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**Department of Agriculture
and Water Resources**
ABARES

Exotic invasive species

Identification of species with environmental impacts

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Summary

Australia's strong biosecurity system aims to mitigate the risk of new introductions of pests and diseases that could impact on our unique environments, industries and way of life. The Australian Government Department of Agriculture and Water Resources is the primary agency responsible for biosecurity measures pre-border. The department undertakes a number of activities that aim to prevent and prepare for new incursions of exotic species should they occur.

Previous introductions of invasive species (for example, European fox, European carp and lantana)—many of them intentional—have had significant impacts on Australia's environment. Invasive species threaten biodiversity, cause environmental degradation and reduce the diversity and abundance of native species. Impacts on the environment can have flow-on effects—impacting tourism and the economy more broadly. Preparedness activities, such as identifying exotic species (and their pathways) that are a major threat to Australia's industry, environment and social amenity, are important steps in mitigating the risk of incursions.

The Intergovernmental Agreement on Biosecurity (IGAB) provides for a strategic approach to biosecurity in Australia. It aims to minimise the impacts of pests and diseases on Australia's environment, economy and community. The National Environmental Biosecurity Response Agreement (NEBRA), established under the IGAB, sets out the Australian emergency response arrangements should there be an incursion or biosecurity incident that impacts primarily on the environment and/or social amenity. The NEBRA does not provide for an agreed list of priority species with environmental impacts and there is limited understanding of those exotic species that could impact on the environment should an incursion occur.

To strengthen environmental biosecurity preparedness, the Stronger Biosecurity and Quarantine Initiative commissioned ABARES to identify exotic invasive species that have the potential to impact the environment. A horizon scanning approach was adopted by scanning databases, government data, legislation, scientific journals and reports for invasive species (plants, vertebrates and invertebrates) recorded around the world. Species identified from these sources were recorded in a database. Species in the database were then assessed to determine their status in Australia (exotic or present). At July 2017 the database contained approximately 430 plant, 800 vertebrate and 815 exotic invertebrate species identified as invasive or as a concern in countries and regions across the world. Species that were exotic and of concern for two or more countries/regions were further examined for their impacts (environment, agriculture and social), resulting in 160 plant, 177 vertebrate and 208 invertebrate species examined for the purpose of this report. Although a comprehensive evaluation of impacts was not performed, scanning of literature suggested that 43 per cent of plants, 58 per cent of vertebrates and 36 per cent of invertebrates exotic to Australia had at least some documented impacts on the environment in their overseas range.

The resulting database is not an official or exhaustive list of exotic species of concern. The database may be used as a basis to select species for further assessment. For example, to conduct prioritisation assessments to determine the likelihood of the species arriving and establishing and the potential impact in Australia. This project is the first step of a proposed broader invasive species prioritisation framework—the identification of exotic species. The invasive species prioritisation framework has been designed to inform future policy development and to support arrangements for prevention, preparation and national eradication and management.

1 Introduction

Invasive species are deliberately or accidentally introduced species that have become established in natural or semi-natural ecosystems or habitats, are agents of change and threaten native biological diversity (IUCN 2000). They may also have a negative impact on the economy and social amenity (Bomford 2008). Exotic invasive species are defined here as those species not native and not introduced to Australia, which have been identified as causing a negative impact in areas where they have been introduced.

Invasive species already established in Australia have had a significant impact on the environment, threatening biodiversity, causing environmental degradation and reducing species diversity and abundance (Department of the Environment and Energy 2016a). For example, the European fox (*Vulpes vulpes*) has had a direct impact on the reduction of native fauna, and has been estimated to cost the environment (in terms of loss to biodiversity) approximately \$190 million per annum (McLeod 2004). The European carp (*Cyprinus carpio*) has also had a significant impact on the environment, causing water turbidity issues, displacing native fish and reducing the abundance of native plants and invertebrates (McLeod 2004). The estimated cost of European carp to biodiversity is \$11.8 million per year (McLeod 2004). Australia's biodiversity is also significantly impacted by weeds. Weeds can affect the richness and diversity of native species, ecosystem structure and the frequency of fires. Lantana (*Lantana camara*) is considered one of the worst weeds in terms of its impact on the environment and industry. It excludes native species and is toxic to animals. It is currently known to threaten 1,400 native species (including 279 plants and 93 animals listed as threatened under legislation) and 100 ecosystems (Department of Employment, Economic Development and Innovation 2009). Given the impacts of invasive species, prevention of further incursions of exotic invasive species is an Australian Government priority.

Australia's biosecurity system aims to protect our unique environment, economy and way of life from the risk of harmful exotic invasive species arriving and establishing. The Department of Agriculture and Water Resources is the primary agency responsible for biosecurity measures pre-border, aiming to prevent and be prepared for incursions of exotic species. Australia has a strong quarantine system. However, the risk of invasive species entering Australia may never be reduced to zero. Therefore, preparedness activities are important steps in mitigating the risk of incursions of exotic invasive species. These activities include prioritising species (and their pathways) that are a major threat to Australia's industry, environment and human health.

Understanding the most harmful species is also an international priority, being the primary goal of Aichi Biodiversity Target 9. The goal of Target 9 is that invasive alien species and their pathways are identified and prioritised by 2020 (Convention on Biological Diversity 2010). The Convention on Biological Diversity has determined that the identification and prioritisation of species with the greatest impacts on biodiversity is necessary to prevent their spread, introduction and establishment.

The identification of pests and diseases with the greatest impacts on the economy have been prioritised under several deeds and agreements. These agreements also set out management responsibilities and cost-sharing arrangements to enable a rapid response should an incursion occur. These include the Emergency Animal Disease Response Agreement (EADRA) and the Emergency Plant Pest Response Deed (EPPRD). The EADRA and EPPRD are agreements between government and industry. Each deed provides for a number of pests and diseases of national importance to be listed prior to an incursion. The focus of the deeds are primarily on those pests

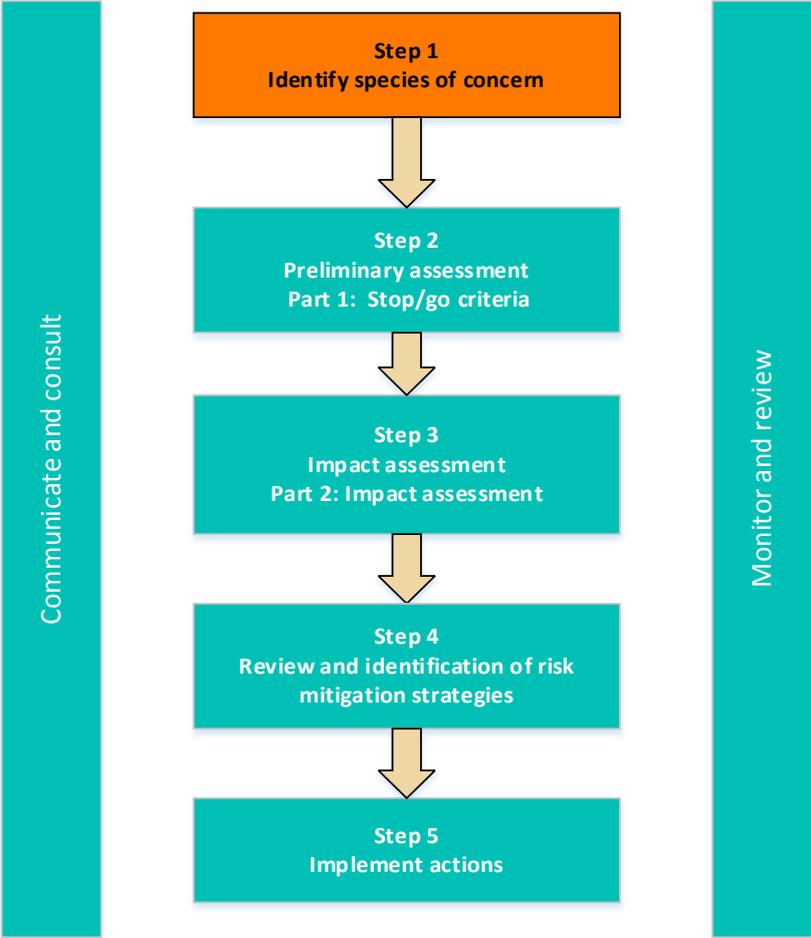
and diseases that impact agricultural production, however both deeds provide for the listing of pests and diseases that impact human health and the environment. The National Environmental Biosecurity Response Agreement (NEBRA), established under the Intergovernmental Agreement on Biosecurity (IGAB), sets out emergency response arrangements for incursions and biosecurity incidents that primarily impact on the environment and/or social amenity. The NEBRA aims to strengthen Australia's biosecurity preparedness and enable early response assistance to pest and disease incursions that threaten the environment. The NEBRA does not include a process to pre-list exotic species of concern and there is limited understanding of the suite of exotic species that pose the greatest environmental threat to Australia.

Project objective

The focus of the Stronger Biosecurity and Quarantine Initiative (SBQI) is on strengthening Australia's biosecurity preparedness capabilities, to enable a rapid response to pest and disease incursions. The objective of this project, funded by the SBQI, is to identify exotic invasive species (plants, vertebrates and invertebrates) that have the potential to impact on Australia's environment. It is the first step in a proposed Exotic Invasive Species Prioritisation Framework (Figure 1). The framework has been designed to assist in identifying national priorities for prevention and preparedness.

This report describes the methods used to develop a database of exotic species with potential environmental impacts. It also provides an overview of species in the database at July 2017. The database is not an exhaustive list of all exotic invasive species. It is a dynamic database that can be added to as new sources of information are collected.

Figure 1 Overview of proposed Exotic Invasive Species Prioritisation Framework



Note: Step 1 in the process is within the scope of this project. Adapted from the National Post-Border Weed Risk Management Protocol (Standards Australia 2006).

2 Methods

Scope

Across the biosecurity spectrum, work is underway to prioritise invasive species that are the greatest threat to Australia's environment and economy. These processes are outlined in Appendix A.

This project focuses on areas where there are potential gaps: exotic plants, vertebrates and invertebrates that may be a threat to the environment. Exotic species in scope include:

- 1) Plants—all terrestrial and aquatic freshwater plant families, including trees, shrubs, palms, rushes, sedges, herbs, succulents and vines/climbers. This category does not include marine plants.
- 2) Vertebrates
 - a) terrestrial classes—Mammalia (mammals), Aves (birds), Amphibia (amphibians), Reptilia (reptiles)
 - b) aquatic freshwater classes—Actinopterygii (bony fish), including species that spend part of their lifecycle in freshwater/brackish water, and Cephalaspidomorphi (jawless fish).
- 3) Invertebrates—freshwater and terrestrial invertebrates of the phyla: Arthropoda (for example, wasps, ants, moths and butterflies, crustaceans, beetles and bugs), Mollusca (slugs and snails), Annelida (including earthworms), Platyhelminthes (flatworms) and Nematoda (nematodes).

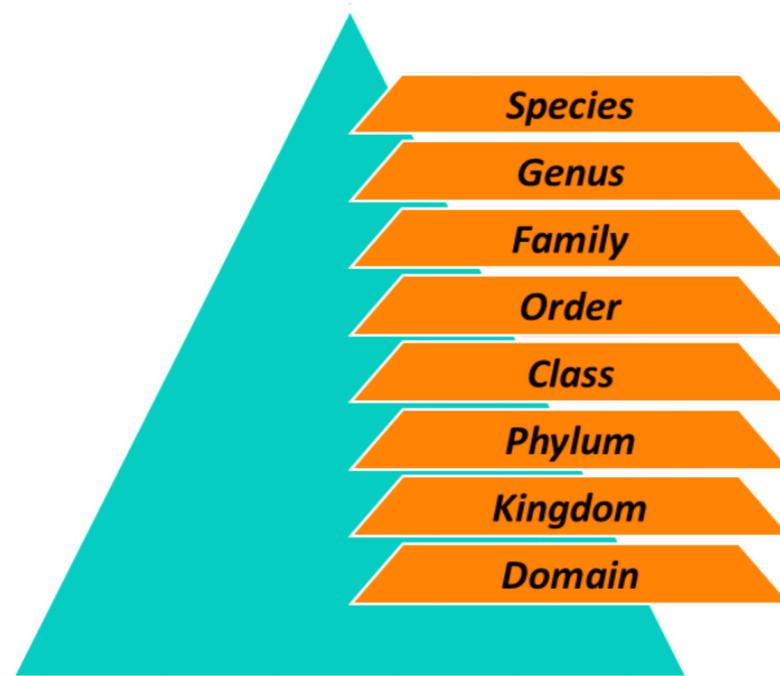
See Figure 2 for an understanding of taxonomic classification.

References to invasive species in the text include only those species of plants, vertebrates or invertebrates described in scope.

Species of concern

Species listed as invasive or identified of concern by other countries and regions were the focus of this project. Of the exotic species that may be introduced to Australia, it has been estimated that only 10 per cent of those will become established, and only 10 per cent of the established species will become invasive (Williamson & Brown 1986; Williamson & Fitter 1996). Therefore, it was important for this study to focus on scanning literature of invasive species rather than exotic species that may or may not become invasive. Invasive species are deliberately or accidentally introduced species that have become established in natural or semi-natural ecosystems or habitats, are agents of change and threaten native biological diversity (IUCN 2000). They may also have a negative impact on the economy and social amenity (Bomford 2008). It is recognised that some species that have never displayed invasive characteristics may become invasive in Australia if they arrive. However, it is beyond the scope of this project to predict the potential invasiveness of a species. Detailed assessments exist, for example, for plants, to determine the likelihood of a plant species becoming a weed (Pheloung, Williams & Halloy 1999).

Figure 2 Taxonomic classification

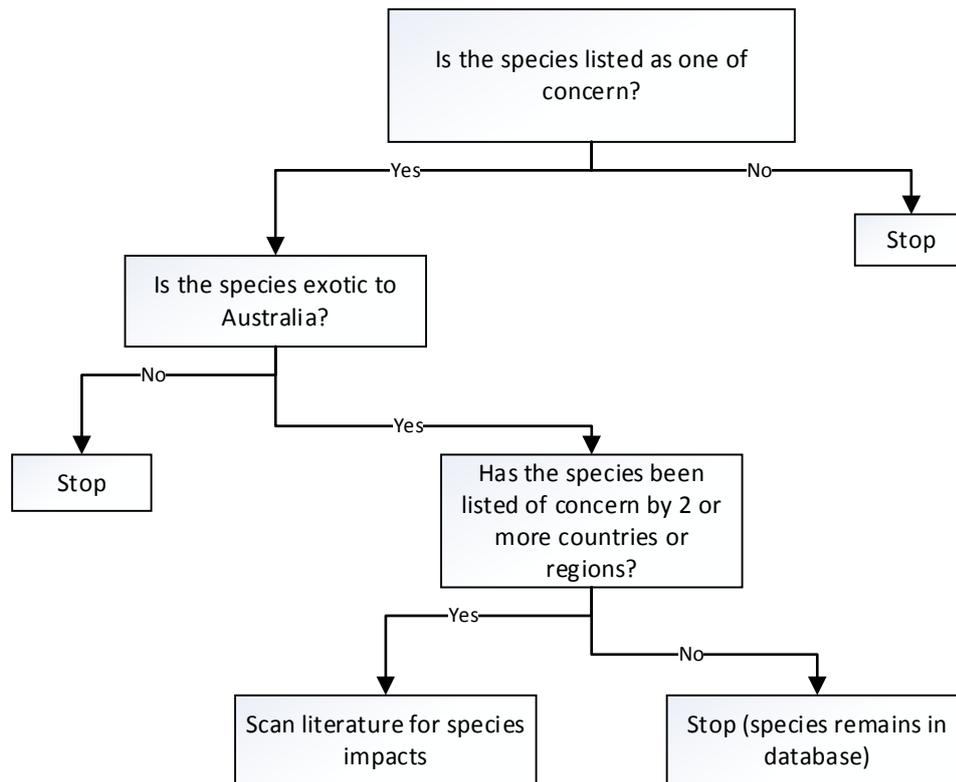


Approach

The process to identify exotic invasive species with environmental impacts involved three steps (Figure 3):

1. Identifying invasive species and species of concern. Species were identified by compiling lists of invasive species and species listed of concern from Australian, global (for example, global databases of invasive species), country and region lists (for example, Europe, Asia Pacific) and scientific literature.
2. Checking the presence/status of each species in Australia.
3. Identifying the potential impacts of exotic species (for the purpose of this report, only those species listed on two or more country/region lists).

Figure 3 Approach to identifying exotic species with environmental impacts



Identifying invasive species

Horizon scanning

To compile a database of invasive species, horizon scanning was used to identify invasive species. Horizon scanning is most often based on desktop research, helping to develop the big picture behind the issues to be examined (OECD 2016). For invasive species, horizon scanning can help prioritisation of preventative measures, surveillance of possible entry pathways and provide information on early response if prevention fails and the species appears in the area (Roy et al. 2015). The research involves examining a wide variety of sources such as databases, government data, scientific journals and literature reports, books and grey literature.

Global scanning of invasive species

Climatic suitability is deemed an important factor in the likelihood of a species establishing in a new area or region (Forsyth et al. 2004; Hayes & Barry 2008; Kumschick & Richardson 2013). However, as Australia is a continent with diverse climates, ABARES has sourced information from countries across a range of climatic regions.

To enable a global overview of invasive species and those listed as species of concern, the focus was on the following:

- Species listed as invasive in global databases
 - Assumption: Species assessed by an expert panel as global problems are species of concern
- Species listed as invasive or of concern by countries as well as regions (for example, Europe, Asia-Pacific)

- Assumption: Given the global nature of trade and transport, invasive species from all regions of the world were considered a potential risk. Australia has strict legislation and controls for the import of products. The increase in the movement of trade and transport between countries is a key risk factor to the movement of invasive species. Arrivals of species as contaminants and as stowaways may also increase with trade.

For this project, species listed as invasive or as a concern by other countries and regions were identified as:

- species already causing harm in the specific country or region
- 'unwanted' species absent in the country or region.

For species listed as invasive by countries, these species were often listed in national legislation. Species listed in national legislation are presumed to have been assessed as those causing significant impacts in the country or those posing a significant threat to the country and that warrant control. Species listed in national legislation were an important source of information when compiling the database of species for this project. All international sources identifying species of concern compiled for this project are listed in Table 1. Information compiled from Australian lists of exotic invasive species of concern are at Table 2. Appendix B provides details on all sources of information used.

Species identified from all sources (Australian and international) were compiled and added to a master database (separated into groups of plants, vertebrates and invertebrates) for further analysis and assessment.

Table 1 International sources with listed species of concern, by region

Region	Country/Region	Source	Invertebrates	Plants	Vertebrates
Africa	South Africa	National list of IAS	Yes	Yes	Yes
Americas	Central America – Mexico	CONABIO	Yes	Yes	Yes
	North America – Canada	CBCN	-	Yes	-
		CFIA	Yes	Yes	-
		Environment Canada	Yes	Yes	Yes
		Province lists	-	Yes	-
Weed seed order	-	Yes	-		
North America – United States	Noxious Weed List	-	Yes	-	
	UC Davis	Yes	Yes	Yes	
South America – Brazil	I3N	Yes	Yes	Yes	
Asia	Asia-Pacific	APASD	Yes	Yes	Yes
	China	Xu et al. 2012	Yes	Yes	Yes
	Indonesia	Setyawati (2013)	-	Yes	-
		Tjitrosoedirdjo (2005)	-	Yes	-
Japan	Japan MoE	Yes	Yes	Yes	
	Japan NIES	Yes	-	-	
Europe	Europe	DAISIE 100 Worst	Yes	Yes	Yes
	United Kingdom	WCA	-	Yes	Yes
Global	Global	CABI compendium	Yes	-	-
		GISD	Yes	Yes	Yes
Oceania	New Zealand	Country Freedom	Yes	-	-
		DOC	-	-	Yes
		Notifiable	Yes	Yes	-
	Unwanted	-	Yes	Yes	
Papua New Guinea	Kiapranis & Banka (n.d.) Gehrke (2013)	- -	Yes -	- Yes	

Note: Detailed information on sources can be found in Appendix B. **CABI** Centre for Agriculture and Biosciences International. **CBCN** Canadian Botanical Conservation Network. **CFIA** Canadian Food Inspection Agency. **CONABIO** National Commission for the Knowledge and Use of Biodiversity. **DAISIE** Delivering Alien Invasive Species Inventories for Europe. **DOC** Department of Conservation. **GISD** Global Invasive Species Database. **i3N** IABIN Invasive Information Network. **IAS** Invasive alien species. **IASPP** Invasive Alien Species Partnership Program. **MoE** Ministry of the Environment. **NIES** National Institute for Environmental Studies. **UC** University of California. **UK WCA** United Kingdom Wildlife and Countryside Act.

Table 2 Australian lists and databases of species of concern

Category	Australian lists/processes
Invertebrates	National priority plant pests 2016 (Department of Agriculture and Water Resources 2016c) <i>Forests and timber: a field guide to exotic pests and diseases</i> (Department of Agriculture Fisheries and Forestry 2000)
Plants	<i>Northern Australian Quarantine Strategy: Weeds Target List</i> (Brown, Johnson & Raphael 2008) Exotic Weeds Watch List (Department of Agriculture and Water Resources 2015) Prohibited weeds list (Department of Agriculture and Water Resources 2016f) and Quarantine Proclamation 1998 Schedule 4 Part 2 – Plants that are quarantinable pests (Department of Agriculture and Water Resources 2016g) Example list of exotic weeds of trade concern (Department of Agriculture and Water Resources unpublished)
Vertebrates	<i>List of Exotic Vertebrate Animals in Australia</i> (Vertebrate Pest Committee 2007) <i>Detecting and preventing new incursions of exotic animals in Australia</i> (Henderson and Bomford 2011)

Checking species status and presence in Australia

Each species added to the database was checked for its current status (exotic or present) in Australia. Status was based on information in publicly accessible databases and literature (Table 3). However, the extent of a species presence in Australia, whether widespread or restricted, has not been quantified.

A number of rules were applied to determine species presence across all plants, vertebrates and invertebrates:

- If presence of a species could not be confirmed from the sources listed (Table 3), a high-level search of the literature was performed. If no further information could be found on presence within Australia, it was assumed that the species was exotic.
- Species kept in contained environments (for example, zoos and botanic garden collections) were considered exotic if no wild populations existed.
- Species that were listed as present in Australia's external territories and islands (for example, Christmas Island) but not recorded as present on the mainland were considered exotic.
- Any species under an eradication campaign in Australia at the time of compiling this report were also considered exotic.

For plants additional rules were applied:

- A species was classed as 'exotic' if records in the Australasian Virtual Herbarium were limited (for example, one or two records) and these records predated 1980.
- A species was classed as 'present' if it was listed on the Department of Agriculture and Water Resources permitted seeds list.
- Aquatic species were considered 'exotic' if it was unclear whether the species could be purchased or traded in Australia and there was no evidence to suggest that the species had escaped cultivation. A note was applied to these species to flag their status.

Table 3 Sources of information for species status in Australia

Category	Resource
Invertebrates	Australian Faunal Directory (ABRS 2009)
	Atlas of Living Australia (ALA 2016)
	PaDIL website (PaDIL n.d.)
	Entomology AICN Checklist (CSIRO 2004)
Plants	<i>The introduced flora of Australia and its weed status</i> (Randall 2007)
	Australasian virtual herbarium (AVH 2016)
	Permitted Seeds List (Department of Agriculture and Water Resources 2016d)
	AusGrass2 (Simon & Alfonso 2011)
	FloraBase—the Western Australian Flora (Western Australian Herbarium 1998)
	Australian Plant Census IBIS database (Council of Heads of Australasian Herbaria 2017)
	PlantNET (Royal Botanic Gardens and Domain Trust n.d.)
Vertebrates	Australian Faunal Directory (ABRS 2009)
	Atlas of Living Australia (ALA 2016)

Identification of impacts

The IGAB defines a pest or disease of national significance as ‘one that would be likely to have far-reaching and/or national impacts’ (Council of Australian Governments 2012). To be considered nationally significant, a pest or disease must be considered to have the potential to cause a significant impact at a national level on at least one of the following:

- international market access and/or trade
- the economic health of the nation
- human health
- the natural environment and ecosystems
- substantial damage to or deterioration of infrastructure used by a significant proportion of people over an extensive area
- amenity of resources, such as public lands, and that has the potential to affect more than one state/territory

or

- Australian culture, cultural assets, practice or custom or national image (National Biosecurity Committee 2016).

For the purpose of this report, impacts were condensed into three themes:

- agriculture—market access and economy, including impacts on the forestry and fishery industries
- environment
- social—infrastructure, human health, amenity of resources; culture and practice and custom.

An in-depth analysis of impacts was not performed. However, a high-level scan of literature was conducted to obtain a general understanding of the impacts. For the purpose of this report, only species on two or more country/region/global lists were checked for their impacts. This was undertaken for two reasons. Firstly, it is assumed that species that have been identified as invasive by several countries or regions have invasive characteristics that enable their success in a variety of habitats and environments that warrant their concern. Secondly, adopting this method enabled a more manageable analysis. Impacts for species on only one list may be performed at a later stage. Impacts for each species were based on evidence of these impacts overseas. No further analysis has been undertaken on the likelihood of these impacts occurring in Australia because it is outside the scope of this project.

To ascertain species impact, an online search was conducted on each species, using the following search terms 'Species name and impact' and 'Species name and invasive'. If insufficient information was provided, the search terms were expanded to 'Species name and environmental impact', 'Species name and agricultural impact', 'Species name and social impact' or 'Species name and human health impact' as necessary. More detailed search terms were used if information on impacts was difficult to obtain. Information on impacts was derived from the literature (such as peer-reviewed journals) by searching Web of Science, Google Scholar and validated online databases such as the Invasive Species Compendium (CABI) and the Global Invasive Species Database (GISD), as well as country databases and risk assessments. If no information was available from these sources, grey literature and other web resources were used. Impacts were only recorded if there was evidence in the literature of documented impacts for the species. If no information could be sourced on impacts, this was recorded as 'Insufficient information'.

3 Results

The database produced by this project contains a large number of species identified as invasive or as species of concern around the world. This information was sourced from a range of geographic regions: Africa, Asia (including South-East Asia), Americas (North America, Central and South America), Europe and Oceania. Global databases were also included to provide an understanding of species that are considered the highest risk globally. There are omissions, such as India. The database is intended to be dynamic and updated as required. The database is not to be considered an official list of species because the data has not been confirmed by experts and is based solely on publicly sourced information.

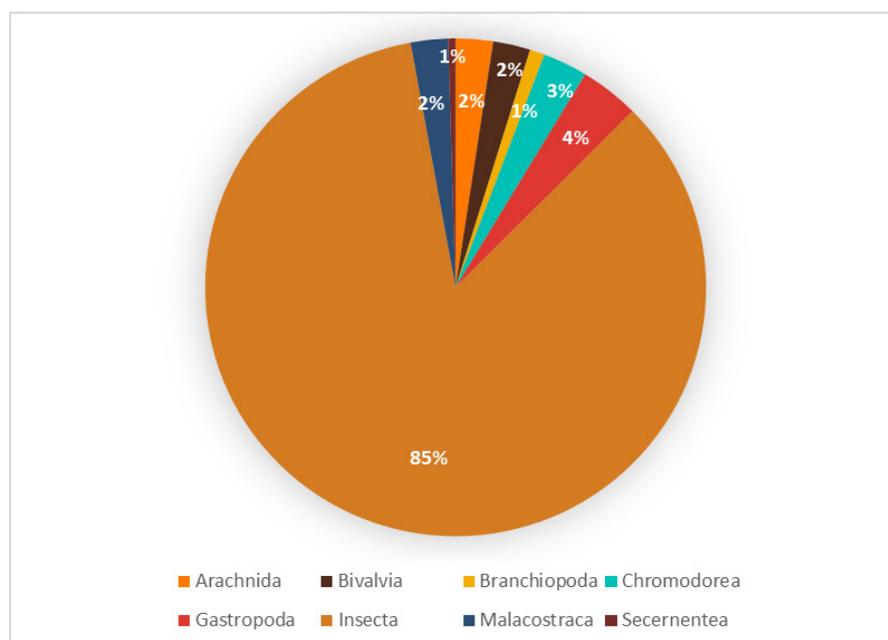
The results presented in this report are based on species identified as exotic and present on two or more country/region lists of concern as at July 2017. Information on impacts were gained through a literature scan of species impacts overseas. The results presented here are indicative only because a detailed consideration of the impacts of these species and their potential impact in Australia is required by risk assessment.

Invertebrates

Data was compiled from 17 lists of invertebrate invasive species from 11 countries/regions of the world and on global databases. Approximately 815 species were exotic to Australia. The analysis was reduced to 208 species that were exotic and were present on two or more country/region lists.

The 208 species were mostly of the class Insecta (85 per cent, Figure 4) and comprised 87 taxonomic families. Species belonging to the family Tephritidae (fruit flies) were the most common, representing 18 per cent of the resultant list, followed by Curculionidae (true weevils), with 8 per cent of species from this family.

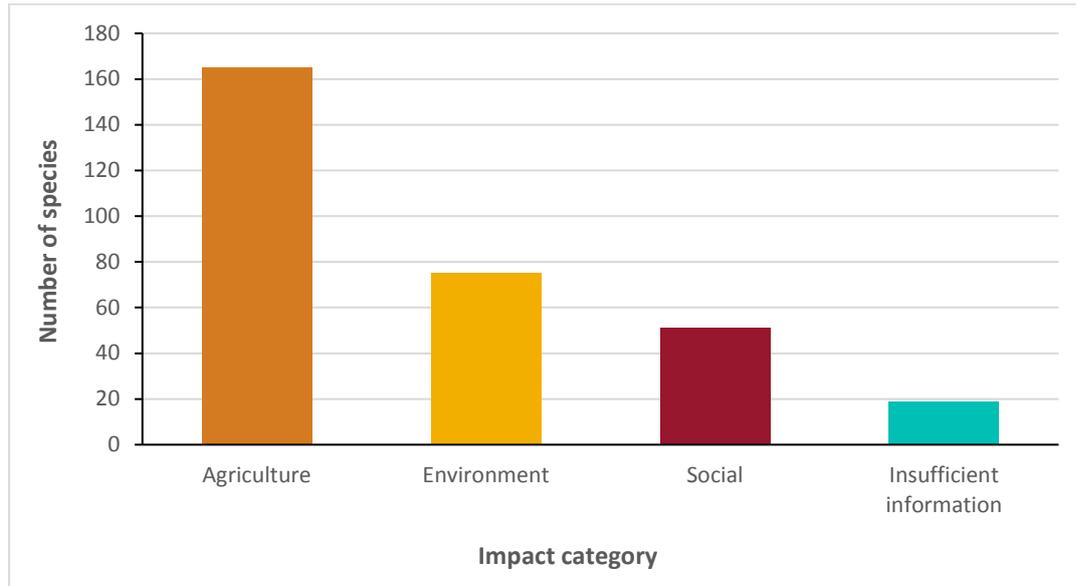
Figure 4 Proportion of invertebrate species exotic to Australia, by taxonomic class



Impacts

A high-level analysis of species impacts was performed by a literature scan of the 208 species. Species were found to have an impact on either one or multiple impact categories. Of the 208 species, 79 per cent (165 species) had an agricultural impact, 36 per cent (75 species) had an environmental impact, 25 per cent (51 species) had a social impact. Insufficient information was available for 9 per cent (19 species) of species and therefore their impacts could not be determined (Figure 5).

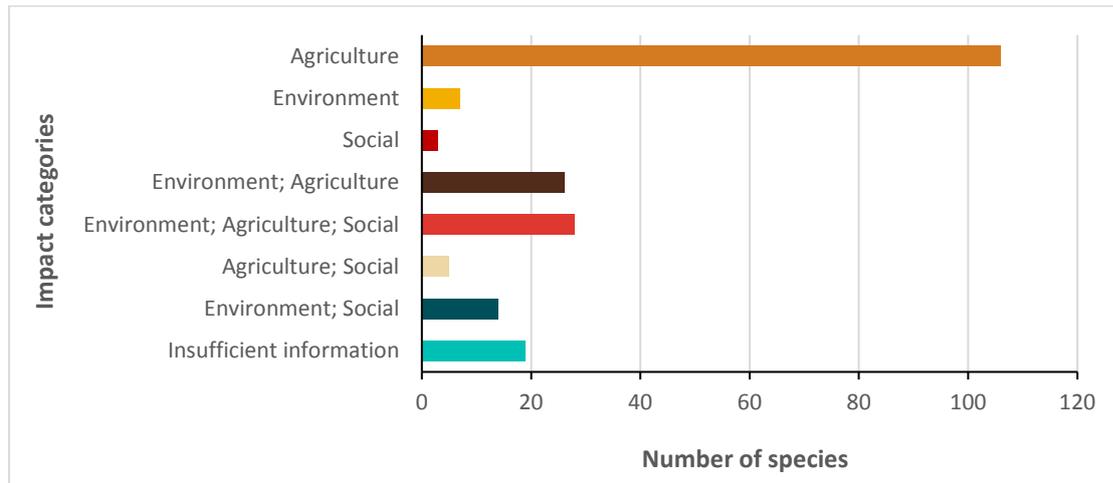
Figure 5 Number of invertebrate species exotic to Australia with documented environment, agriculture or social impacts



Note: Data was compiled from scanning literature on the impact of species in their overseas range. An assessment of potential impacts of these species in Australia has not been performed.

Approximately half of the exotic species (56 per cent) were documented to have an impact on only a single category—either agriculture, environment or social (Figure 6). The majority of species were documented to have an impact on agriculture only (51 per cent). Only 21 species (10 per cent) were documented to pose a threat to the environment only or had both environment and social impacts. Of these, the orders Coleoptera (beetles) and Hymenoptera (ants, bees and wasps) were the most represented, with four species each having environmental impacts, followed by Decapoda (crayfish) and Veneroida (mussels) with three species each.

Figure 6 Number of invertebrate species with specific impacts



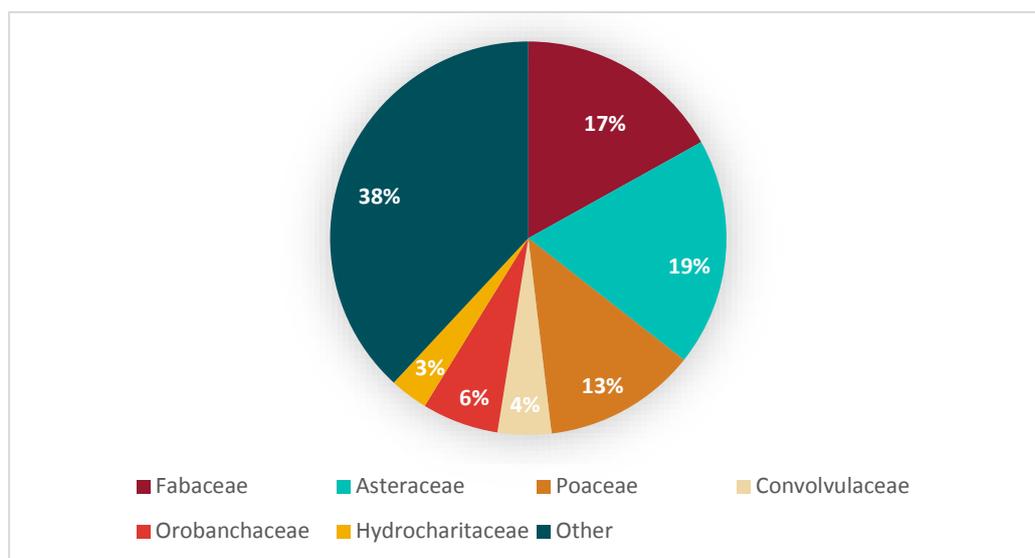
Note: Data was compiled from scanning literature on the impact of species overseas. An assessment of potential impacts of these species in Australia has not been performed.

Plants

A total of 35 lists of invasive plants were collated, representing species of importance for 12 countries, two regions (Europe and Asia) and on global databases. This resulted in approximately 430 species exotic to Australia. Due to the large number of exotic species, further examination was performed for those species on the lists of two or more countries/geographic regions. This resulted in more detailed analysis being performed on 160 species—the results presented in this section refer to these species.

The 160 plant species were from 44 different families. The Asteraceae (widespread flowering plants, often referred to as daisies, and sunflowers), Fabaceae (legumes) and Poaceae (grass) families were highly represented, comprising 48 per cent of all exotic taxa (Figure 7). The Fabaceae family was largely represented by *Prosopis* spp. (Mesquite), with 23 out of the 27 species of Fabaceae belonging to this genus.

Figure 7 Proportion of plant species exotic to Australia, by family

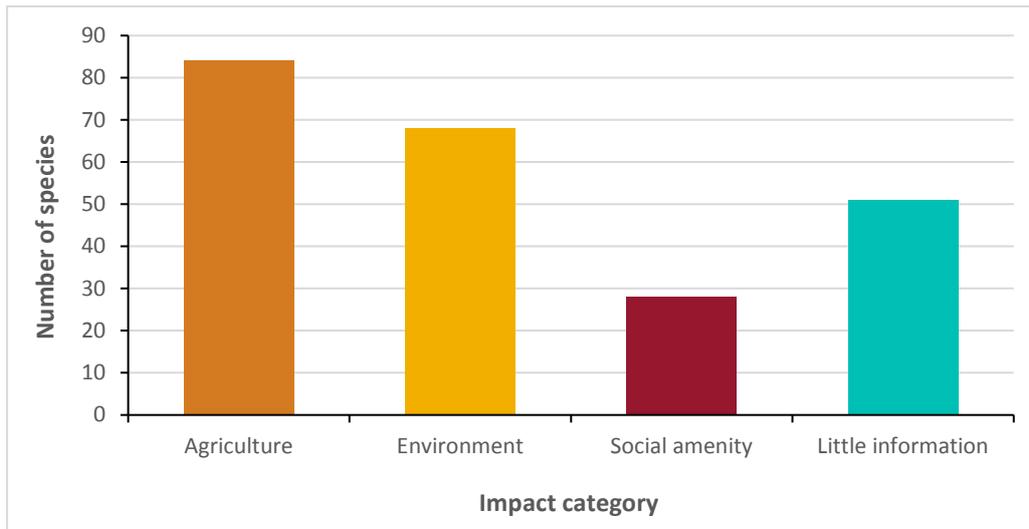


Note: Families are those with five or more species. The category 'other' comprises multiple families with four species or less per family.

Impacts

Species impacts were ascertained through a literature scan. Species were found to have an impact on either one or multiple impact categories. Of the 160 species, documented information indicated that 53 per cent (84 species) had an agricultural impact, 43 per cent (68 species) had an environmental impact, 18 per cent (28 species) had a social impact and for 32 per cent (51 species) their impacts could not be determined (Figure 8). ABARES was unable to find documented evidence of impacts for 21 of the 23 species of Mesquite (*Fabaceae* family) exotic to Australia.

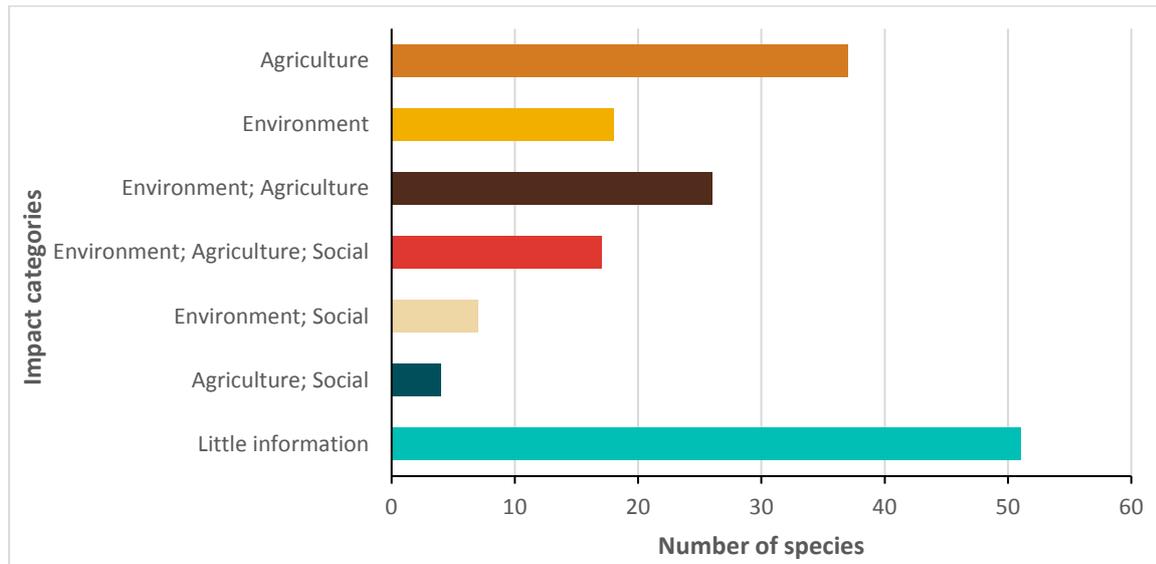
Figure 8 Number of plant species with documented environment, agriculture or social impacts, outside Australia



Note: Data was compiled from scanning literature on the impact of species in their overseas range. An assessment of potential impacts of these species in Australia has not been performed.

ABARES examined the data for specific impacts of a species to clarify whether, for example, impacts were recorded for the environment only or across both agriculture and the environment (Figure 9). This revealed that impacts only on agriculture accounted for 23 per cent of species, and impacts only on environment accounted for 11 per cent of species. Of the 160 species, 23 were aquatic weeds. Of these, 19 species had documented impacts on the environment, but insufficient information was available on the impacts of four other species.

Figure 9 Number of plant species with specific impacts, outside Australia

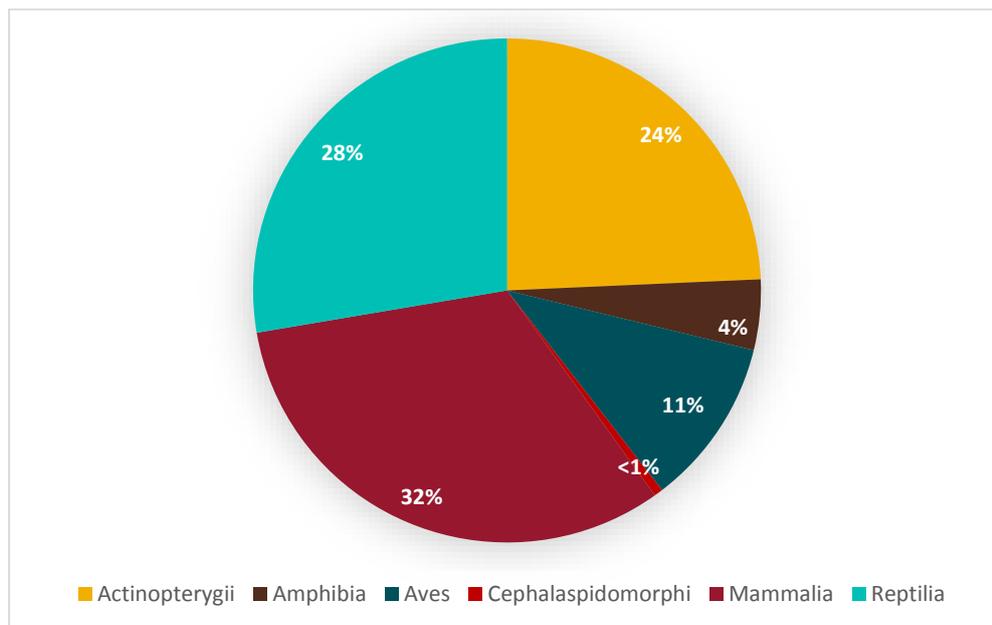


Note: Data was compiled from scanning literature on the impact of species in their overseas range. An assessment of potential impacts of these species in Australia has not been performed.

Vertebrates

Data was compiled from 16 lists across 13 countries/regions and globally. Approximately 800 species were exotic to Australia. Due to the large number of exotic species, 177 species that were exotic and appeared on two or more country/region lists were selected for further analysis. The resultant list comprised species from six classes and 75 families of vertebrates (Figure 10). The classes Mammalia (mammals) and Reptilia (reptiles) represented the highest number of exotic species on the database.

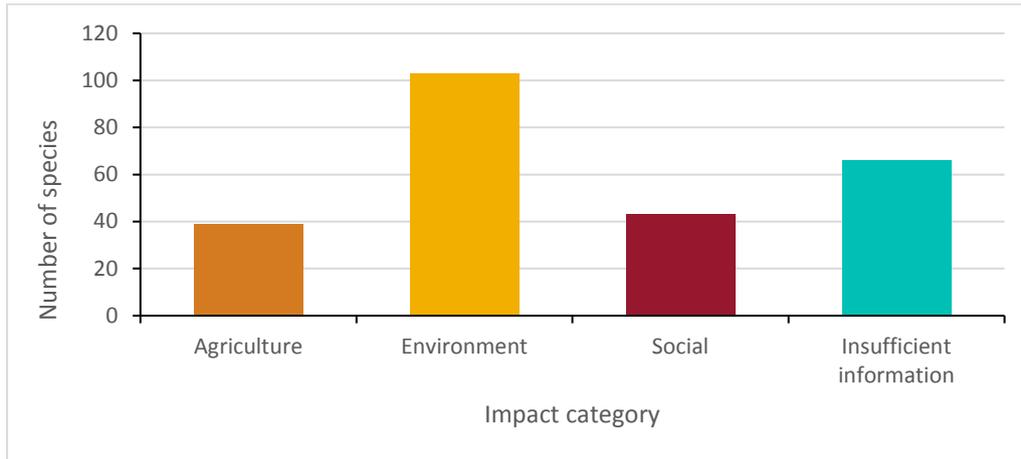
Figure 10 Proportion of vertebrate species exotic to Australia, by taxonomic class



Impacts

A high-level analysis of species impacts was performed by a literature scan of the 177 species. Species were found to have an impact on either one or multiple impact categories. Of the 177 species, 22 per cent (39 species) were documented to have an agricultural impact, 58 per cent (103 species) were recorded to have environmental impact, 24 per cent (43 species) had a social impact. Insufficient information was available for 37 per cent (66 species) and therefore impacts for these species could not be determined (Figure 11).

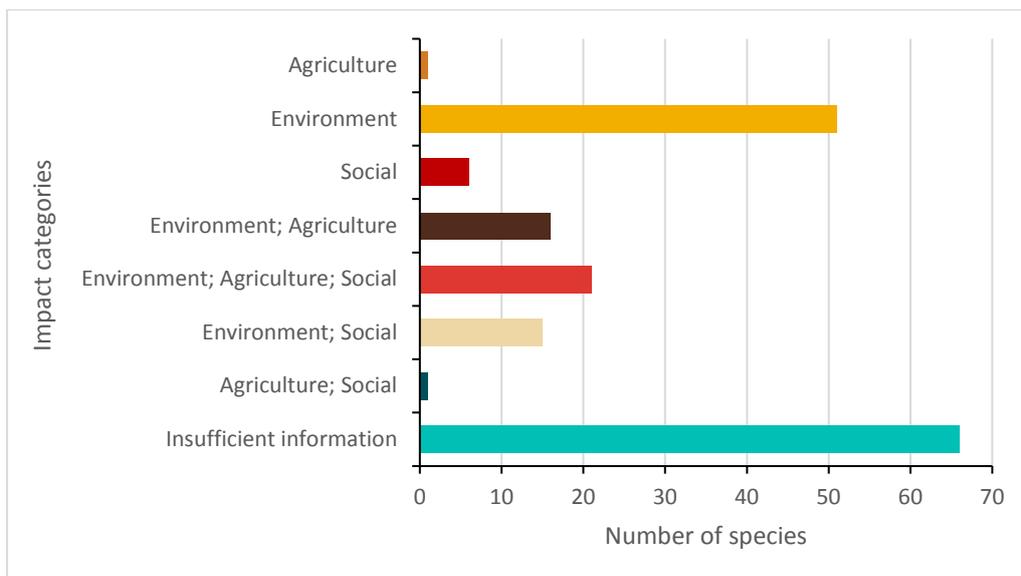
Figure 11 Number of vertebrate species with documented environment, agriculture and social impacts, outside Australia



Note: Data was compiled from scanning literature on the impact of species in their overseas range. An assessment of potential impacts of these species in Australia has not been performed.

ABARES examined the data on the specific impacts of a species to clarify whether, for example, impacts were only recorded for environment or across agriculture and environment (Figure 12). Approximately 29 per cent of species had an impact on the environment only, but 12 per cent (21 species) had an impact on all three categories.

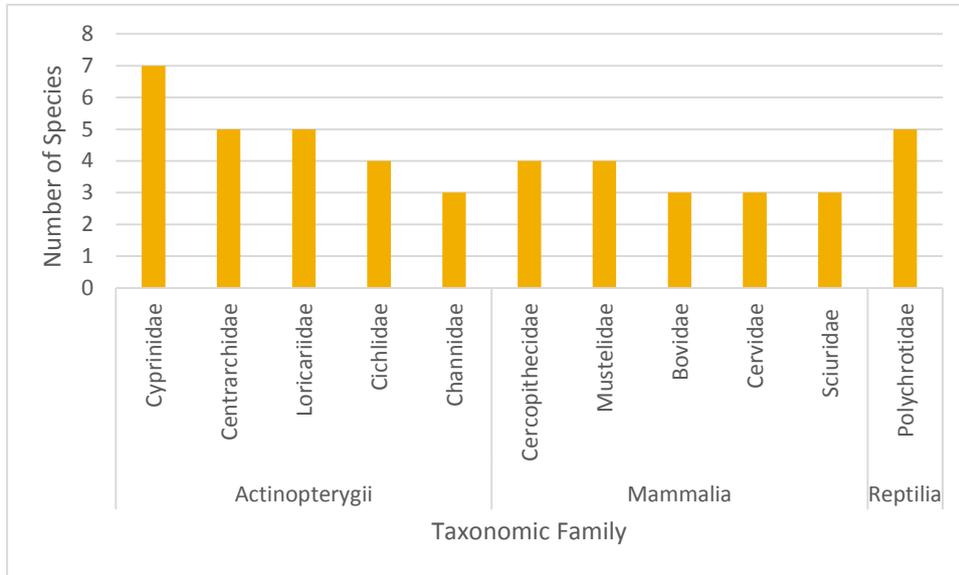
Figure 12 Number of vertebrate species with specific impacts, outside Australia



Note: Data was compiled from scanning literature on the impact of species in their overseas range. An assessment of potential impacts of these species in Australia has not been performed.

The numbers of species in each family that had an impact on the environment were also assessed. A total of 57 families were found to have species with environmental impacts. Figure 13 shows the top families (three or more species) that have environmental impacts. The Cyprinidae family had the highest number of species with environmental impacts, with a total of seven species.

Figure 13 Top vertebrate families with documented environmental impacts, by number of species, outside Australia



Note: Cyprinidae (carp), Centrarchidae (sunfish), Loricariidae (catfish), Cichlidae (cichlid fish), Channidae (snakeheads) Cercopithecidae (Old World monkeys), Mustelidae (carnivorous mammals such as weasels, stoats), Bovidae (cloven-hoofed, ruminant mammals), Cervidae (deer), Sciuridae (squirrels), Polychrotidae (iguana lizards). Data was compiled from scanning literature on the impact of species in their overseas range. An assessment of potential impacts of these species in Australia has not been performed.

4 Discussion

Preventing the entry of invasive species is considered the most cost-effective way to manage the risk they pose (Department of Primary Industries 2010). Australia's strong quarantine system facilitates the import and export of goods while mitigating the risks of introducing harmful pests and diseases. However, no risk is ever reduced to zero, so from time to time, incursions of exotic species may occur.

The focus on identifying the most harmful invasive species is promoted internationally and is a primary goal of Aichi Biodiversity Target 9: invasive alien species and their pathways are identified and prioritised (Convention on Biological Diversity 2010). The convention recognises that it is necessary to prioritise efforts to manage those species with the greatest impacts. This project, the identification of invasive species of environmental concern, is the first step in a proposed framework for the prioritisation of invasive species (Figure 1). The project has produced a database of exotic plants, vertebrates and invertebrates that potentially pose a threat to Australia's environment. It provides an indication of the pool of exotic species that have the potential to impact on Australia's environment.

In developing the database of species, ABARES considered that species listed as invasive or of concern in other countries or regions were important factors for a species to be a threat to Australia. At July 2017 the database of exotic species contained approximately 430 plant, 800 vertebrate and 815 invertebrate species that have been identified of concern across the globe. Of these, 160 plant, 177 vertebrates and 208 invertebrates exotic to Australia and present on two or more country/region lists were further investigated for their impacts. Only a high-level scan of impacts was conducted for the purposes of this report. However, a more detailed risk assessment of these species is required to determine their potential impact in Australia.

The impacts of plants were largely across both agriculture and the environment, with 43 per cent of species having some impact on the environment. For many plant species, their impacts could not be determined. This may be due to the species having invasive congeners—for example, *Prosopis* spp. (mesquite)—where all species of the genus are prohibited entry to a country, regardless of the individual species impacts. Although a large number of vertebrates were recorded as invasive, insufficient information was available on the impact of just under half of the total. Of those vertebrate species where impacts could be determined, 58 per cent were found to have an impact on the environment.

The plant pest prioritisation process (PHC 2015) considers impacts of plant pests on the environment (plants) and social amenity. However, invertebrates were examined in this study to determine those that impact primarily on biodiversity, such as on native invertebrates, to address a potential gap. The majority of invertebrates documented as invasive had impacts on agriculture (79 per cent), with 36 per cent of the species having at least some impact on the environment. There were very few invasive invertebrates that were identified that impact either only on the environment or had environment and social impacts (10 per cent). Freshwater invertebrates accounted for around half of the invertebrate species determined to impact solely the environment or had environment and social impacts. Species from the orders Coleoptera (beetles), Hymenoptera (wasps and ants), Decapoda (crayfish) and Veneroida (mussels) were the most represented invertebrates with solely an environmental or a combined environmental and social impact.

Many of the species listed as exotic and invasive may not be a threat to Australia under current settings because they are unlikely to enter Australia. Australia's risk-based quarantine system

prohibits the import of species that pose an unacceptable risk to the environment and economy. Therefore, the most likely pathways for exotic species to arrive may be unintentional, such as contaminants of produce (for example, seeds) or hitchhikers (for example, stowaways in vessels). For vertebrate pests, stowaways pose the highest risk of exotic species entering and then potentially establishing in Australia (Henderson, Bomford & Cassey 2011). Reptiles are the most commonly intercepted stowaways, followed by amphibians and birds.

Illegal importation is another introduction pathway for exotic species, for example, imports of prized ornamental plants or animals. Data on illegal imports of vertebrates between 1999 and 2010 show that birds, reptiles and fish were the most commonly identified species at Australia's border (Henderson & Bomford 2011). Illegal imports of parrots are commonly intercepted. Parrots (family Psittacidae) are listed by Bomford (2008) as one of the high-risk families that are likely to hybridise with native species. Data from stowaways and illegal imports combined could suggest that reptiles, amphibians and birds are the most likely vertebrates to arrive in Australia. A review of the likely pathway of entry for species in the database will need to be undertaken as part of any prioritisation process.

The database produced by this project adds to the awareness of the potential threat to Australia of exotic invasive species. There are many concurrent processes across the biosecurity sector to identify priority exotic species (marine pests, plant pests and animal diseases). Therefore, the review focused on areas where there were potential knowledge gaps: vertebrate pests, weeds and invertebrate pests with environmental impacts. Notably the review has not focused on freshwater algae. The freshwater algae *Didymosphenia geminata* has been listed as a threat by many countries worldwide. There is scope for freshwater algae to be considered in the database in the future.

This SBQI-funded project supports future strategic planning and policy on invasive species that could have nationally significant impacts on the environment should there be an incursion. The work presented here is step one of a proposed broader framework for identifying exotic species. The next phase is to prioritise species on the database and then undertake threat assessments to determine which species that are the greatest threat to Australia's environment (an assessment of likelihood of entry (pathway analysis), establishment and impact). A threat prioritisation process has been developed for plants (Parsons et al. forthcoming). However, it will require refinement for vertebrates and invertebrates based on differences in biology and invasive characteristics.

Appendix A: Prioritisation processes in Australia

A number of existing and new processes are aimed at prioritising species of national significance across the biosecurity spectrum. This report has concentrated on weeds, vertebrate pests and invertebrates with potential environmental impacts. These areas represent a gap in our knowledge that has not been covered in the processes described in this appendix. Here we provide a brief overview of the prioritisation processes in other sectors, which were out of scope for this project.

Marine pests

The Australian Priority Marine Pest List working group, established by the Marine Pest Sectoral Committee is developing a process to determine marine pests of national significance. The outcome of this process is a list of priority marine pests of national significance (MPSC 2017).

Plant pests and diseases

Plant pests include fungi, rusts, diseases and invertebrate pests that impact plants. The scope of the Plant Health Committee is plant pests that impact agricultural industries and the environment. Pests include terrestrial or freshwater herbivorous invertebrates that are pollinators, parasites or parasitoids of plants, vectors of plant pathogens, or that impact on social amenity (Department of Agriculture and Water Resources 2016e). The Plant Health Committee endorsed a framework for prioritising plant pests of national significance (PHC 2015). The committee has endorsed a list of 'top 40' national priority plant pests. Although the list contains a large number of plant pests with agricultural impacts, plant pests with impacts on the environment and social amenity are included, for example, tramp ants and phytophthora.

The Emergency Plant Pest Response Deed includes three plant pests that have been categorised as Category 1 emergency plant pests. These are plant pests:

- that predominately cause major environmental damage to natural ecosystems and/or
- potentially affect human health or cause a major nuisance to humans and/or
- cause significant damage to amenity flora, with little impact on agricultural production.

Animal diseases

The national list of notifiable animal diseases is agreed by the Animal Health Committee based on the list of Diseases Notifiable to the OIE (World Organisation for Animal Health). The majority of these diseases are exotic to Australia. However, for surveillance purposes, the list includes endemic diseases to help detect unusual incidents involving mortality or sickness of animals and diseases of public health significance (Department of Agriculture and Water Resources 2016b). Most of the notifiable diseases are a major threat to Australian livestock industries and access to overseas export markets.

The Emergency Animal Disease Response Agreement includes five diseases that have been categorised as Category 1 emergency animal diseases. These are diseases that predominantly seriously affect human health and/or the environment (depletion of native fauna).

Wildlife Health Australia provides information on exotic diseases of concern to Australia that can affect wildlife or where wildlife are involved in the ecology of the disease (Wildlife Health Australia 2016).

Aquatic animal diseases

The national list of notifiable aquatic animal diseases is agreed by the Animal Health Committee. All states and territories are responsible for disease surveillance within their jurisdiction, and they ensure their reporting is in line with the national notifiable list (Department of Agriculture and Water Resources 2016a).

Appendix B: Sources of information

International sources

Global

Global Invasive Species Database (GISD)

Data from the Global Invasive Species Database (GISD) (Invasive Species Specialist Group 2015) covers all taxonomic groups of alien and invasive species that have a negative impact on biodiversity (GISD 2016). The database is managed by the Invasive Species Specialist Group (ISSG) of the IUCN Species Survival Commission. Species on the GISD were compiled through consultation with experts and analysis of available data.

Invasive Species Compendium (CABI)

The Invasive Species Compendium (CABI 2016) comprises datasheets on invasive species. The datasheets are edited by CABI's scientific staff, peer reviewed and supported by data from specialist organisations.

South Africa

Department of Environmental Affairs, Republic of South Africa

The department published the Alien and Invasive Species Regulations in August 2014, listing 559 alien invasive species in four different categories. A further 560 species are listed as prohibited. The regulations include vertebrates (mammals, birds, fish, amphibians and reptiles), invertebrates and terrestrial and freshwater plants listed under the National Environmental Management: Biodiversity Act (10/2004) (Department of Environmental Affairs 2014).

Mexico

The Mexican National Commission for the Knowledge and Use of Biodiversity (CONABIO 2015) maintains a database of invasive species of Mexico, 'Especies exóticas invasoras' (CONABIO 2016). This database includes plants, algae, invertebrates, fish, amphibians, reptiles, birds and mammals.

Canada

Canadian Invasive Alien Species Partnership Program

The Canadian Government's Invasive Alien Species Strategy supported prevention activities for invasive plants, vertebrates and invertebrates (Environment Canada 2012). This included funding \$5 million for the Invasive Alien Species Partnership Program (IASPP). The IASPP funded 141 projects targeting 277 identified invasive alien species. It focused primarily on education and awareness to prevent introductions and spread.

List of pests regulated by Canada

The Canadian Government's Food Inspection Agency (CFIA) is responsible for mitigating risks relating to food safety in Canada (Canadian Food Inspection Agency 2016a). The CFIA also conducts work on maintaining environmental biodiversity by highlighting the risks associated with invasive animal and plant diseases and plant pests. The CFIA maintain a list of pests regulated by Canada. This includes a list of insect, fungus, nematode, mollusc, virus, phytoplasma and plant species that are regulated under the Plant Protection Act. Details on how the list was compiled are not known.

Canadian Botanical Conservation Network

The network prepared a list of invasive plants found in Canada. The list includes a description of each species and control methods for small-scale invasions (Canadian Botanical Conservation Network 1997). It was compiled to increase public knowledge of the dangers of invasive species. The list includes 84 species of trees, shrubs, grasses and herbaceous plants and indicates where each species can be found in Canada.

Weed Seeds Order, Canada

The Weed Seeds Order is enabled by the Seed Order Act 2005 which oversees the creation of a database of seeds from species considered weeds by the Canadian Government (Canadian Food Inspection Agency 2016b). Seeds are grouped into different classes according to the threat they represent if imported into the country (Classes 1–5). The details of how this list was compiled are unknown. The Weed Seeds Order is published by the Minister of Justice.

Canadian province lists

Canadian province noxious weed lists for the provinces of Alberta, British Columbia, Saskatchewan were sourced from the 'State and Province Noxious Weeds Lists' (Center for Invasive Species Management 2014). The noxious weed list for Quebec was regulated by the Agricultural Abuses Act (Gouvernement du Quebec n.d.), the noxious weed list for Manitoba was sourced from the Government of Manitoba (n.d.), invasive plants for Yukon were sourced from Environment Yukon (2015) and the noxious weed list for Nova Scotia is regulated by the Agricultural Weed Control Act (Government of Nova Scotia n.d.).

United States

United States Noxious Weed List

The Federal Noxious Weed Act of 1974 enacted in January 1975 established a program aimed at managing noxious weeds in the United States. The authority to designate plant species as noxious was delegated to the United States Secretary of Agriculture and allowed for the inspection, seizing and destruction of produce or property in order to limit the spread of such species. The list is composed of terrestrial, marine and aquatic plant species and is hosted on the US Department of Agriculture website (US Department of Agriculture 2010).

California Invasive Species Advisory Committee

The committee's invasive species list includes 1,700 species and over 200 scorecards of some of the worst species (California Invasive Species Advisory Committee n.d.). The list of species that could potentially threaten the state was compiled by the advisory committee. This list is not regulatory.

Brazil

The I3N thematic network on invasive alien species is part of the Inter-American Biodiversity Information Network (IABIN). The Brazil National Invasive Alien Species Database only lists species already present in the country (I3N Brazil Invasive Alien Species Database n.d.).

Species are included in the database if they:

- are present in Brazil
- have a history of invasion in Brazil or elsewhere, usually in climatic conditions that favour their adaptation to a climate type in the country.

There may be exceptions for species that have many traits common to invasive alien species but still do not express invasiveness and are considered of high risk to Brazilian biodiversity.

Asia

Asian-Pacific Alien Species Database

The database is managed by the National Institute for Agro-Environmental Sciences of Japan. This database was created in 2004 to establish countermeasures to prevent the invasion and spread of invasive alien species and minimise potential economic and environmental damage (National Institute for Agro-Environmental Sciences 2007). Representatives from a number of Asian-Pacific countries have contributed to this database. However, the decision-making processes behind the compilation of the invasive species on this database are not known.

China

A list of invasive alien species in China was compiled by Xu et al. (2012). The list in China includes plants, invertebrates and vertebrate pests where there is evidence of their impacts on biodiversity, human activities or the economy.

Indonesia

A list of invasive plant species in Indonesia was compiled from Setyawati (2013) and Tjitrosoedirdjo (2005). Setyawati lists 20 species considered to represent the most serious plant invaders in natural areas of the Indonesian forest. Tjitrosoedirdjo lists plant species that have been documented as important invasive plants because they are 'seriously problematic' and require control and monitoring.

Japan

Ministry of the Environment

The ministry compiled three lists:

- 1) designated invasive alien species
- 2) uncategorised alien species
- 3) living organisms requiring a certificate for importation.

These lists were integrated into the Regulated Living Organisms list as required by the Invasive Alien Species Act 2004 (Ministry of the Environment, n.d.). Each species on the list was selected by academic experts. This list was then subjected to public comment.

National Institute for Environmental Studies, Japan

This list was created and is hosted by the National Institute for Environmental Studies in the National Research and Development Agency. The list of species was compiled by consulting a variety of Japanese invasive species lists (National Institute for Environmental Studies Japan n.d.). The list contains species from a range of organism types (plants, invertebrates, vertebrates, bacteria and viruses).

Europe

United Kingdom

The Wildlife and Countryside Act 1981 is the principal legislation in the United Kingdom dealing with non-native species (GB NNSS 2016). A number of species are listed under the Act which are

prohibited for release in the United Kingdom (animals) or are prohibited for sale (plants). This list of species was last updated in 1996.

Delivering Alien Invasive Species Inventories for Europe (DAISIE)

The Delivering Alien Invasive Species Inventories for Europe (DAISIE) project (DAISIE 2003) has compiled the Alien Species Database, an inventory of invasive species that threaten European terrestrial, freshwater and marine environments. The content is the result of compiling, extending and peer reviewing several hundred national lists of species of fungi, plants, invertebrates, fish, amphibians, reptiles, birds and mammals. The DAISIE database includes 12,122 species. The database provides a top 100 list of the most widespread and/or noxious invasive species across all taxa and represents some of the worst species in terms of their impact on biodiversity, economy and health. It contains 15 vertebrates, three terrestrial fungi, 16 terrestrial invertebrates, 18 terrestrial plants, 16 aquatic inland plants/vertebrates/invertebrates and 32 marine species. ABARES included the 'top 100' species in their database.

New Zealand

Unwanted organisms

An 'unwanted organism' is defined in New Zealand in the Biosecurity Act 1993 as any organism a chief technical officer has reason to believe is capable of causing unwanted harm to natural and physical resources and/or human health (Ministry for Primary Industries n.d.). This includes organisms that the Environmental Risk Management Authority has declined approval to import or any organism specified in the Second Schedule of the Hazardous Substances and New Organisms Act 1996. The organisms in the list include vertebrates, invertebrates, plants, viruses, fungi, bacteria, prions and protozoans (Ministry for Primary Industries n.d.). ABARES did not include invertebrates from the unwanted organism list in the compilation of the database.

Biosecurity (Notifiable Organisms) 2010 Order

The Order established a schedule of organisms deemed to be 'notifiable' for the purposes of the Biosecurity Act 1993 (NZ Government, 2010). If any organism listed in the schedule is detected in New Zealand, they are to be reported immediately to the NZ Ministry for Primary Industries. Species in the schedule include invertebrates, plants, pests of vertebrates and diseases. Details of how the list was compiled are not known.

NZ Country freedom status

The NZ Country freedom status is a list of plant pest species that have had their presence or absence from New Zealand checked by ministry staff (NZ Ministry of Primary Industries 2016). This list was compiled by ministry staff, who conducted domestic and international literature searches on species to determine whether they had been present in New Zealand previously. The country freedom list enables New Zealand exports to satisfy the phytosanitary standards of some importing countries. This list includes fungi, insects, bacteria, viruses, mites and nematodes.

NZ Department of Conservation

The department has compiled a list of the animal pests that are present in New Zealand (Department of Conservation 2016). There is no indication as to the status of these species in relation to New Zealand's invasive policies.

Papua New Guinea

Invasive plants

A list of 39 invasive plants present in Papua New Guinean forests was compiled by the Papua New Guinea Forest Research Institute (Kiapranis & Banka n.d.).

Fish

A risk assessment was conducted on three fish species of concern in Papua New Guinea (Gehrke 2013).

Australian lists and processes

Invertebrates

Forests and timber: a field guide to exotic pests and diseases

The purpose of the guide was to provide basic information relating to some of the high-risk exotic pests and diseases of forestry and amenity trees and imported timber industries (Department of Agriculture, Fisheries and Forestry 2000). It was created to help wharf workers, container depot staff, timber handlers, timber yard workers, forest workers and forest technical staff identify relevant pests and diseases affecting these industries. The list contains species of invertebrate pests and fungal pathogens (Department of Agriculture, Fisheries and Forestry 2000).

National priority plant pests

The Plant Health Committee (PHC 2015) endorsed a list of national priority plant pests. These are plant pests that are exotic to Australia, are under eradication or have limited distribution in Australia. Species on this list are not the only plant pest species of biosecurity concern to Australia and have been selected to highlight various threats that Australia faces. Species on this list include bacteria, viruses, fungi, arthropods, molluscs and nematodes (Department of Agriculture and Water Resources, 2016c). This list was created to benefit researchers, policymakers and regulators and help them manage threats to plants in Australia in agricultural, environmental and/or social amenity systems.

Plants

ABARES compiled a list of Australian exotic plants of concern from several sources: the Department of Agriculture and Water Resources Exotic Weeds Watch list; the Northern Australia Quarantine Strategy Weeds Target List; the example list of Exotic Weeds of Trade concern; the Prohibited seeds list and the Plants that are quarantinable pests list.

Department of Agriculture and Water Resources Exotic Weeds Watch list

This list is composed of weed threats to primary industries and the environment. The list includes serious weeds that are exotic to Australia, under eradication or have limited distribution (Department of Agriculture and Water Resources 2015). There is no information on how this list was generated.

Northern Australia Quarantine Strategy (NAQS): Weeds Target List

The NAQS weeds target list was developed to focus NAQS survey activities and to raise public awareness about quarantine risks to the Australian environment and agricultural industries. The list is based on those species that are not known to be present in Australia and are considered to pose a threat. The first target weeds list was compiled in 1989 and comprised 23 weeds of quarantine concern. This list was reviewed and expanded to 41 species by Waterhouse and

Mitchell (1998). The NAQS weeds target list was again revised in 2008 and now consists of 79 target weeds, 31 species on the 'primary NAQS target weeds list' and 48 species on the 'appendix list' (Brown, Johnson & Raphael 2008). The list was compiled through literature review and extensive consultation with NAQS field survey officers (Brown, Johnson & Raphael 2008). The primary weeds list includes species with a great potential for invasiveness and deleterious impacts on agriculture and the environment.

Example list of exotic weeds of trade concern

A list was compiled by the Department of Agriculture and Water Resources (unpublished) to provide an example of weeds that may potentially be of trade concern, should they arrive in Australia. This list was based on the prohibited seed lists of several of Australia's major grain trading countries.

Prohibited weeds list and Plants that are quarantinable pests

Until 16 June 2016 the Department of Agriculture and Water Resources regulated the import of live animals and plants into Australia under the *Quarantine Act 1908* and its subordinate legislation and the *Environment Protection and Biodiversity Conservation Act 1999*. From 16 June 2016 the *Biosecurity Quarantine Act 2015* is the overarching legislation regulating the import of plants into Australia. At the time of the compilation of this database, the *Quarantine Act 1908* was still in force. Under this legislation, prior to any new plant being imported into Australia, the plant had to be assessed for its potential impacts (Department of the Environment and Energy 2016b). Plant species are assessed using the Weed Risk Assessment system to determine whether they are safe to be allowed into Australia. Based on this assessment, a plant may be prohibited, allowed entry or may require a permit.

The department regulated the import of seeds from plant species into Australia through the Quarantine Proclamation 1998. Schedule 5 contains a list of all species that are permitted entry into Australia without requiring an import permit. Any species not listed in Schedule 5 required an import permit and depending on the requested end use, requires an assessment to determine weed risk (Department of the Environment and Energy 2016b). Species that have been assessed as posing a weed or quarantine risk are listed as prohibited on the Department of Agriculture Import Conditions (BICON) database. For the purposes of this report, species on the Prohibited seeds list and the Plants that are quarantinable pests list were used in the database. The Prohibited weeds list is an incomplete list of seeds that are prohibited for import (Department of Agriculture and Water Resources 2016f). However, large numbers of plant species are yet to be assessed and are not listed. The Plants that are quarantinable pests were listed in Schedule 4, Part 2 of the Quarantine Proclamation 1998 (Department of Agriculture and Water Resources 2016g).

Vertebrates

ABARES compiled information on Australian exotic vertebrate species of concern from Henderson and Bomford (2011) and the Vertebrate Pests Committee (VPC) (2007).

The VPC compiled a list of all non-indigenous vertebrate mammals, birds, amphibians and reptiles being held in Australia under state and territory legislation. Each species was assigned a threat category according to their ability to establish and their risk of becoming a pest. Processes in Australia that have helped identify the risk of a species establishing and becoming a pest have relied on the risk assessment models created by Bomford (2008). VPC used these models to assign levels of risk. The three risk assessment models created by Bomford (2008) cover mammals and birds, reptiles and amphibians, and freshwater fish. Species on the VPC list were

exotic to Australia, but they were not necessarily invasive. ABARES has included only those species assessed as a high or extreme risk by the VPC (2007).

The data provided by Henderson and Bomford (2011) comprised several lists, including exotic animals reported at large between 1999 and 2010; exotic vertebrates intercepted from private keeping; and lists of illegal imports seized at the border where data was provided by Customs and the former Australian Quarantine and Inspection Service.

Glossary

Term	Definition
Exotic	Non-native species that have not been introduced into Australia. Synonyms for exotic can include non-native, non-indigenous. Within this report, species that had previous introduction attempts but had been eradicated, or species where there is lack of records regarding species presence were listed as exotic. For vertebrate pests, exotic species includes those in captivity such as zoos.
Introduced	Non-native species that have been introduced to Australia (for example, as ornamentals, pets) but have not established self-sustaining populations.
Invasive	A species that is non-native to the ecosystem under consideration and whose introduction causes, or is likely to cause economic or environmental harm or harm to human health or social amenity.
Noxious	The term noxious typically applies to weeds only. A noxious weed or plant is a non-native plant which is considered to be harmful to the environment or animals and may be the subject of regulations governing attempts to control it.

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