 Increased public and regulatory scrutiny with regards to release of alien biocontrol agents and ethics of management methods for vertebrate pests Scarce funding specifically to address fundamental science questions 	 Increased international and national recognition of invasive organisms as key problems for the environment and community
 to advance biosecurity issues Loss of capabilities and collaboration post-Invasive Animal CRC unless replaced by an analogous collaborative institution/model, as has been seen after the end of the weed CRC in 2008 (The Australian Government initially supported the establishment of a collaborative institution/model called 'Australian Weed Research Centre' after the end of the CRC for Australian Weed Management in 2008, which became a grant funding scheme called 'National Weeds and Productivity Passarch Program' from 2009, 2012, managed by the 	 Growing interest from agencies in funding research that addresses causes of invasion rather than only treating symptoms Scope to address fundamental science questions as part of applied projects Synergies and expansion of
 On-ground actions favoured by investors without regard to R&D requirements. 	collective ability to tackle invasive organisms problems through partnerships between organisations
 Re-inventing the 'wheel' – that is, not build on previous knowledge and achievements. Focusing of resources in one place or one institutional framework. 	• Scope to engage with the primary industry sector to address generic biosecurity issues and tackle pests, weeds and diseases in common.
	• Complement existing capabilities and access new ones through partnerships with overseas research organisations.
	• Publish research results in open- access journal articles on the internet to increase accessibility and uptake by end-users.

7 Recommendations for implementation

7.1 Embracing change

Changes in scale and levels of coordination and ownership, and in attitudes and behaviours amongst investors, providers and end-users of biosecurity RD&E for the environment and community is fundamental to the successful implementation of this Strategy. The transition from the current fragmented approach to RD&E to a more collaborative and cost-efficient model that focuses on nationally agreed RD&E priorities will require commitments from all stakeholders.

The implementation of this strategy should be guided by the following change management approaches (Kotter International 2015):

- Develop an appropriate sense of urgency—identify champions and inspire stakeholders to engage in the process
- Assemble the right implementation team—committed representatives of each stakeholder groups with the right mix of expertise, credibility and leadership
- Clearly articulate how the future will be different from the past—essential to motivate stakeholders to engage and take action in the right direction
- Communicate, in a simple way, the essential aspects of this strategy in order to foster commitment from stakeholders
- Identify and seek to remove barriers and impediments to stakeholder engagement and capacity to act
- Aim for visible short-term successes within the first 12-18 months of commencement of implementation to increase buy-in from stakeholders, and publicise and celebrate successes
- Foster and encourage determination, persistence and ongoing progress to retain momentum and ensure long-term success
- Weave new approaches into stakeholders' understanding and culture by demonstrating that the 'new' way is superior to the 'old'.

7.2 Proposed model

All stakeholders should have shared responsibility for implementation of this Strategy. Government recognition of its importance and national leadership in its delivery under the IGAB, within the legislative and constitutional responsibilities of governments, is necessary to provide the long term stability, commitment and continuity required to implement this strategy and ensure outcomes are delivered. Strong collaboration, linkages and coordination between government departments (environment and agriculture) will be crucial for implementation.

The growing non-government sector also needs to be more effectively harnessed, as it could have an important role in the successful implementation of this Strategy. In response to lack of investment from governments in biodiversity conservation, non-government nature conservation agencies have attracted strong public membership and philanthropic investments and multiplied in number. They undertake vital RD&E for managing biological threats to biodiversity and natural ecosystems.

It is recommended that a national committee, with well-defined terms of reference and sufficiently empowered to make national-level recommendations on priorities and strategies that are in the national interest, be established to implement this strategy (Box 2). The National Implementation Committee should be endorsed by and report to the NBC or an Australian Government agency with appropriate levels of legislative and constitutional authority for the coverage of this Strategy, such as the Department of the Environment. The committee should comprise representatives from each of the key stakeholder groups, including states and territories, and NGOs, which are strongly committed to this strategy and would need to be resourced adequately. It is important to realise though that financial support from community stakeholders to implement this strategy is likely to be difficult to achieve and thus support from government will be required.

Box 2. National Implementation Committee proposed for implementation of this strategy at the national level.

Role

Coordinate the implementation of this strategy and on-going evaluation and refinement in partnership with stakeholders

Key activities

- Identify and engage relevant stakeholders by sector.
- Identify organisations to champion and take responsibility of this strategy by sector.
- Develop strategic actions (with key performance indicators) to achieve the objectives of this Strategy.
- Identify suitable funding sources to support implementation of this strategy and coordinate those funding sources.
- Develop and execute an operational plan to undertake strategic actions, including lead organisations and responsibilities.
- Monitor and report on progress towards achieving objectives of this Strategy.

Resources

Committee to appoint coordinator, to be hosted with one of the participant organisations, to provide support across all activites undertaken (pending funding arrangements can be made).

Members to contribute to funding their own participation in the Committee.

Membership

A balance of up to 12 representatives from the key stakeholder groups, who are strongly committed to this strategy and selected through a transparent process.

- Representatives from each of the NBC sectoral committees (AHC, PHC, MPSC, IPAC; Table 6).
- Additional stakeholders to represent sectors not covered by representatives of the sectoral committees
- Representatives from key RD&E funding sources (for example, Australian Government Department of the Environment and Department of Agriculture and Water Resources, industry, benevolent groups)

- Representatives from key RD&E providers (for example, universities, CSIRO, Invasive Animal CRC, state and territory government agencies)
- Representatives from key NGOs and end users of RD&E

Working groups

Working groups may be formed at the discretion of the Committee to advance specific strategic actions.

An alternative to the proposed National Implementation Committee would be a government organisation willing to 'champion' this strategy and invest and seek resources to oversee its implementation. Strong involvement by stakeholders, however, would still be required and could take the form of an advisory committee.

As a starting point, the National Implementation Committee or champion organisation for implementation of this strategy should promote examples of where a coordinated approach has worked well (for examples, around Tasmanian devil facial tumor disease, post-border weed risk management protocol) to demonstrate the potential effectiveness and benefits of this Strategy. Initially targeting the strategy implementation against one of the seven identified important cross-sectoral RD&E priority areas would be another avenue to demonstrate effectiveness. This would involve engaging key contributors, nominating leadership and exploring funding options (traditional and innovative paths) in order to show that this strategy can be effectively implemented.

8 Consultation and approvals

This strategy was approved by the NBC in March 2016.

This strategy was developed under the guidance of a national steering committee (Table 1) and through consultation with a wide range of stakeholders (Appendices 1, 2).

The draft strategy was endorsed by the Steering Committee and reviewed by the former IGAB Schedule 8 Working Group before the final strategy was submitted to the NBC.

9 Appendices

Appendix 1 Workshop participants

The following experts participated in the national workshop held in February 2014 in Canberra, during the early stages of development of this strategy.

Workshop participant	Organisation
Steering Committee members	
Greg Devine	QIMR Berghofer Medical Research Institute
Andreas Glanznig	Invasive Animal CRC
Lyn Hinds	CSIRO
Louise Morin	CSIRO
Joanne Nathan	Australian Government Department of the Environment
Dean Paini	CSIRO
Kim Ritman	Australian Government Department of Agriculture and Water Resources
Karrie Rose	Taronga Conservation Society Australia
Andy Sheppard	CSIRO
Carol Sheridan	Australian Government Department of Agriculture and Water Resources
Jim Thompson	Biosecurity Queensland
John Virtue	Biosecurity South Australia
Judy West	Australian Government Department of the Environment, Parks Australia
Other participants	
David Cahill	Deakin University
Phillip Casey	University of Adelaide
Melodie McGeogh	Monash University
John Robertson	Biosecurity Queensland
John Rodger	University of Newcastle
Don Sands	CSIRO
Lee Skerratt	James Cook University
John Tracey	NSW Department of Primary Industries
Peter Turner	NSW Office of the Environment and Heritage
Marc Widmer	Department of Agriculture and Food, Western Australia
Andrew Woolnough	Department of Environment and Primary Industries, Victoria

Appendix 2 Additional stakeholders who provided inputs/comments

List of stakeholders, other than members of the Steering Committee (Table 1) and participants to the workshop (Appendix 1), who engaged with the development of this strategy by providing inputs or comments on the most important RD&E priority areas and/or a draft of this Strategy.

Organisation	Name(s)
Animal Health Committee	Rod Andrewatha (Chair)
Australian Government Department of Agriculture and Water Resources	Paula Brown, Peter Stoutjesdijk, Kylie Higgins, Ingo Ernst, Mark Schipp (Australian Chief Veterinary Officer), Peter Wilkinson
Australian Government Department of the Environment	Team – Environmental Biosecurity Section, Katrina Daniels
Australian Marine Sciences Association Inc.	Sabine Dittmann and members
Biosecurity NSW, NSW Department of Primary Industries	Angus Carnegie
Bush Repair (South Australia)	Ken and Katrina Jones
Consultant (former senior biosecurity manager, Queensland Government)	Bruce Wilson
Council of Australasian Weeds Societies	Anna-Marie Penna (vice-president) and members
CSIRO	Nic Bax, Mark Crane, Gary Fitt, Tony Grice, Mikael Hirsch, Ben Hoffmann, John Scott, Tanja Strive, Bruce Webber
Department of Agriculture and Food, Western Australia	Mark Kabay, Trevor Lacey, Sandy Lloyd, Greg Pickles, Alison Wilson,
Department of Environment and Primary Industries, Victoria	Nigel Ainsworth, John Baker, Pam Clunies
Department of Environment, Water and Natural Resources, South Australia	Andrew Triggs, Renate Velzeboer and other members of the Conservation and Sustainability Unit
Department of Fisheries, Western Australia	Rae Burrows
Western Australian Fisheries and Marine Research Laboratories	Justin McDonald
Department of Land Resource Management, Northern Territory	Keith Ferdinands
Department of Primary Industries, Parks, Water and Environment, Tasmania	Chinatsu Yahata
Intergovernmental Agreement on Biosecurity (IGAB), RD&E Working Group	Duncan Rowland
Invasive Species Council	Andrew Cox (CEO)
James Cook University	Tom Burkot
Murdoch University	Giles Hardy
National Aquatic Council	Pheroze Jungallwalla (Chair)
Primary Industries and Regions South Australia (PIRSA), Biosecurity South Australia	Heidi Alleway, David Cooke, Michaela Heinson, Roger Paskin, David Peacock, Michael Sierp, Nick Secomb, Mark Williams
Primary Industries and Regions South Australia (PIRSA), Fisheries and Aquaculture	Shane Roberts

Organisation	Name(s)
Sub-Committee on Aquatic Animal Health (SCAAH)	Comments collated by Claire Taylor, Department of Agriculture and Water Resources
The University of Melbourne	Roger Cousens
The University of Sydney	Robert Park
University of Queensland	Nigel Beebe
University of Western Australia	Michael Renton
Vertebrate Pest Committee	Will Zacharin (Chair)
Weed Management Society of South Australia	Rachel Melland and members

Appendix 3 Scope of the Animal Biosecurity RD&E Strategy

The scope of the Animal Biosecurity RD&E Strategy comprises:

- pests and diseases that pose a significant risk to the livestock (including horse), fisheries and aquaculture industries, and affect trade or public health
- pests and diseases of companion animals and wildlife, if they affect trade or public health. The Animal Biosecurity RD&E Strategy states that no specific diseases or issues in companion animals have been identified to date.

Components that are out of scope are:

- invasive marine species and invasive animal species, except for species that contribute to biosecurity risks that affect trade
- foodborne pathogens and their direct health effects on people
- chemical contamination and residue issues
- genetically modified organisms
- animal welfare issues.

Source: National Animal Biosecurity Research, Development and Extension Strategy Steering Committee 2014, 'Animal Biosecurity RD&E Strategy', available at

npirdef.org/files/resourceLibrary/resource/68_AHA0353_Animal_Biosecurity_RDE_WEB.pdf (PDF, 1.44MB), accessed 20 January 2016.

Appendix 4 Scope of the National Plant Biosecurity RD&E Strategy

The scope of the National Plant Biosecurity RD&E Strategy comprises:

- all plant pests affecting plants, plant products or bees and/or impacting on trade and market access
- all production plant pests that impact on the environment.

This table summarises the components that are in and out of scope.

Scope	Plant health	Weeds
In scope	Primary production crops: Broad acre Native and improved pastures Horticulture Forestry and timber production Nursery production (includes native plants produced by the nursery and garden industry) Bees (bee pests and diseases and invasive bees) Floriculture Native plants (acting as an alternative host or reservoir for pests, diseases impacting primary production) Pests of fresh water aquatic primary production plants Timber in service (for example, European house borer, Lyctus, termites) Postharvest horticulture and grains	Terrestrial weeds impacting primary production (for example, crop and pasture weeds) Environmental weeds which impact on primary production Freshwater aquatic weeds which impact primary production
Out of scope	Native plant pests/diseases not impacting production Fresh water aquatic plant pests/diseases not impacting production	Environmental weeds not impacting production

Source: Plant Health Australia 2013, 'National Plant Biosecurity Research, Development & Extension Strategy 2013-16', available at <u>planthealthaustralia.com.au/wp-content/uploads/2015/01/National-Plant-Biosecurity-RDE-Strategy.pdf</u>, accessed 20 January 2016.

Appendix 5 National biosecurity research and development priorities

Priorities	Objectives
1. Minimise the risk of entry, establishment, or spread of pests and diseases	1A. Develop the knowledge base for assessing and managing the risks of new pests and diseases, invasion pathways, and the susceptibility of ecosystems to invasion, in a changing global environment.
	1B. Enhance detection, surveillance and diagnostic systems.
	1C. Understand the sociological factors associated with the adoption of risk mitigation measures by stakeholders.
	1D. Develop knowledge and strategies to prevent and contain the spread of pests and diseases within national borders.
	1E. Develop tools and decision-making frameworks for prevention and eradication.
2. Eradicate, control or mitigate the impact of established pests and diseases	2A. Characterise the movement of pests and diseases through complex environments.
	2B. Develop effective and integrated approaches to managing established pests and diseases of national priority.
	2C. Understand risk factors that drive emergence of new pests and diseases.
	2D. Understand the interaction of pests and diseases with the invaded system.
3. Understand and quantify the impacts of pests and diseases	3A. Improve understanding of the environmental, economic, and social impacts of pests and diseases and of management activities to control them.
	3B. Develop the knowledge base and protocols for managing the invasion risks posed by one sector for others.
4. Cost-effectively demonstrate the absence of significant pests and diseases	Develop tools that can cost effectively demonstrate the absence of national priority pests and diseases.

Source: Intergovernmental Agreement on Biosecurity—Research, Development and Extension Working Group 2012, National Biosecurity Research and Development Capability Audit 2012

Appendix 6 Outcomes from the National Primary Industries RD&E Framework

Sought outcomes from the National Primary Industries RD&E Framework (available at npirdef.org/framework, accessed 20 January 2016):

- To provide shared strategic directions and priorities for national and sector level primary industries RD&E in Australia that enhance the productivity and sustainability of Australia's primary industries
- 2) Research capability will more comprehensively and holistically cover the present and future strategic needs of stakeholders nationally
- 3) Public research capability will become more integrated, interdependent and specialised, and have larger critical mass with less fragmentation across the nation
- 4) Efficiency and effectiveness of RD&E will be improved and as a consequence returns on investment will improve
- 5) RD&E investment will improve the capability of the national system in priority areas and ensure effective and efficient use of resources, including infrastructure
- 6) The Parties will collaborate to retain and build capability in fields strategically important to their jurisdictions and industries
- 7) The national research capability will be an integral component of a wider innovation agenda, supporting development and extension
- 8) Research undertaken in one location will be developed and extended nationally for primary industries.

Appendix 7 Key negative impacts and benefits of terrestrial vertebrate pests

Adapted from draft Australian Pest Animal Strategy R&D investment guidelines.

Negative impacts	Environmental	Economic	Social
Predation on native animals, and consequences at species, community and ecosystem levels	yes	-	yes
Competition with native animals for resources (for example, food, water, shelter, breeding sites)	yes	-	yes
Damage to vegetation with consequences at species, community and ecosystem level, and associated effects on for example, native animal populations, soil ecology, water quality and agricultural productivity	yes	yes	yes
Damage to watering points, particularly in drier areas where high density congregations of herbivores can foul water through bank erosion, and faecal and carcase accumulation	yes	yes	yes
Predation on livestock, with economic and animal welfare implications	-	yes	yes
Competition with livestock for food and water, and fouling of food/water supplies in intensive livestock production systems	-	yes	yes
Risk of livestock disease where pests act as potential reservoirs and/or vectors, particularly where there is effectively unrestricted movement between property tenures	-	yes	yes
Spread of weeds particularly where herbivore and omnivore species travel long distances	yes	yes	-
Damage to infrastructure, including fences and watering points	-	yes	-
Reduced productivity and consequent effects on producer incomes and commodity prices	-	yes	yes
Damage to agricultural products where feeding, residual attack outcomes, and blemishing or contamination reduce product value	-	yes	-
Damage to stored products, particularly through rodent attack	-	yes	yes
Greenhouse gas emissions from unmanaged ruminant pests	yes	yes	-
Human health risk through direct disease transmission ('zoonoses') and social costs associated with predator attacks, mouse plagues, etc.	-	yes	yes
Impacts on amenity in urban situations (for example, cane toads in backyards) and recreational settings (for example, carp in waterways)	-	-	yes
Opportunity cost of resource investment in pest animal management and R&D activities	-	-	yes
Benefits	-	-	
Opportunities for use through commercial and recreational routes		yes	yes
Negative effects on other pest species (for example, fox predation on rabbits; feral goats eating weed species)	yes	yes	

Appendix 8 Interim list of top 20 high risk pathogens and invertebrates

This interim list was developed by the Bureau of Rural Sciences in 2009 (Raphael et al. 2009) for the discontinued Environmental Biosecurity Committee. See reference for detail on the process used to develop this interim list. Note that this list pertained to high risk organisms for the environment and not primary industries. The list is most likely out of date and current priorities need to be identified and the list updated.

Species	World Distribution	Potential Introduction Pathway	Australian taxa and ecosystems at risk in predicted range
Achatina fulica Giant African snail	Most regions of the humid tropics.	Most pathways regulated, unintentional introduction as undetected eggs and small snails. Has been deliberately introduced. The risk of illegal import/smuggling (for example, pet trade) remains. In the period 2003-2007, there were 151 incursions.	Tropical and subtropical vegetation, known to eat eucalyptus seedlings. Linked to declines in both invertebrates and plants, primarily as a result of competition for resources.
Aedes albopictus Asian tiger mosquito	Pacific, America, Africa and Europe.	Highly regulated pathways, eggs or larvae could unintentionally arrive in cargo capable of holding water such tyres, machinery, bulk steel and yachts. Eggs are regularly found on lucky bamboo (Dracaena spp.). Unconventional pathways (for example, monsoonal winds) would be seasonal and rare.	Spreads diseases such as yellow fever, dengue and several types of viruses.
Eriocheir sinensis Chinese freshwater edible crab	Native to China, Japan (and Russia?) introduced range Finland, Sweden, Russia, Poland, Germany, Czech Republic, Netherlands, Belgium, England, France, recorded in Portugal, Iran, Poland. Reports in US/Hawaii but not established.	Most pathways regulated. Possible introduction through ballast water. The crab is a delicacy and potential for smuggling to occur.	Contributes to local extinction of native invertebrates, modifies habitats due to burrowing activities.
Pomacea canaliculata Golden apple snail	Wide - native range Argentina, Bolivia, Paraguay. Introduced range Philippines, Japan, Taiwan, Vietnam, Cambodia, Thailand, Laos, Korea, Sri Lanka, Indonesia, Malaysia, southern China, Singapore; Hawaii, Guam, PNG, Dominican Republic, USA	Most introduction pathways are regulated, unintentional introduction through the nursery trade- eggs or juvenile stages attach to aquatic plants. Some potential for smuggling.	Tropical and subtropical vegetation. Linked to declines in both invertebrates and plants, primarily as a result of competition for resources.

Species	World Distribution	Potential Introduction Pathway	Australian taxa and ecosystems at risk in predicted range
Chrysomya bezziana Screw-worm fly	Tropical and subtropical Africa, the middle east, Indian subcontinent, South-East Asia, and Papua New Guinea.	Highly regulated pathways. Live animals inspected at quarantine facilities (including inspection for disease), surveillance strategies and public awareness in the north of Australia. High risk for smuggled animals from PNG.	Maggots infest and can even kill animals (livestock and native species) and people.
Lymantria dispar Asian gypsy moth	Native range: southern Europe, northern Africa, central and southern Asia, and Japan, Korea. The European strain has been introduced to USA and Canada.	There is a high risk of the moth arriving on ships carrying cargo containers. Egg masses are tolerant of climatic extremes and travel well. Possible for caterpillars attaching to travellers.	Threat to native forests, demonstrated preference for Australian native plant species (E. gunnii, E. risdonii, E. urnigera, Corymbia maculata, and Callistemon brachyandrus) and E. gunnii, E. delegatensis hybrid (E. irbyi).
Acarapis woodi Honey bee tracheal mite	Global except Australia, NZ, Scandinavia and Canada.	Import of bees into Australia has been suspended. Visitors must declare all bee and honey products. Major risks are seagoing vessels exotic bees have been detected on ships destined for Australia. National Sentinel Hive Program was established in 2000.	Although specific to the honeybee, the honeybee is a pollinator of many native species. In the absence of native pollinators loss of pollinators would impact on native flora.
Corbicula fluminea Asian clam	Japan, China, Korea (native range), introduced to San Francisco bay, USA	Regulated pathway but high volume of trade from source countries. Regulations governing ballast water assist.	Linked to dramatic changes to the soft sediment communities of invaded areas. Is thought to be responsible for the decline in the diversity and abundance of many benthic species.
Apis cerana Asian honeybee	Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, Pakistan, Indonesia, Japan, Malaysia, Papua New Guinea, Thailand, Vietnam, Korea	Import of bees into Australia has been suspended. Visitors must declare all bee and honey products. Major risks are seagoing vessels exotic bees have been detected on ships destined for Australia. National Sentinel Hive Program was established in 2000.	Competes for the same food source as many native bees and could affect the pollination of native plants. Also potential to compete with possums, parrots and cockatoos for nesting hollows
Xylosandrus compactus Black twig borer	USA, Hawaii, Canada, Brazil, Indonesia, Sri Lanka, Japan, Cuba, Africa, Madagascar, Malaysia.	Regulated pathways, but the species has hundreds of host species. Scolytids were the most commonly intercepted group of insects in solid wood packing materials. Also intercepted in food products.	Host range of over 224 recorded hosts in 62 families, including Cattleya, Dendrobium, Epidendrum, Vanda. Other hosts include paper- bark (Melaleuca leucadendron), redironbark eucalyptus (Eucalyptussideroxylon), blackbutt eucalyptus (E. pilularis), robust eucalyptus (E. robusta).
Highly pathogenic Avian influenza	Worldwide.	Predominantly unregulated. A 'Cross-Jurisdictional Model for Targeted Surveillance of Wild Bird Species' has been developed and should be maintained.	Pandemic effect on susceptible bird species, particular risk for waterfowl.

Species	World Distribution	Potential Introduction Pathway	Australian taxa and ecosystems at risk in predicted range
Didymosphenia geminate Didymo	Northern Hemisphere, including the rivers of northern forests and alpine regions of Europe, Asia and parts of North America. Now in New Zealand.	Didymo can establish from a single viable cell. AQIS, and other government departments and research organisations, are proactively engaged in public awareness campaigns and border surveillance. Pathway is regulated and there are increased quarantine restrictions on the importation of used fishing and other freshwater recreational equipment.	Severe blooms can completely carpet river beds smothering other aquatic life and altering aquatic communities.
West Nile Virus	The Americas, Europe, Asia.	Predominantly unregulated. A 'Cross-Jurisdictional Model for Targeted Surveillance of Wild Bird Species' has been developed and should be maintained.	Causes extreme morbidity and mortality in novel hosts, and much of Australia's native avifauna has likely had no prior exposure, so the impact of this spread on native biodiversity is potentially serious.
Cryphonectria cubensis Cryphonectria canker	Prevalent in many tropical parts of the world.	Some introduction pathways are regulated. The pathogen is prevalent in the tropical parts of the world and it is possible that the pathogen could introduced to Australia through imports of wooden articles, sawn timber or wood packaging materials in particular if bark is present on such materials.	Eucalyptus and cloves.
Puccinia psidii Eucalyptus rust	Native to parts of South America. It now also occurs in North America (Mexico, Florida (USA)) and parts of Central America including the Caribbean.	Some introduction pathways are regulated. Unintentional pathways include seeds, nursery stock, bark crevices, lumber and wood packaging material including dunnage with attached bark. Positive results were returned for tests of spores found on the timber, plastic wrapping and the surface of the shipping container. Spores are easily dispersed in air currents, tropical storms and could unintentionally enter Australia on clothes, hair or luggage.	Infects eucalypts, particularly severe on susceptible species and can cause death.
Plasmodium relictum Avian malaria	Worldwide.	Predominantly unregulated. A 'Cross-Jurisdictional Model for Targeted Surveillance of Wild Bird Species' has been developed and should be maintained.	Causes extreme morbidity and mortality in novel hosts, and much of Australia's native avifauna has likely had no prior exposure, so the impact of this spread on native biodiversity is potentially serious.

Species	World Distribution	Potential Introduction Pathway	Australian taxa and ecosystems at risk in predicted range
Rabies	Worldwide, excluding Australia, New Zealand, Papua New Guinea, United Kingdom and some parts of Europe.	Most of the introduction pathways of rabies are regulated. Unintentional introduced could be via a rabid animal coming from a country where the disease is present. Regulation is high and all imported animals are subject to strict quarantine requirements, including vaccination for dogs and cats from all affected countries.	Rabies is a fatal, contagious, viral disease affecting humans and all mammals, including cats, dogs, wildlife and farm animals.
Newcastle disease	Native range: Ethiopia, Zimbabwe. Spread into Europe, India, the Americas, south-east Asia.	Domestic birds can be vaccinated. Industry is proactive with awareness campaigns. Major risk is from unregulated pathways (wild birds or smuggling). A 'Cross- Jurisdictional Model for Targeted Surveillance of Wild Bird Species' has been developed and should be maintained.	Causes extreme morbidity and mortality in novel hosts, and much of Australia's native avifauna has likely had no prior exposure, so the impact of this spread on native biodiversity is potentially serious.
Aeromonas salmonicida Furunculosis	Belgium, France, Switzerland, Austria, Germany, Great Britain. The disease has spread from the continent of Europe to the United States and Canada, detected in Australia in 1970's in the pet trade.	Pathway is regulated and there are increased quarantine restrictions on the importation of used fishing and other freshwater recreational equipment. Major risk is from the unregulated 'pet trade'.	Affects a variety of salmonid and non- salmonid species in freshwater, brackish water and sea water. Not known to demonstrate zoonotis.
Heterobasidion annosum Root and butt rot	USA, Canada, India, China and throughout Europe.	Regulated pathways, although bark, lumber and wood packaging are high risk. Unintentional pathways could be via long distance aerial spread of sporidia.	Wide host range, including gymnosperms and angiosperms. Australia is home to several endemic genera of gymnosperms including Athrotaxis (for example the King Billy pine, A. selaginoides), Actinostrobos, Microcachrys, Lagarostrobos (L. franklinii is the huon pine), Microstrobos and Diselma. The primitive cycad genera Lepidozamia, Macrozamia and Bowenia are also endemic Other more widespread genera found as fossils include kauri pines (Agathis species), plum pines (Podocarpus species), and celery-top pines, Phyllocladus. Australia has 14 families of endemic angiosperms: including Mimosaceae (acacias), Myrtaceae (eucalypts and allied genera) and Proteaceae (banksias, grevilleas etc.).

Appendix 9 Important RD&E priority areas for each sector

RD&E priority areas selected as most important for future focus and investment in each of the sectors by a range of stakeholders (Table 1Appendices 1, 2). More details on the sectors in Table 4. Number in each cell of the matrix corresponds to the number of stakeholders who selected the RD&E priority area as one of the five most important areas for that sector (Note that a few stakeholders selected less than five areas as most important within a sector). The number of stakeholders who undertook the exercise in each of the sectors is listed in the last row of the table.

Category	RD&E priority area	Diseases of terrestrial wild	Diseases of marine and freshwater wild animals	Diseases of captive animals	Human disease animal vectors	Vertebrate pests	Invertebrate pests of social amonities and freshwater	Environmental weeds	Marine pests	Pests and diseases of nlants	Total
1. Risk analysis and decision making	1.1 Develop and apply risk analysis approaches to prioritise pests, weeds and diseases for management actions pre- and post-border, including ecological and socio-economic modelling of distribution, spread and impacts.	4	5	_	3	4	3	6	8	3	36
-	1.2 Characterise and prioritise pathways of pest, weed and disease movement, including between land uses and between jurisdictions.	2	3	1	3	3	3	3		5	23
_	1.3 Identify mechanisms (for example, genetic, ecological, epidemiological, evolutionary, social/human behaviours and interactions with the environment) that increase new pest, weed and disease risks.	2	1	1	2	3	-	1	2	5	17
_	1.4 Identify criteria for understanding the status of biological invasions along the invasion continuum to assist decision making around feasible management interventions.	3	3	1	-	3	4	4	3	1	22
-	1.5 Develop approaches to quantify cumulative effects of multiple pest, weed and disease invasion, and develop prioritisation and management decision- making processes to such scenarios.	-	-	-	-	1	-	6	-	-	7
_	1.6 Refine and further develop approaches to understand and quantify potential socio-economic and environmental direct and indirect beneficial and harmful impacts of pests, weeds and diseases, including cross-sectoral risks, and the cost effectiveness and benefits from policy and management options.	5	3	2	3	4	3	6	7	5	38

Category	RD&E priority area	Diseases of terrestrial wild animals	Diseases of marine and freshwater wild animals	Diseases of captive animals	Human disease animal vectors	Vertebrate pests	Invertebrate pests of social amenities and freshwater	Environmental weeds	Marine pests	Pests and diseases of plants	Total
-	1.7 Refine decision-making frameworks for eradication programs (for example, to assist the NEBRA process).	1	-	1	-	-	2	-	2	1	7
2. Detection, diagnosis and surveillance	2.1 Refine or develop novel detection and surveillance techniques and best practice diagnostic procedures for pests, weeds and diseases not yet established or established at low levels, including probabilities of absence (for example, remote diagnostics, genetic identification techniques, automated approaches, social media).	2	7	2	2	7	5	5	8	3	41
-	2.2 Develop methods to assess the effectiveness of routine detection and surveillance systems currently undertaken by government, industries and communities.	1	2	1	1	2	3	3	2	1	16
3. Management methods and strategies	3.1 Review and improve eradication and containment tools and strategies for national and regional use against priority pests, weeds and diseases.	1	2	_	2	7	1	3	6	4	26
-	3.2 Identify key biological vulnerabilities of pests, weeds and diseases to exploit for management (for example, behavioural, physiological, ecological).	1	-	-	2	6	2		2	-	13
-	3.3 Refine and further develop management tools and integrated strategies for priority pests, weeds and diseases, including biological control.	1	1	1	2	7	-	10	1	3	26
-	3.4 Incorporate integrated management strategies into whole-of-system management to ensure sustainable outcomes.	3	3	-	-	3		5	-	5	19
_	3.5 Develop approaches to design landscapes and townscapes to increase resilience to multiple pest, weed and disease invasions and their impacts.	-	-	-	-	1	1	2	-	-	4
_	3.6 Review and improve effectiveness of existing policy instruments and, management guidelines and techniques regarding the use and/or management of contentious invasive organisms (for example, invasive pastoral grasses, cats, wild dogs).	1	-	_	-	4	-	5	-	2	12

Category	RD&E priority area	Diseases of terrestrial wild animals	Diseases of marine and freshwater wild animals	Diseases of captive animals	Human disease animal vertors	Vertebrate pests	Invertebrate pests of social amonities and freshwater	Environmental weeds	Marine pests	Pests and diseases of nlants	Total
4. Stakeholder engagement	4.1 Understand diverse community perceptions of risks and impacts of pests, weeds and diseases and the socioeconomic drivers and incentives that lead to response and action.	3	2	3	1	2	2	7	2	-	22
-	4.2 Improve methods to increase public awareness of the impacts of pests, weeds and diseases, and influence behaviours in response to biosecurity issues.	5	5	3	2	6	2	5	4	4	36
_	4.3 Develop training for different stakeholders in decision making and implementation of biosecurity measures.	1	2	1	-	-	1		1	1	7
_	4.4 Develop approaches to optimise stakeholders' engagement in all stages of biosecurity RD&E (for example, citizen science).	3	2	1	-	1	1	3	3	3	17
-	4.5 Review existing frameworks and consultative processes to encourage greater co-governance across sectors for management of pests, weeds and diseases.	1	1	-	1	1	-	-	2	2	8
_	4.6 Develop guidelines to encourage and facilitate strategic adaptive management of pests, weeds and diseases by stakeholders.	-	-	-	1	-	-	-	-	-	1
Number of stakeholders who undertook the exercise	_	8	9	5	5	13	8	15	11	10	Total: 84

Note: the total of each row indicates Number of stakeholders across all sectors who selected the priority area as amongst five most important.

Appendix 10 Limitations of the national biosecurity R&D capability audit

Extract from the National Plant Biosecurity RD&E Strategy that summarised limitations with the national biosecurity capability R&D capability audit.

- Different approaches and interpretations of questions, scope and definitions.
- Missing data.
- Capability may be found in organisations that were not audited.
- Human capability commonly extends across disciplines, species and/or pests and the audit may not have captured this.
- The age categories limit interpretation of the extent to which an aging workforce is an issue.
- There is the potential to confound a large number (FTE or dollars) with a demand being met or the reverse, that low numbers mean there is unmet demand. For example the data show a relatively large number risk analysts employed by DAFF (former Australian Government Department of Agriculture, Fisheries and Forestry; now known as Department of Agriculture and Water Resources). However they do not conduct R&D.
- Exclusion of 'extension' from the audit scope.
- The survey did not canvas input from the RDCs.
- Questions about whether students should be considered as part of a stable Biosecurity R&D base.
- The audit is a snap shot in time. It does not show trends and is already dated. For example post audit there have been budget cuts to departments of primary industries with significant downsizing in Queensland and New South Wales and the closure in Queensland of its two regional laboratories.

Appendix 11 Additional capability information specific to this strategy

Initial inventory of capabilities – methodology

To illustrate the breadth and depth of R&D capabilities relevant to this Strategy, an inventory was performed across a range of organisations. Information on extension capabilities was not obtained. Numbers of full time equivalent R&D staff were not captured due to limited resources available to the writing team to gather such detail information from organisations. Only the names of permanent staff members were recorded, omitting post-doctoral fellows, as well as PhD and Masters students.

All Australian university home pages were searched for three terms; biosecurity, invasion biology, invasive species. The terms 'invasion' and 'invasive species' were used as filters since they are more commonly associated with biosecurity issues of the environment and community than with primary industries. Search results were scanned for researchers and their university home pages were scanned for evidence of R&D relevant to biosecurity issues. Some universities had more than one researcher in this area and at least one of these researchers was subsequently emailed for clarification of both their research and that of others in their institution.

For CSIRO, an internal and informal survey of researchers was conducted to determine which researchers are active in areas relating to this Strategy.

For relevant departments of Australian, state and territory governments, emails were sent to at least one departmental representative who was asked for details of research capabilities in the relevant areas. Home pages were scanned when no information was received from departmental representative.

Relevant R&D capabilities in other organisations such as zoos, botanical gardens, herbaria and natural museums (for example, insect collections) were not systematically searched.

Stakeholders who reviewed the draft of this strategy were asked to provide additional information on R&D capabilities that was not captured in web searches or by contacting the above organisations. This additional information has been incorporated in the final version of this Strategy.

Each person from which information was gathered or received was allocated to the relevant sectors. Capabilities were allocated to one of the two general disciplines when it was not possible with information obtained to allocate them to specific sectors.

Despite all these efforts to produce this inventory of R&D capabilities in biosecurity relating to the environment and community, not all relevant organisations or capabilities within listed organisations have been captured. Further, it is highly likely that some of the capabilities inventoried are primarily devoted to primary industry biosecurity issues, although could potentially be redirected to environment or community biosecurity if needs arise.

Appendix 12 Members of the National Environment and Community Biosecurity RD&E Strategy Steering Committee.

Sectors representing	Member	Organisation
Vertebrate pests; Weeds	John Virtue (Chair)	Biosecurity South Australia; Member of Australian Weeds Committee and Vertebrate Pests Committee
Vertebrate pests; Weeds	Jim Thompson	Biosecurity Queensland; Chair – Australian Weeds Committee; Member of Vertebrate Pests Committee
Vertebrate pests	Andreas Glanznig	CEO; Invasive Animal Cooperative Research Centre (CRC); Observer on Vertebrate Pests Committee
Vertebrate pests	Lyn Hinds a	CSIRO; Observer on Vertebrate Pests Committee
Vertebrate pests	Jane Frances	NSW Department of Primary Industries; Member of Vertebrate Pests Committee
Marine pests	Carol Sheridan	Department of Agriculture and Water Resources; Chair (2013-2014) of Marine Pest Sectoral Committee
Marine pests	Dean Paini a	CSIRO; Observer on Marine Pest Sectoral Committee
Weeds	Andy Sheppard a	CSIRO; Observer on Australian Weeds Committee
Weeds; Plant pathogens	Louise Morin a	CSIRO
Social amenity pests	Judy West	Department of the Environment; Parks Australia
Wild animal diseases	Rupert Woods	Wildlife Health Australia Inc. (formerly Australian Wildlife Health Network)
Captive animal diseases	Karrie Rose	Taronga Conservation Society Australia, Australian Registry of Wildlife Health
Human disease animal vectors	Greg Devine	Mosquito Control Laboratory, QIMR Berghofer Medical Research Institute
Cross-sectors	Joanne Nathan	Department of the Environment; Member of Australian Weeds Committee and Vertebrate Pests Committee
Cross-sectors	Kim Ritman	Department of Agriculture and Water Resources; Chair of IGAB Schedule 8 Working Group

Note: a Members of writing team.

Glossary

Bilateral agreement	Agreement between two nations or entities.
Biosecurity	Managing risks to Australia's economy, environment and community of pests and diseases entering, emerging, establishing or spreading in Australia.
Drivers	Forces of change, either positive or negative, that affects supply and demand. For example, population growth or limits on natural resources.
Economies of scale	That range of production or output over which the average cost of production falls as the volume of its output increases.
Green paper	A government discussion paper which presents a range of ideas and are developed for the purpose of generating public discussion and comment. They do not commit the government to the views expressed or particular future actions.
Infrastructure	Facilities, services and installations that support society, such as water, power, transport and communication systems.
Regulation	A rule or order, as for conduct, prescribed by authority; a governing direction or law.
Safe food	Food that is produced in accordance with recommended safety guidelines for the commodity, to minimise risks such as contamination.
Sustainability	The capacity for development that can be sustained into the future, within the capacity of the natural resource base. This includes encouraging sustainable agricultural and fishing practices which maintain and improve the natural resource base.
Trade barriers	Any regulation or policy that restricts international trade.
White paper	A statement of government policy on a particular issue.

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