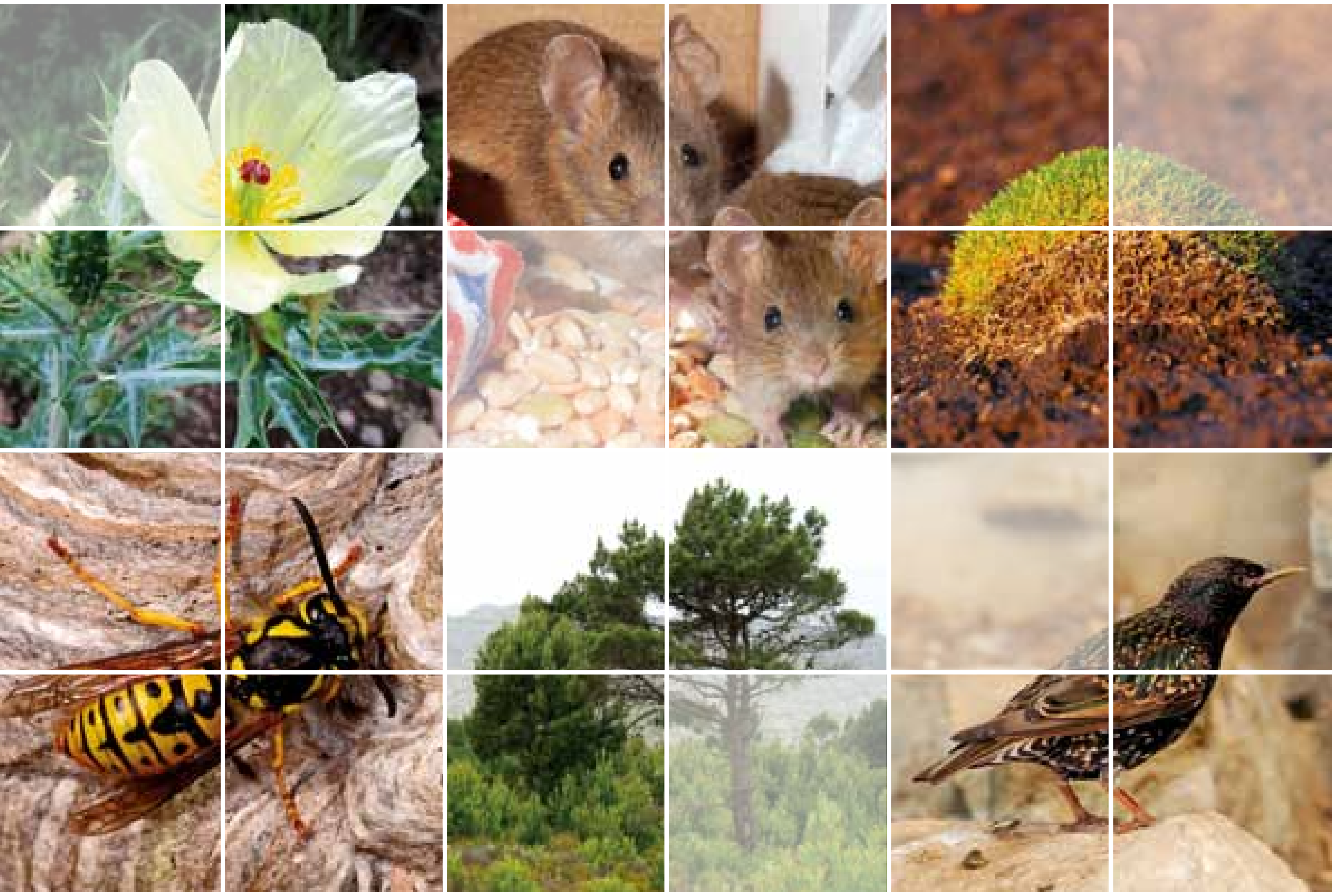
2017

THE STATUS OF BIOLOGICAL INVASIONS AND THEIR MANAGEMENT IN SOUTH AFRICA



2017

THE STATUS OF BIOLOGICAL INVASIONS AND THEIR MANAGEMENT IN SOUTH AFRICA

PRETORIA

SANBI
Biodiversity for Life
South African National Biodiversity Institute

THE STATUS OF BIOLOGICAL INVASIONS AND THEIR MANAGEMENT IN SOUTH AFRICA IN 2017

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Top left – *Argemone mexicana*, yellow-flowered Mexican poppy (photograph S. Turner)
Top middle – *Mus musculus*, house mouse (photograph C. Griffiths)
Top right – *Sagina procumbens*, bird-eye pearlwort (photograph M. Greve)
Bottom left – *Vespula germanica*, German wasp (photograph S. van Noordt)
Bottom middle – *Pinus* species, pine trees (photograph B. van Wilgen)
Bottom right – *Sturnus vulgaris*, common starling (photograph C. Griffiths)

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INDEPENDENCE OF THE STATUS REPORT

This status report constitutes an independent assessment of the status of biological invasions and their management in South Africa. It is the first such country-level assessment specifically on biological invasions anywhere in the world. The report is intended to inform the development and ongoing adaptation of appropriate policies and control measures, both to reduce the negative impacts of invasive species on ecosystems, the economy, and people, and to retain any benefits of invasive species where possible and desirable.

The compilation of the report was overseen by a team of editors and contributing authors employed by the South African National Biodiversity Institute (SANBI) and the DST-NRF Centre of Excellence for Invasion Biology at (C·I·B). Inputs (including data, peer-reviewed papers, and unpublished reports) were also obtained from researchers and managers from diverse institutions across South Africa. Funding for the compilation of the report was obtained through the national Department of Environmental Affairs (DEA) as part of SANBI's Medium Term Expenditure Framework. In order to address any potential conflicts of interest, and to ensure independence of the report, the following steps were taken:

- Drafts of the status report were widely circulated to contributing authors and other stakeholders, who were invited to submit comments, concerns or additional information, with two dedicated rounds of review in 2017;
- Comments and concerns raised were captured in a database, along with the drafting team's responses to these comments and concerns. This database is available on request;
- A Review and Advisory Committee was appointed, chaired by an expert on assessments, from the University of the Witwatersrand, South Africa. This committee approved the review process and took responsibility for ensuring editorial independence; and
- An independent Review Editor will be appointed to assess the review process on completion of the first status report, with a view to strengthening the process if necessary for future reports.

Furcraea foetida (Mauritian hemp) – SANBI

EDITORIAL CONVENTIONS

Species

Both scientific and common names are provided when referring to species. Authorities for scientific names are provided in Appendix 3, and are not used in the main text or in tables. Each species is assigned only one common name. The common name used is in English, recognising that more than one English common name may exist, and that common names in other South African official languages also exist. Exceptions are made when a non-English common name is predominantly or exclusively used to describe a species (e.g. in the case of *Acacia cyclops*, the common name "rooikrans" is used in preference to the English "red eye").

Acronyms

All acronyms are defined at first use in every chapter, and are also defined in table headings and in the legends of figures. A full list of acronyms and their definitions is provided at the beginning of the report.

Terminology

To assist the reader who may not be familiar with commonly-used terms in invasion biology, a glossary of terms is provided at the beginning of the report.

Currency

South African rands are denoted as ZAR, and not R.

References

All references for the text and for appendices are provided in a single list at the end of the report. In the bibliography, references with more than ten authors only have the first four authors listed, followed by "*et al.*"

Indicators

All indicators are numbered wherever they are mentioned in the text or in tables. The numbering of indicators follows the numbers set out in Chapter 2.

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DR MOSHIBUDI RAMPEDI

Chief Executive Officer: South African National Biodiversity Institute

Republic of South Africa

PREFACE

It gives me great pleasure to present South Africa's first national status report on biological invasions. Biological invasions pose enormous threats to South Africa's ecosystems and the services that they deliver to our people. We are among the few countries that have legislation specifically aimed at managing the problem of biological invasions. The South African National Biodiversity Institute (SANBI) is mandated under this legislation to promote the conservation of South Africa's exceptional biodiversity, and to monitor and report on the status of both biodiversity and of biological invasions. The economic damage caused by these invasions has been estimated at billions of rands per year, and the problem is growing rapidly as more species are introduced, as more introduced species start to invade, as invasive species spread, and as the impacts that they have increase.

This status report provides a comprehensive assessment of biological invasions and informs policy for their management in South Africa. This report also provides a framework for reporting on the status of biological invasions at a national scale using a set of indicators. These indicators will serve as a baseline for assessing trends and for setting realistic management targets and they also highlight several important gaps in our ability to provide evidence to support decision making. The report is structured around the status of pathways of introduction and spread, the status of alien species, the status of invaded areas and the effectiveness of interventions.

- In terms of ***pathways*** of introduction and spread, the report highlights the fact that alien species continue to enter the country in a variety of ways. Although new regulations are expected to substantially reduce the rate at which high-risk species are deliberately introduced, it can also be expected that the rate of accidental introductions will increase along with growth in international trade and tourism.
- For the establishment, distribution and impact of alien ***species***, the report highlights that we have reasonably good data on the distribution of terrestrial and freshwater plants, birds, amphibians and reptiles, but not for other groups of species. There are also very few studies on the impact of invasive alien species. There are over 100 species that likely already have major impacts, and this number can be expected to grow as more naturalised species become invasive.

- Although there is very little information to accurately assess the degree to which ***areas*** are invaded, it is clear that some areas are worse off than others. Fynbos catchments are disproportionately affected by invasive trees, and some rangelands and protected areas are seriously threatened by herbaceous plants and cacti. In addition, several important catchment areas are producing significantly less water due to alien plant invasion, and this is set to grow.
- The ***Alien and Invasive Species Regulations*** have not been in place for long enough for an assessment of their effectiveness to be made. However, a number of key issues have emerged, including high levels of non-compliance with some regulations, and a shortage of capacity within the Department of Environmental Affairs, and elsewhere in government, to ensure compliance.
- A robust assessment of the ***effectiveness of control measures*** is also not possible due to the absence of monitoring of the outcomes of control measures. Based on a few research studies, it is possible to show that there has been good progress in some areas, and with some techniques (e.g. the biological control of invasive alien plants), but that by and large current control measures are inadequate to stem the spread of invasive species.

The overall assessment of the effectiveness of management (at < 6%) highlights how much still needs to be done in South Africa to address biological invasions. This score can, however, easily be improved by strategically focusing our interventions and collecting the data necessary to support policy and management decisions. SANBI is committed to facilitating this process and, through this report and the monitoring activities required to support it, we will strive to provide the evidence base necessary for the appropriate decisions to be made to support our biodiversity and ecological infrastructure.

I would like to extend my gratitude to the Honourable Minister for Environmental Affairs, Ms. Edna Molewa, together with her team, for their confidence in and support to SANBI to carry out this work. I am grateful to the SANBI Board Chairperson, Ms. Nana Magomola and the entire Board, for the vision and strategic leadership they provide and the support to staff working on these key national documents. Thanks to our partners in the biodiversity sector for providing data and information and constructive comments on this huge task. Lastly, a heartfelt thanks to the status report coordinating team with guidance from the Reference and Advisory Committee, for their drive and commitment to the achievement of our mandate and in overcoming barriers to success in compiling a national level report, the first of its kind in the world.

LIST OF ACRONYMS

ADU	Animal Demography Unit (University of Cape Town)
ASRARP	Alien Species Risk Analysis Review Panel
A&IS	Alien and Invasive Species (as referred to in the regulations published under the auspices of the National Environmental Management: Biodiversity Act).
CBD	Convention on Biological Diversity of the United Nations
BODATSA	Botanical Database of Southern Africa
BRAHMS	Botanical Research and Herbarium Management Software (see http://newposa.sanbi.org/).
CARA	Conservation of Agricultural Resources Act
CAPRA	Corrective Action and Preventive Actions in Risk Assessment
C•I•B	Centre for Invasion Biology (the DST-NRF Centre of Excellence for Invasion Biology)
CFR	Cape Floristic Region
CPS	Cape Piscatorial Society
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
DOT	Department of Transport
DST	Department of Science and Technology
EICAT	Environmental Impact Classification for Alien Taxa
EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization of the United Nations
GBIF	Global Biodiversity Information Facility
GDP	Gross Domestic Product
GEO BON	Group on Earth Observations Biodiversity Observation Network
GRNP	Garden Route National Park
HiP	Hluhluwe iMfolozi Park
IAP	Invasive alien plant
IAS	Invasive alien species
IMO	International Maritime Organisation
IPPC	International Plant Protection Convention
IUCN	International Union for Conservation of Nature
KNP	Kruger National Park
MAR	Mean Annual Runoff
NEMA	National Environmental Management Act (Act 107 of 1998)
NEM:BA	National Environmental Management: Biodiversity Act (Act No. 10 of 2004)
NPPO	National Plant Protection Organization
NRF	National Research Foundation
NRM	Natural Resource Management (a division of the Department of Environmental Affairs)
PEI	Prince Edward Islands
QDGC	Quarter-Degree Grid Cell
SAIAB	South African Institute for Aquatic Biodiversity
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
SANRAL	South African National Roads Agency
SAPIA	Southern African Plant Invaders Atlas
SASRI	South African Sugarcane Research Institute
SARS	South African Revenue Service
SEICAT	Socio-Economic Impact Classification for Alien Taxa
SUSPECT	Species Under Surveillance - Possible Eradication or Containment Targets
UN	United Nations
USD	United States Dollars
WCTA	Western Cape Trout Association
WfW	Working for Water
WIMS	Working for Water information management system
ZAR	South African Rands

GLOSSARY OF TERMS

These definitions are based on those in Richardson, Pyšek & Carlton (2011), and Wilson, Panetta & Lindgren (2017), with consideration of definitions given in relevant South African legislation [specifically the National Environmental Management: Biodiversity Act, 2004 (Act no. 10 of 2004), Alien and Invasive Species (A&IS) Regulations, 2016].

- **Abundance** (cf. **distribution**, **extent**): a measure of the number of individuals, coverage, or biomass of an organism in a specified area.
- **Alien species**: a species that is present in a region outside its natural range as a result of human action that has enabled it to overcome biogeographic barriers.
- **Area**: a defined spatial unit, for example a protected area (as defined by the National Environmental Management: Protected Areas Act, 2003); or an administrative unit (with national and provincial administrative boundaries as defined by the Constitution of the Republic of South Africa, 1996).
- **Assessment**: a critical evaluation of information.
- **Biological invasions** (cf. **introduction-naturalisation-invasion continuum**): the phenomenon of, and suite of processes that are involved in determining the transport of organisms to **areas** outside their natural range by human activities and the fate of the organisms in their new ranges.
- **Biome**: a large naturally occurring community of plants and animals that have common characteristics in similar physical environments, e.g. desert or forest.
- **Containment**: the goal of preventing or reducing the **spread** of **invasive species**.
- **Control**: any action taken to prevent the recurrence, re-establishment, re-growth, multiplication, propagation, regeneration or spreading of an **alien** species.
- **Corridor**: a **dispersal** route or a physical connection of suitable habitats linking previously unconnected regions.
- **Dispersal**: movement of organisms that is facilitated either intentionally or unintentionally by humans.
- **Distribution**: the **extent** and **abundance** of a species over a given **area**.
- **Dominance**: the last stage of the **invasion** process, where an **invasion** begins to reach high local abundance and starts to develop relatively stable margins in its new range.
- **Environmental pests**: organisms (usually referring to animals) that negatively **impact** biodiversity and ecosystem functioning in natural ecosystems. They can be **alien** or **indigenous**.
- **Environmental weeds**: plants that invade natural ecosystems, and that **impact** on biodiversity and ecosystem functioning. They can be **alien** or **indigenous**.
- **Eradication**: the complete removal of all individuals and propagules of a population of an **alien species** from a particular area to which there is a negligible likelihood of reinvasion. The probability of reinvasion must have been explicitly assessed, and if it is negligible it can result in a reallocation of management resources (i.e. ongoing control and monitoring is no longer required).
- **Eradograph**: a graph of progress towards containment and eradication. The trajectory of the graph is used to indicate the relative need to invest in surveys to further delimit infested sites versus the need to eliminate local populations.
- **Established**: see **naturalised**.
- **Establishment**: a process whereby **alien species** form self-sustaining populations over multiple generations without direct intervention by people, or despite human intervention.

- **Expansion** (syn. **spread**): the unaided movement of **alien** organisms within a defined area. The third stage of the **introduction-naturalisation-invasion continuum**, during which invasive species increase in their ranges.
- **Extent** (cf. **abundance**, **distribution**): the broad-scale area over which an organism occurs. The spatial scale over which extent is measured needs to be specified. The occupancy of areas at a fine-spatial scale is often equivalent to the **abundance**.
- **Extirpation** (cf. **eradication**): the result of a **control** operation whereby all individuals in a population are removed. Other populations might be close by or pathways or introduction and dispersal are still operating such that the probability of re-invasion is probable or not known.
- **Impact reduction**: the goal of reducing the negative **impact** of **alien species** while retaining the positive benefits.
- **Impact**: the description or quantification of how an **alien species** affects the physical, chemical and biological environment, it can include both negative and positive effects.
- **Incursion**: an isolated population of a pest, weed, or **alien species**, that usually has a limited spatial extent and has been recently detected in an area.
- **Indicator**: as used here, indicators are statistical measures which help scientists, managers and politicians understand the condition of biodiversity and the factors that affect it.
- **Indigenous species** (syn. **native specie**s): species that are found within their natural range where they have evolved without human intervention (intentional or accidental). Also includes species that have expanded their range as a result of human modification of the environment that does not directly impact dispersal (e.g. species are still indigenous if they increase their range as a result of watered gardens, but are alien if they increase their range as a result of spread along human-created corridors linking previously separate biogeographic regions).
- **Introduced**: see **Introduction**.
- **Introduction dynamics**: see **Introduction**.
- **Introduction**: movement of a species, intentionally or accidentally, owing to human activity, from an area where it is native to a region outside that range.
- **Introduction-naturalisation-invasion continuum**: a conceptualization of the progression of stages and phases in the **status** of an **alien** organism in a new environment which posits that the organism must negotiate a series of barriers. There are four major invasion stages: **pre-introduction**, **incursion**, **expansion** and **dominance**.
- **Invasibility**: the properties of a community, habitat or ecosystem that determine its inherent vulnerability to **invasion.**
- **Invasion**: see **Biological invasions**.
- **Invasion debt**: the potential increase in the biological invasion problem that a given region will face over a particular time frame in the absence of any strategic interventions (Rouget *et al.*, 2016). It is composed of the number of new species that will be introduced (introduction debt), the number of species that will become invasive (species-based invasion debt); the increase in area affected by invasions (area-based invasion debt); and the increase in the negative impacts caused by introduced species (impact-based invasion debt).
- **Invasive alien species**: see **Invasive species**.
- **Invasive species**: **Alien species** that sustain self-replacing populations over several life cycles, produce reproductive offspring, often in very large numbers at considerable distances from the parent and/or site of introduction, and have the potential to **spread** over long distances.
- **Invasiveness**: the features of an **alien** organism, such as their life-history traits and modes of reproduction that define their capacity to invade, i.e. to overcome various barriers to **invasion.**

- **Listed alien species**: all **alien species** that are regulated under the National Environmental Management: Biodiversity Act, 2004 (Act no. 10 of 2004), Alien and Invasive Species (A&IS) Regulations, 2016.
- **Native species:** see **Indigenous species.**
- **Naturalised** (syn. **established**): **Alien species** that sustain self-replacing populations for several life cycles or over a given period of time without direct intervention by people, or despite human intervention.
- **Net present value**: the present-day value of money when compared to its past value after factoring in inflation.
- **Pathways**: a broadly defined term that refers to the combination of processes and opportunities that result in the movement of alien species from one place to another.
- **Permit**: an official document issued in terms of Chapter 7 of National Environmental Management: Biodiversity Act, 2004 (Act no. 10 of 2004).
- **Pest** (cf. **environmental pest** and **weed**): an organism that causes negative impacts. The affected sector might be specified, so an agricultural pest will **impact** negatively on agricultural production. Pests can be **alien** or **indigenous**, and are usually taken to refer to animals, with pest plants more specifically referred to as **weeds** and pest fungi or microbes referred to as diseases.
- **Pre-introduction**: a stage in the **invasion** process where a species is not currently present in a region of interest.
- **Prohibited species**: species that are not native to South Africa listed as prohibited under the National Environmental Management: Biodiversity Act, 2004 (Act no. 10 of 2004) Alien and Invasive Species (A&IS) Regulations, 2016. These species are assumed to be absent from the country and new introductions are prohibited.
- **Propagule pressure**: a concept that encompasses variation in the quantity, quality, composition and rate of supply of seeds, individuals, or other reproductively viable material of an **alien** species resulting from the transport conditions and **pathways** between source and recipient regions.
- **Port of entry**: an official point of entry or departure from South Africa through which goods and people may enter or leave a country, for example a border post, airport or harbour.
- **Regulation**: a law, rule or other order prescribed by authority, especially to regulate conduct.
- **Risk analysis:** the assessment of the nature, likelihood and consequences of a given **alien taxon** causing negative **impacts** (i.e. **risk assessment**), and the identification of measures that can be implemented to reduce or manage such risk, taking into account socio-economic considerations.
- **Risk assessment**: part of **risk analysis**, assessing the nature, likelihood and consequences of a given **alien taxon** causing negative **impacts**.
- **Spread**: see **Expansion**.
- **Status**: the state, condition or stage of affairs at a particular time.
- **Taxon** (pl. **taxa**): a group of organisms that all share particular properties (usually evolutionary history). The grouping can be below, at, or above the species level.
- **Unified Framework:** a framework the defines **biological invasions** in terms of the **introduction-naturalisation-invasion continuum** and provides a method for categorising **alien species** in terms of their introduction **status** (see Appendix 3 for details).
- **Vectors**: a broadly defined phenomenon involving **dispersal** mechanisms that can be both non-human and human mediated. It is often used to refer to the actual mechanism by which **alien species** are able to arrive at new areas.
- **Weed** (cf. **pest**, **environmental weed**): a plant that causes negative impacts. Weeds can either be **alien** or **native**.

EXECUTIVE SUMMARY[1]

Biological invasions are a large and growing environmental problem, globally and in South Africa. Many thousands of species have been translocated from their indigenous ranges to novel environments, where some become invasive and spread across natural ecosystems, threatening indigenous biodiversity and reducing the ability of ecosystems to deliver vital services. These biological invasions often have direct negative impacts on the wellbeing of many people, and in particular threaten rural livelihoods.

This report constitutes the first comprehensive attempt to assess the status of biological invasions across all aspects of the problem at a national level. The report is based on information from a range of sources, including inputs from experts and practitioners, atlas data, published scientific papers and theses, and management records from government agencies. Draft versions of the report were sent out to a wide and representative range of interested parties in two rounds of review, which resulted in the inclusion of additional information.

This report does not cover the social benefits associated with alien species control programmes that are implemented with the additional goals of employment creation and poverty relief, as this is not required in terms of the regulations, as well as because there have been no attempts to date to quantify these benefits. However, these benefits should ideally be considered when returns on investment from control projects are calculated.

The report is structured around four aspects: *pathways* of introduction and dispersal; the number, distribution and impact of individual *species*; species richness and abundance of alien species in defined *areas*, and their impacts on those areas; and the *effectiveness of interventions*, i.e. Have South African regulations and control efforts been effective in reducing the problem? A total of 21 indicators were developed to assess the status of these aspects. In addition, four high-level indicators (one for each aspect) were developed for use in the national suite of environmental indicators on which the Department of Environmental Affairs reports on a regular basis.

Most alien species found in South Africa today were intentionally introduced many years ago, either deliberately with the goal of establishing populations in nature, or for horticulture, agriculture, forestry or the pet trade (from where some escaped to become invasive). The remainder were introduced accidentally as commodity contaminants or as stowaways on transport vectors. While the rate of intentional introduction of high-risk species is expected to decline due to improved regulation, it is also expected that the rate of unintentional introductions will increase due to increases in trade and tourism. The rate at which species are arriving in the country appears to be gradually increasing.. Once an alien species is introduced to South Africa, further spread within the country

1 This executive summary provides a brief, high-level overview of the contents of this report. More detailed summaries appear at the start of each chapter. Chapter 9 also provides a set of key policy-relevant messages.

is highly likely and very difficult to stop. There is a thriving trade in alien species for a variety of purposes within South Africa's borders. Alien species can also be accidentally transported along the country's extensive transport networks, and invasive species can spread naturally.

A total of 556 invasive taxa have been listed under the National Environmental Management: Biodiversity Act's Alien and Invasive Species Regulations. The actual number of invasive species is higher, with 775 having been identified to date. Most of these invasive species are terrestrial and freshwater plants (574 species) or terrestrial invertebrates (107 species).

A total of 107 species were considered by experts to be having either major or severe impacts on biodiversity and/or human wellbeing; the vast majority of these (75%) were terrestrial or freshwater plants.

Alien species richness was highest in the Savanna, Grassland, Indian Ocean Coastal Belt and Fynbos biomes, with relatively low species richness in the more arid Karoo and Desert biomes. Alien trees and shrubs can dominate areas such as fynbos catchments and coastal areas; mesquite trees (*Prosopis spp.*) dominate arid areas; many riparian zones are invaded by trees; many rangelands are invaded by cacti and herbaceous annual and perennial plants; and few indigenous fish species survive in streams invaded by alien fish.

There are very few studies that cover the combined impacts of invasive species on particular areas. Available studies estimate the combined impacts of invasive plants on surface water runoff at between 1 450 to 2 450 million m^3 per year. If no remedial action is taken, reductions in water resources could rise to between 2 600 and 3 150 million m^3 per year, severely impacting drought-stricken cities like Cape Town. Reductions in the productivity of rangelands, and in biodiversity intactness, are low at present (between 1 and 3%), but these impacts are expected to grow rapidly as invasive plants enter a stage of exponential growth. Biological invasions account for 25% of the reduction in South African biodiversity seen to date.

In terms of control measure inputs, South Africa's Alien and Invasive Species Regulations are substantial, as they cover most aspects of the problem. Large sums of money have been spent (currently ZAR1.5 billion per year), especially on the control of terrestrial and freshwater plant species. This is almost certainly an underestimate as it only includes funding from the Department of Environmental Affairs, and not from other government or semi-government entities, or the private sector. Planning coverage is low, and there is little evidence of adequate levels of goal-setting or monitoring.

Control measure outputs are assessed in terms of the proportion of pathways, species or areas that have been subjected to control. The Convention on Biological Diversity recognises 44 pathways of introduction, and 34 of these pathways (77.3%) are managed to some extent. Although 556 taxa are listed in the Alien and Invasive Species regulations, not all of these are subjected to active management. For example, ~126 out of 379 alien terrestrial and freshwater plant taxa have been targeted for some control, and of these, eight species make up 80% of the area subjected to treatment. In terms of areas, less than 1% of invaded land has been reported to have been the subject of control measures.

Data on the outcomes of control measures are sorely lacking. The impact of pathway regulation on rates of introduction of invasive species cannot yet be determined, given that they have only been in place for a short time. Control measures have been shown to be effective in some localized areas but not so in others. While the situation would arguably have been worse had there been no control, current control efforts have not been effective in preventing the ongoing spread of invasive species when viewed at a national scale.

The level of confidence in almost all these estimates is low. This can be improved in future status reports as more data are collated and curated, but in many cases new processes are required to monitor and report on biological invasions if policy and management decisions are to be evidence-based. In particular three key areas of focus are identified: (1) the need for more research to determine and assess the impacts of alien species; (2) better monitoring of the effectiveness of current control measures; and (3) the development of methods to look at the impact of biological invasions and their management on society as a whole.

The report concludes by providing a list of policy-relevant messages that have been distilled from the assessment, and these should be considered when formulating environmental policies for the country as a whole. Besides expanding on the points described above, it is noted that it should be imperative to improve management efficiency, given the substantial economic and social consequences that would be associated with a failure to adequately address the problem of biological invasions. This will require difficult choices and trade-offs to be made, including the need to practice conservation triage by focussing effort on priority pathways, species, and areas.

Acridotheres tristis (common myna) – Richard Taylor

1 INTRODUCTION

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EFFECTIVENESS OF RESPONSES

The current effectiveness of management interventions varies. In some cases, good progress has been made, but in others the interventions have been less effective. Undoubtedly, we would be worse off if no action had been taken, but effectiveness can be increased substantially by better planning and monitoring and the more widespread use of accepted best-practice control measures.

Lythrum hyssopifolia (hyssop loosestrife) – Christian Fischer

Chapter summary

Biological invasions can have profound negative impacts on biodiversity, reduce the ability of ecosystems to deliver the services needed to maintain and improve the livelihoods of the people of South Africa, and impact directly upon people's wellbeing.

This report presents the first comprehensive national-scale assessment of the status of biological invasions in South Africa, and the first such country-level assessment specifically on biological invasions anywhere in the world. The report is intended to inform the development and ongoing adaptation of appropriate interventions to reduce the negative impacts of biological invasions on biodiversity and ecosystems, the economy, and people, while preserving any benefits.

Status is addressed in terms of five aspects: *pathways* of introduction and spread; the establishment, distribution, and impact of *species*; the level to which *areas* are invaded and the resulting overall impacts; the *effectiveness of control measures*; and the *effectiveness of regulations*.

This report also fulfils the legal requirement for the South African National Biodiversity Institute to submit a report on the status of biological invasions, and the effectiveness of control measures and regulations, to the Minister of Environmental Affairs. This first report also provides a framework for future reports, with reports due every three years.

This chapter briefly describes the process followed to produce the report, which included the appointment of a Reference and Advisory Committee to provide guidance and advice, the gathering of information from a wide range of sources, and review by stakeholders and contributors.

1.1. THE IMPORTANCE OF BIOLOGICAL INVASIONS

Biological invasion is the phenomenon of the transportation of organisms through intentional or accidental human activity to areas outside of their natural range, and the fate of such organisms in their new ranges, including their ability to survive, establish, reproduce, disperse, spread, proliferate, and influence invaded ecosystems (Richardson *et al*., 2011a). Biological invasions are a growing environmental problem worldwide, and South Africa in particular is home to a large and growing number of invasive species.

Thousands of species have been introduced to South Africa over the years. Many of these alien species are beneficial. Almost all agriculture and forestry production is based on alien species, and alien species are widely used in horticulture, aquaculture, and mariculture, or are kept as pets. Only a small proportion of alien species become invasive though this varies markedly between taxa (~0.1–10%). This subset of alien species can reduce the ability of ecosystems to deliver services, negatively affecting the economy of invaded areas, and ultimately impacting upon all South Africans. Invasive trees and shrubs reduce water runoff and groundwater recharge, reducing the water supplies to already-stressed farms, towns and cities; plants that invade rangelands reduce the capacity of the land to support livestock and threaten the livelihoods of people that depend on livestock production; and invasive plants and animals impact negatively on biodiversity and the services that South Africa's diverse natural ecosystems provide (from ecotourism to harvesting food, cut flowers, and medicinal products).

In 1996, South Africa adopted a new Constitution (Constitution of the Republic of South Africa Act, Act 108 of 1996). The Bill of Rights (Chapter 2) is central to this Constitution as it enshrines the rights of all people in the country. Section 24 of the Bill of Rights guarantees the right to an environment that is not harmful to people's health or wellbeing, and provides for environmental protection for the benefit of future generations through reasonable legislative and other measures that prevent "ecological degradation, promote conservation, and secure ecologically sustainable development". This imparts a responsibility both to control invasive species so as to reduce their negative impacts, and to try to preserve any benefits that such invasive species may provide. Crucially this is not only a matter of balancing ecological and economic imperatives, as in some situations invasive species are economically useful to some people but economically damaging to other people Van Wilgen & Richardson, 2014; Woodford *et al.*, 2016).

South Africa has been actively managing biological invasions for well over a century (e.g. Moran, Hoffmann & Zimmermann, 2013). While historically the focus was on limiting direct impacts to agricultural production, the ultimate goal of these measures is to prevent the erosion of ecosystem services and to protect people from the ongoing expansion of negative impacts. This is in line with the constitutional obligation.

1.2. PURPOSE OF THE STATUS REPORT ON BIOLOGICAL INVASIONS

This status report is intended to inform the development and ongoing adaptation of appropriate policies and control measures, both to reduce the negative impacts of invasive species on ecosystems, the economy, and people, and to retain any benefits of invasive species where possible and desirable. Such control measures and policies ideally need to be based on an understanding of the dynamics of biological invasions, the magnitude and distribution of the impacts of biological invasions, an assessment of the implications of those impacts, and on the prospects for containing or reducing them. Once management goals are set and implemented, their outcomes should be monitored and evaluated regularly, with observations feeding back to adjust priorities for basic inventory and ecological research. However, this process is rarely as straightforward as this (Figure 1.1). This status report synthesizes current understanding of the problem arising from inventories and ecological research, as well as on the outputs of exercises to monitor and evaluate the outcomes of control measures, in a form that is of value to policy makers and managers. The current requirement is to repeat this cycle every three years (see section 1.3 below).

FACT

The National Status Report on Biological Invasions in South Africa is the first such report anywhere in the world. Its purpose is to set a benchmark against which trends in this problem can be tracked over time.

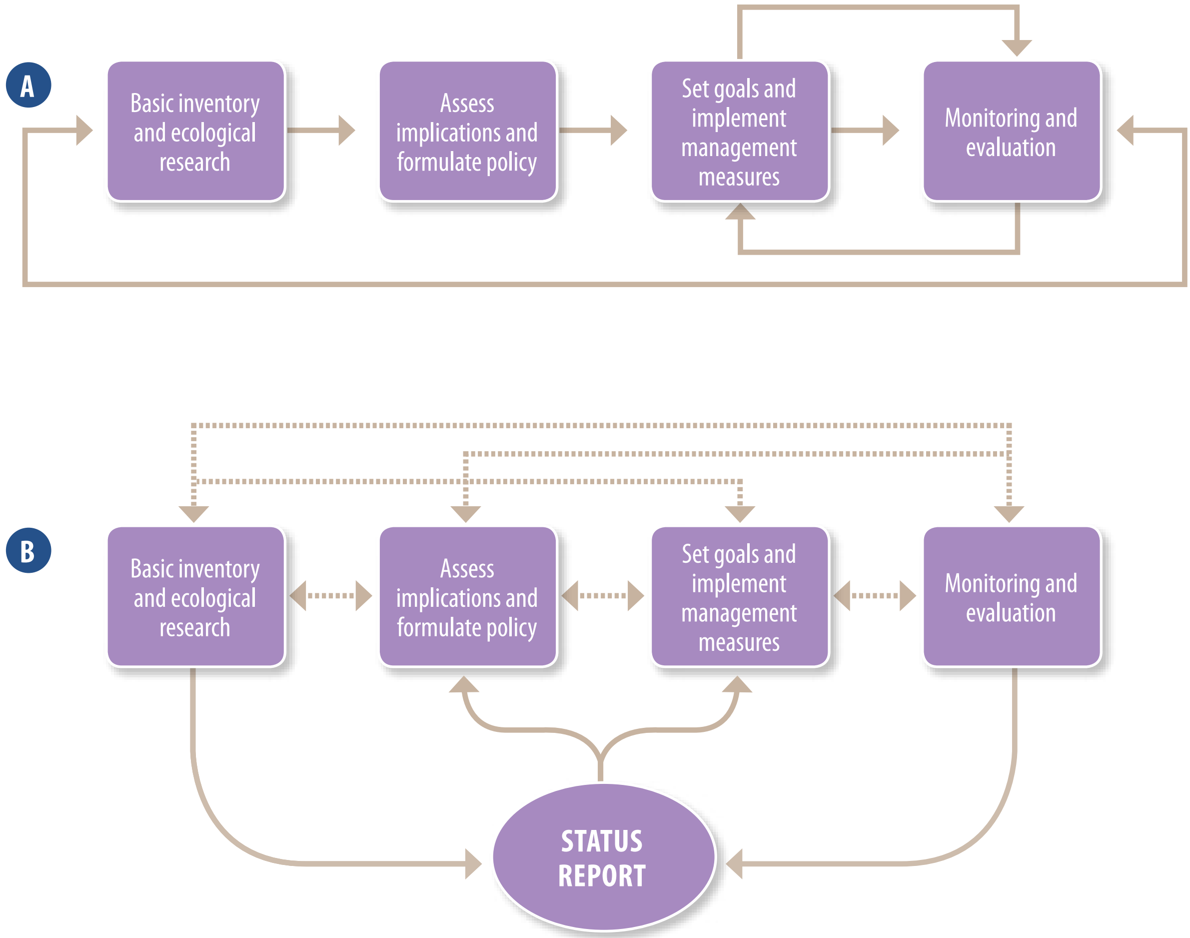


FIGURE 1.1 The National Status Report is a formal mechanism to increase the connectivity between research, policy and implementation. The top panel (A) shows an idealised process whereby research is conducted that is interpreted in terms of implications for management expressed in appropriate policy, which in turn is implemented. Implementation is monitored and evaluated and adjusted accordingly, i.e. management is adaptive. How and what is monitored and evaluated is informed by basic inventory and ecological research and vice versa. The bottom panel (B) shows the real situation. There are sometimes direct links between basic research and implementation, and many more feedbacks, but often the links are incomplete or broken. Different people and organisations are involved in research, policy formulation, management, and evaluations, and their specific goals and interests are often not closely aligned, nor do they always have the time to interact. There is a variety of mechanisms to increase communication between different role players. A national status report is one formal way of collating information from basic inventories and ecological research and from monitoring and evaluation, and providing it in a form that can assist with the processes of assessing implications and formulating appropriate policy, and setting goals and implementing management measures.

EFFECTIVENESS OF RESPONSES

South Africa has comprehensive national regulations to deal with biological invasions. Many provisions are innovative, allowing for benefits to be derived from some invasive species while simultaneously requiring their control where it is required. The regulations have only been in force for three years, so it is too early to be able to assess the degree to which they have affected the status of biological invasions in the country.

1.3. LEGISLATIVE BACKGROUND

Historically, South Africa has responded to the threat posed by invasive species by *ad hoc*, often piecemeal, legislation. Recently, there has been a more comprehensive sector-specific approach. In particular, regulations under the Conservation of Agricultural Resources Act (CARA) (Act 43 of 1983), were promulgated to govern the management of certain (listed) invasive plant species ("weeds"); while the Agricultural Pests Act, 1983 (Act 36 of 1983) provides for measures to combat agricultural pests and prevent their introduction. Despite the initial intent of the CARA (which was to control agricultural weeds), the species listed included plants whose impacts were primarily felt in untransformed natural ecosystems, i.e. environmental weeds.

In 1998, the National Environment Management Act (NEMA) (Act 107 of 1998) was enacted to provide a framework for environmental management. In 2004, the National Environmental Management: Biodiversity Act (NEM:BA, Act 10 of 2004) was passed. NEM:BA is one of the laws built around the NEMA framework, and is intended to promote the protection and conservation of South Africa's rich biodiversity. In 2014, a set of regulations was promulgated in terms of this Act, by which the management of biological invasions is to be governed. These regulations address the import of new alien species, place existing alien species into a number of categories, and specify how these species are to be controlled or managed. One of the specific requirements contained in these regulations is for the South African National Biodiversity Institute (SANBI) to produce regular status reports (Box 1.1).

Section 2 of NEM:BA states that South Africa should "give effect to ratified international agreements relating to biodiversity which are binding on the Republic". The most important of these agreements is the Convention on Biological Diversity (CBD), which South Africa ratified in November 1995. Article 8(h) of this convention requires each Contracting Party, as far as possible and as appropriate, to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species". Article 19 also requires each contracting party to take legislative, administrative or policy measures to provide for effective participation in the convention. Other relevant conventions include the International Plant Protection Convention (IPPC), which requires that signatory countries meet requirements designed to reduce the risks of pests of plants from either leaving or entering the country (while pests originally referred to animals and fungi, the IPPC definition has recently been expanded to include plants as pests themselves). From a marine perspective, the UN Convention on the Law of the Sea obliges parties to prevent, reduce and control the intentional or accidental introduction of species to the marine environment where they may have significant harmful effects. The International Convention for the Control and Management of Ship's Ballast Water and Sediments imposes obligations to prevent, minimise, and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ship's ballast water and sediments.

BOX 1.1 REGULATORY REQUIREMENT FOR A NATIONAL STATUS REPORT

In terms of section 11 of the Alien and Invasive Species Regulations promulgated under the National Environmental Biodiversity Act (NEM:BA) (Act 10 of 2004), the South African National Biodiversity Institute (SANBI) is required to draw up a status report on biological invasions. The wording of the relevant section of the regulations is as follows:

1. The Institute [i.e. SANBI] or a body designated by the Institute must, for the purpose of reporting as contemplated in section 11(1) (a) (iii) of the Act, submit a report on the status of listed invasive species to the Minister within three years of the date on which these regulations come into effect, and at least every three years thereafter [the regulations came into effect on 1 October 2014].
2. A report contemplated in sub-regulation (1) must contain a summary and assessment of:
   a. the status of listed invasive species and other species that have been subjected to a risk assessment; and
   b. the effectiveness of these regulations and control measures based inter alia on information from:
      i. notifications received from owners of land regarding listed invasive species occurring on their land;
      ii. permits issued for listed invasive species;
      iii. Invasive Species Monitoring, Control and Eradication Plans received from organs of state and management authorities of protected areas; and
      iv. emergency interventions and enforcement actions involving listed invasive species issued by the Minister.
5. In preparing a report contemplated in sub-regulation (1), the Institute must carry out the research and monitoring necessary to identify the matters contemplated in sub-regulation (2).

Note: the "Invasive Species Monitoring, Control and Eradication Plans" referred to in the regulations are intended to be drawn up for specific areas. For the purposes of this report these are referred to as area management plans. This is distinct from species management programmes which focus on controlling particular species often across the whole of South Africa.

1.4. ASPECTS OF BIOLOGICAL INVASIONS THAT ARE NOT COVERED

Box 1.1 outlines what has to be covered in the report, but it is worth explicitly noting what is not considered. First, as the status report's primary function is to report on environmental issues, this initial report has a limited focus on the socio-economic problems caused by biological invasions. The most damaging invasive species are human diseases. These are not included in this report. Similarly, pests and weeds that affect agricultural crops are a major threat to sustainable development, but are not within this report's remit unless such taxa also impact upon, or threaten, natural ecosystems.

Secondly, there is a suite of indigenous species that can have undesirable impacts that are similar to the impacts caused by alien species, but which are precipitated by changes in land use or other aspects of global change. Examples include bush encroachment by indigenous plants, and the spread of many indigenous bird species into urban areas. These can present particular problems, but their management needs to be in the context of them as indigenous to the region and as pests within their indigenous ranges.

Finally, the social benefits associated with alien species control programmes that are implemented with the additional goals of employment creation and poverty relief are not covered in this report, as this is not required in terms of the regulations, as well as because there have been no attempts to date to quantify these benefits. However, these benefits should ideally be considered when returns on investment from control projects are calculated (Box 1.2).

See Chapter 8 for a more detailed discussion of gaps, challenges, and potential directions for future reports.

BOX 1.2 SOCIAL BENEFITS ASSOCIATED WITH INVASIVE ALIEN PLANT CLEARING PROGRAMS

This report assesses the status of biological invasions and the effectiveness of control and regulatory measures in South Africa, as required by section 11of the Alien and Invasive Species Regulations (Box 1.1). Most of the alien plant control projects across the country are funded by the Working for Water (WfW) Programme (Box 6.2), which is an Expanded Public Works programme of government and has the dual goals of providing employment and development opportunities to disadvantaged individuals in rural areas, as well as managing invasive alien species. The social goals, besides providing a direct income to tens of thousands of beneficiaries, include attempts to develop entrepreneurial and other skills. WfW has adopted employment practices which ensure that previously disadvantaged individuals, women, the youth, and people living with disabilities are given priority. The magnitude and impact of these social benefits has not been formally quantified, but it should be noted that these benefits need to be considered when determining the full extent of returns on investment arising from alien species control projects (see section 6.4.3 of the report). This has not been addressed in this status report as the issue falls outside of the mandate of this report, and also because there are no reliable estimates of the magnitude of the social benefits.

Beneficiaries employed by the Working for Water Programme in the Eastern Cape Province. Benefits reach over 30 000 people across South Africa every year (Photograph: B. van Wilgen).

1.5. STRUCTURE OF THE STATUS REPORT

This document offers a framework for reporting on the status of biological invasions using a set of indicators; provides, where possible, estimates for these indicators that can serve as a baseline for assessing trends in the future; assesses the gaps that exist in the available information and the research that would be needed to fill them; and provides a summary for policy-makers that lists the major conclusions. This content is divided into chapters and appendices as below:

- Chapter 2 describes the development of a framework for monitoring biological invasions, and outlines a suite of indicators that are used in Chapters 3–7 to assess the status of *pathways*, *species* and *areas*, as well as the *effectiveness of control measures* and *the effectiveness of regulations*. It also provides four high-level indicators that can be added to a suite of other environmental indicators for monitoring the state of the environment.
- Chapters 3, 4 and 5 provide assessments of the status of *pathways*, *species* and *areas* respectively.
- Chapter 6 provides an assessment of the *effectiveness of control measures*, differentiating between those aimed at controlling *pathways*, *species* and *areas* respectively.
- Chapter 7 examines the *effectiveness of regulations* specifically in terms of the levels of compliance that have been achieved in the implementation of the NEM:BA regulations.
- Chapter 8 provides an analysis of the key gaps in data and knowledge required to compile the status report, and to assign reliable values to the indicators, as well as the challenges and opportunities of subsequent status reports.
- Chapter 9 lists the key conclusions arising from this status report. These are intended to provide a starting point for the development of policy responses to the findings presented in this status report.
- Appendix 1 provides a set of fact sheets with details on each of the 21 indicators and four high-level indicators of the status of biological invasions. The details include the use and interpretation of the indicator, the units in which it is presented, the method of calculation, sources of data to inform the calculation, and guidelines for assigning a level of confidence to the indicator.
- Appendix 2 provides details of information sources used to compile the chapter on pathways.
- Appendix 3 provides a list of alien species, along with detailed information on the status of each.
- Appendix 4 gives a full list of invasive species monitoring, control and eradication plans (i.e. area management plans) that had been submitted (as required by the NEM:BA regulations) by 31 March 2017, and provides information on the status of each.

Chapters 3–7 start with a table listing the sources of data that were used to assign values to indicators, together with an assessment of the level of confidence that could be placed in each data source based on completeness and accuracy. In some cases, existing data sources were not used because the levels of completeness and/or accuracy were too low, and using them would lead to the assignment of excessively unreliable values to indicators. Chapters 3–7 also conclude with a summary table of the values assigned to indicators, along with the levels of confidence in the indicators concerned.

The report also contains a consolidated list of references cited in this report, a glossary of terms, and a list of acronyms.

1.6. PROCESS FOLLOWED TO PRODUCE THIS STATUS REPORT

The process followed is outlined in Figure 1.2, with a detailed description of each step below.

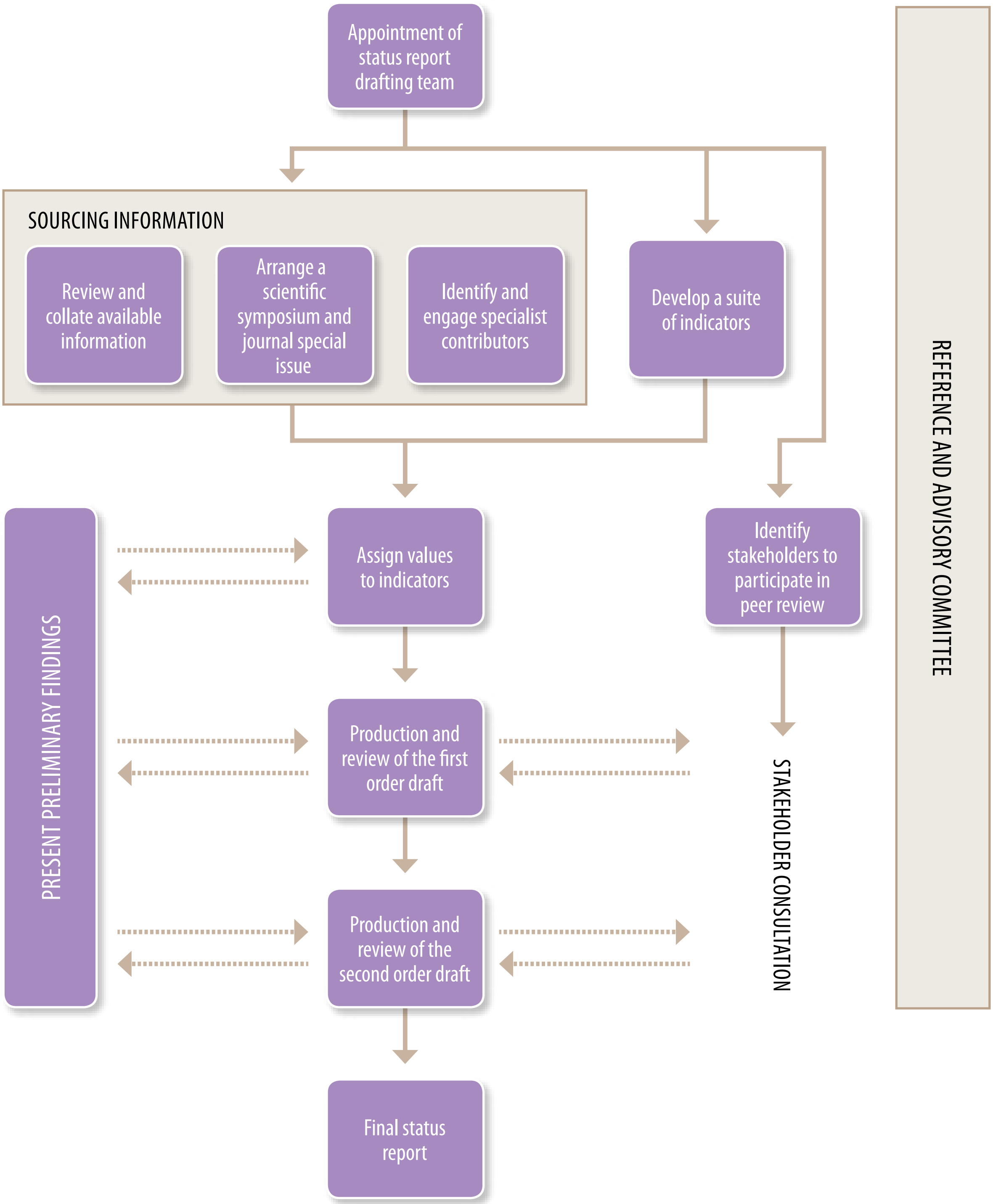


FIGURE 1.2 Process followed for the production of South Africa's first National Status Report on Biological Invasions.

The team responsible for writing the report was composed of staff from the South African National Biodiversity Institute (SANBI) and the DST-NRF Centre of Excellence for Invasion Biology (C•I•B). While activities towards the report commenced in 2015, the drafting team was formally appointed in August 2016, and the official launch of the process was in January 2017 (**Figure 1.3**)

Appoint a status report drafting team – as per the NEM:BA A&IS Regulations, the responsibility for compiling the status report lay with the South African National Biodiversity Institute (SANBI), with provision to involve other stakeholders in the drafting team (Box 1.1). Given the small size of the team available to conduct this work internal to SANBI, the need to engage with a range of institutions and implementing agencies across the country, and the positon of the DST-NRF Centre of Excellence for Invasion Biology (C•I•B) as an established global leader in research on biological invasions (Van Wilgen, Davies, Richardson, 2014), SANBI entered into a collaboration agreement with the C•I•B to produce the report. The SANBI/C•I•B team was responsible for the design of the process, with guidance from a Reference and Advisory Committee.

Reference and Advisory Committee – the project was guided by a reference and advisory committee of six members, drawn from academic institutions and the Department of Environmental Affairs (DEA). The role of the committee was to advise on: (1) the scope and content of the report; (2) the process for the production of the report; (3) the broader engagement required to ensure that the report meets its legal obligations, as well as the expectations of stakeholders; and (4) the sources of information and expertise that could be used to inform the production of the report.

Sourcing Information – the drafting team used three main strategies to obtain information: through the team accessing and collating information themselves; through encouraging experts to contribute a scientific paper to a special issue of a journal; and finally through sending direct requests to domain experts and practitioners for specific inputs.

1. *Review and collate available information* – the drafting team drew on personal knowledge, and undertook a range of literature searches, to identify relevant information and databases. Because the required data were in many cases not available in a readily accessible form, it was also necessary to engage with specialist contributors.
2. *Arrange a scientific symposium and journal special issue* – to provide an impetus for collating information and to raise awareness of the process, experts were invited to present a paper at a scientific symposium, and an open call for paper proposals on the theme of reporting on biological invasions in South Africa was distributed. The symposium was held in May 2016, and manuscripts were subsequently considered for publication in a special issue of the journal *Bothalia: African Biodiversity and Conservation* (Box 1.3; Wilson *et al*., 2017). The information thus generated has proved essential in compiling this report.
3. *Identify and engage specialist contributors* – where the first two strategies were not able to provide information, potential contributors with specialist knowledge about aspects of biological invasions and their management were identified within academic institutions, research institutes and science councils, and in national, provincial and local government. Specialists were approached and invited to contribute information in a format that would allow values to be assigned to indicators.

Develop a suite of indicators – biological invasions are one of several interacting drivers of global change. However, while there are indicators to assess the impact of the other major drivers (e.g. climate change is measured by essential climate variables; land degradation by the rate of conversion of land), an internationally-agreed system of indicators for biological invasions has not yet been developed (though see Latombe *et al*., 2017). It was therefore necessary to further develop a suite of indicators that could be used for the specific purpose of compiling a status report on biological invasions at a national level. The resulting scheme has been submitted to an international journal where it will be subjected to rigorous peer review. The indicators are described in more detail in Chapter 2.

Assign values to indicators – based on the data collated, one of the major tasks of the drafting team was to assign values to the indicators. In most cases, the original data needed to be interpreted in order to assign these values to indicators, and in many other cases data were simply not available. (see Chapter 8 for a discussion of these gaps).

Identify stakeholders to participate in peer review – the impending initiation of the national status report process was communicated to stakeholders in concert with DEA's road-show on the NEM:BA A&IS Regulations in 2015, and as part of the scientific symposium and special issue. But in August 2016, a formal notice informing interested parties of the process to develop a national status report on biological invasions was circulated to the South African invasives list server (invasives@wordlink.co.za); heads of relevant national and provincial government departments; heads of relevant academic departments and institutions; and professional societies and forums (including the Royal Society of South Africa; the Akademie vir Wetenskap en Kuns; the Zoological, Entomological and Botanical Societies; Birdlife South Africa; and the Wildlife and Environment Society of South Africa). Stakeholders were asked to supply their contact details if they wished to be involved in the review of draft chapters of the report.

FIGURE 1.3 In January 2017, the process of drafting the National Status Report on Biological Invasions was officially launched by the SANBI CEO and the Chair of the SANBI Board during the Parliamentary oversight visit attended by members of the Parliamentary Portfolio Committee on the Environment. From left to right: Dr Joseph Matjila (SANBI Board); Prof. Brian van Wilgen (SANBI Board); Mr Thomas Hadebe (Portfolio Committee); Ms Johanna Steenkamp (Portfolio Committee); Mrs Helen Kekana (Portfolio Committee); Mr Solomon Mabilo (Portfolio Committee); Ms Nana Magomola (SANBI Board chair); Dr Sebataolo Rahlao (SANBI); Dr Tanya Abrahamse (SANBI CEO); Mr Phillemon Mapulane (Portfolio Committee chair); Mr Ross Purdon (Portfolio Committee). *Photograph: J. Masilo*.

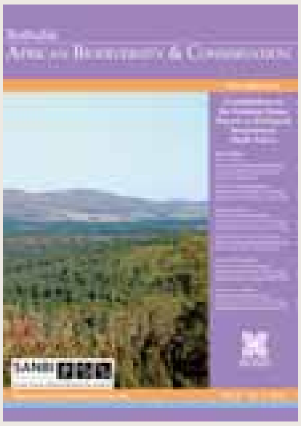
Production and review of the first-order draft – in May 2017, first drafts of chapters were produced by the drafting team, based on information from the sources mentioned above. All identified stakeholders were given an opportunity to provide comments and suggestions for improvement on a first-order draft (which included complete drafts of Chapters 1 to 7; but no Chapters 8 and 9). An opportunity for comment was also extended to members of the Intergovernmental forum: Working Group 1 on Biodiversity and Conservation. Draft chapters were revised to address any issues raised by reviewers and to incorporate any additional information provided. The comments and responses were documented and are available for scrutiny from SANBI on request.

Production and review of the second-order draft – in September 2017, a second-order draft (with versions of all the chapters) of the status report was circulated to all members of the reference and advisory committee, and to domain experts selected to cover the major aspects addressed in the report. Following this review, final revisions of the draft report were made. The comments and responses were again documented and are available for scrutiny from SANBI on request.

Present preliminary findings – parallel to the above processes, preliminary findings, the overall framework, and the indicators were presented at a variety of scientific forums including: the Annual Research Symposium on the Management of Biological Invasions in Southern Africa (May 2016); the annual Biodiversity Planning Forum (June 2016 and June 2017); the Department of Environmental Affair's Research Indaba (August 2016 and August 2017); the South African Association of Botanists' Annual Conferences (January 2017 and 2018); the Biodiversity Management and Planning Forum (August 2017); talks at various research institutions (e.g. the University of the Free State and the University of Venda); and a presentation to the Parliamentary Portfolio Committee on Environment. Invited plenary lectures were also given at the 2017 Annual Research Symposium on the Management of Biological Invasions in Southern Africa (part of the Combined Congress of the Entomological and Zoological Societies of southern Africa, ESSA/ZSSA, July 2017), and the 14th International Conference on the Ecology and Management of Alien Plant Invasions (September 2017). The feedback received was incorporated into the report.

Produce status report – the status report was completed at the end of 2017, and submitted to the Minister of Environmental Affairs early in 2018.

BOX 1.3. A SPECIAL ISSUE OF THE JOURNAL *BOTHALIA: AFRICAN BIODIVERSITY & CONSERVATION* IN SUPPORT OF THE NATIONAL STATUS REPORT ON BIOLOGICAL INVASIONS



The 43rd Annual Research Symposium on the Management of Biological Invasions in Southern Africa was held at Goudini Spa in the Western Cape Province between 18 and 20 May 2016. Following a process of peer review and revision, 19 papers and an editorial overview were published in a special issue of the journal *Bothalia: African Biodiversity and Conservation* (Volume 47, Issue 2, March 2017). This special issue constitutes an additional product arising from the process undertaken to produce this status report. The papers, and the aspects that they address, are listed below. All papers are free to download. https://abcjournal.org/index.php/ABC/issue/view/113

Papers (listed alphabetically by lead author)	Relevant chapter(s)
Clusella-Trullas, S. & Garcia, R.A. Impacts of invasive plants on animal diversity in South Africa: a synthesis. https://doi.org/10.4102/abc.v47i2.2166	Species
Faulkner, K.T., Hurley, B.P., Robertson, M.P., Rouget, M. & Wilson, J.R.U. The balance of trade in alien species between South Africa and the rest of Africa. https://doi.org/10.4102/abc.v47i2.2157	Pathways
Foxcroft, L.C., Van Wilgen, N.J., Baard, J. & Cole, N. Biological invasions in South African National Parks. https://doi.org/10.4102/abc.v47i2.2158	Areas, Control
Greve, M., Mathakutha, R., Steyn, C. & Chown, S.L. Terrestrial invasions on Sub-Antarctic Marion and Prince Edward Islands. https://doi.org/10.4102/abc.v47i2.2143	Areas, Control & Regulations
Henderson, L. & Wilson, J.R.U. Changes in the composition and distribution of alien plants in South Africa: an update from the Southern African Plant Invaders Atlas (SAPIA). https://doi.org/10.4102/abc.v47i2.2172	Species, Control & Regulations

Hill, M.P. & Coetzee, J. The biological control of aquatic weeds in South Africa: current status and future challenges. https://doi.org/10.4102/abc.v47i2.2152	Control, Species
Irlich, U.M., Potgieter, L., Stafford, L. & Gaertner, M. Recommendations for municipalities to become compliant with national legislation on biological invasions. https://doi.org/10.4102/abc.v47i2.2156	Regulations
Kaplan, H., Wilson, J.R.U., Klein, H., Henderson, L., Zimmermann, H.G., Manyama, P., Ivey, P., Richardson, D.M. & Novoa, A. A proposed national strategic framework for the management of Cactaceae in South Africa. https://doi.org/10.4102/abc.v47i2.2149	Control, Regulations & Species
Keller, R.P. & Kumschick, S. Promise and challenges of risk assessment as an approach for preventing the arrival of harmful alien species. https://doi.org/10.4102/abc.v47i2.2136	Regulations
Kraaij, T., Baard, J.A., Rikhotso, D.R., Cole, N.S. & Van Wilgen, B.W. Assessing the efficiency of invasive alien plant management in a large fynbos protected area. https://doi.org/10.4102/abc.v47i2.2105	Control
Marr, S.M., Ellender, B.R., Woodford, D.J., Alexander, M.E., Wasserman, R.J., Ivey, P., Zengeya, T. & Weyl, O.L.F. Evaluating invasion risk for freshwater fishes in South Africa. https://doi.org/10.4102/abc.v47i2.2177	Regulations & Species
Measey, J., Davies, S., Vimercati, G., Rebelo, A., Schmidt, W. & Turner, A. Invasive amphibians in southern Africa: a review of invasion pathways. https://doi.org/10.4102/abc.v47i2.2117	Pathways & Species
Picker, M.D. & Griffiths, C.L. Alien animals in South Africa – composition, introduction history, origins and distribution patterns. https://doi.org/10.4102/abc.v47i2.2147	Species & Pathways
Scholes, R.J., Schreiner, G. & Snyman-Van der Walt, L. Scientific assessments: matching the process to the problem. https://doi.org/10.4102/abc.v47i2.2144	Regulations
Visser, V., Wilson, J.R.U., Canavan, K., Canavan, S., Fish, L., Le Maitre, D., Nänni, I., Mashau, C., O'Connor, T., Ivey, P., Kumschick, S., Richardson, D.M. & the Alien Grass Working Group Grasses as invasive plants in South Africa revisited: patterns, pathways and management. https://doi.org/10.4102/abc.v47i2.2169	Species, Pathways, Control & Regulations
Wood, A.R. Fungi and invasions in South Africa. https://doi.org/10.4102/abc.v47i2.2124	Species & Regulations
Woodford, D.J., Ivey, P., Jordaan, M.S., Kimberg, P.K., Zengeya, T. & Weyl, O.L.F. Optimising invasive fish management in the context of invasive species legislation in South Africa. https://doi.org/10.4102/abc.v47i2.2138	Control, Regulations & Species
Zachariades, C., Paterson, I.D., Strathie, L.W., Hill, M.P. & Van Wilgen, B.W. Assessing the status of biological control as a management tool for suppression of invasive alien plants in South Africa. https://doi.org/10.4102/abc.v47i2.2142	Control, Regulations & Species
Zengeya, T., Ivey, P., Woodford, D., Weyl, O., Novoa, A., Shackleton, R., Richardson, D.M. & Van Wilgen, B.W. Managing conflict-generating invasive species in South Africa: Challenges and trade-offs. https://doi.org/10.4102/abc.v47i2.2160	Regulations

2

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Acacia paradoxa (Kangaroo thorn) – John Wilson

Chapter summary

This chapter outlines the development of a set of 21 indicators for assessing three main aspects of invasions (*pathways*, *species*, and *areas*), as well *interventions* (in terms of both the *effectiveness of control measures*, and the *effectiveness of the regulations*). For each indicator, a fact-sheet was developed, outlining how the indicators are to be measured and providing a method for ascribing a level of confidence when assigning values to indicators.

Indicators for *pathways* describe the opportunities available for introduction to and dispersal within South Africa, as well as the degree to which alien species are being introduced along these pathways.

Indicators for *species* include the number and status of alien species in the country, the extent and abundance of these alien species, and the impacts caused.

Indicators for invaded *areas* include the number of alien species in different areas, the alien species richness relative to indigenous species richness, the abundance of invasive species relative to the abundance of indigenous species, and the impact of invasions on particular areas.

Indicators for the *interventions* include an assessment of key inputs (the regulatory framework, the money spent and the planning coverage), outputs (the degree and quality of treatments applied to pathways, species and areas) and outcomes (the effectiveness of treatments of pathways, species and areas, as well as returns on investment).

This chapter also proposes four high-level indicators: 1) the rate of introduction of new unregulated species; 2) the number of invasive species that have major impacts; 3) the extent of area that suffers major impacts from invasions; and (4) the level of success in managing invasions.

EFFECTIVENESS OF RESPONSES

A set of four high-level indicators has been developed to track trends in:

A	the rate of introduction of new unregulated species to South Africa	7 PER YEAR
B	the number of invasive species that have major impacts	107 SPECIES
C	the extent of South Africa that suffers major impacts from invasions	1.4% OF THE LAND AREA
D	the level of success in managing invasions	5.5%

The values assigned to these indicators set a baseline against which trends in future can be measured, with the overall goal being to implement control and regulatory measures that will improve the situation as measured by these indicators.

2.1. INTRODUCTION

A set of robust indicators is needed to provide a comprehensive picture of the state of biological invasions. While there has been some progress towards this goal at an international level (Hawkins *et al*., 2015, Latombe *et al*., 2017), much remains to be done. It was clear that South Africa's first national status report should build on these international initiatives, but it was also necessary to develop additional indicators to cover those aspects that were not yet catered for in the developing international framework. In addition, there is a specific need to include indicators that directly address the reporting requirements outlined in the regulations. Furthermore, there are no data available to accurately assign values to some indicators for South Africa, nor will it be feasible to collect such data in the medium-term. The process of indicator development in this area will need to continue both in terms of fundamental research, and as part of the development of a practical and informative monitoring framework for biological invasions in South Africa. As such, the indicators proposed here constitute a compromise, partly from international frameworks, partly from first principles, partly simply in terms of a reflection of which data are currently available, while ensuring that there is alignment with the requirements in the regulations.

This chapter presents a set of indicators for use in establishing the status of biological invasions in South Africa based on *basic inventory and ecological research* and the *monitoring and reporting* of the effectiveness of regulations and control measures (Figure 2.1). This chapter also presents a methodology for ascribing a level of confidence when assigning values to these indicators.

2.2. THE RATIONALE FOR THE APPROACH

The phenomenon of biological invasions is caused by a combination of how taxa are moved around by humans (introduction dynamics), the traits of individual taxa (invasiveness), and the susceptibility of the environment to invasions (invasibility). For example, the current distribution of invasive pines in South Africa is a result of how pines have historically been planted for forestry, which species have particular traits that predispose them to invade, and the fact that some areas of the country do not have any indigenous fire-adapted tree species and so are susceptible to woody plant invasions (e.g. the Cape Floristic Region). The explicit consideration of biological invasions in terms of these three aspects [i.e. *pathways*, *species* (or more precisely taxa), and *areas*] is also crucially important for management. Focussing on pathways is important to reduce rates of introduction and spread, but does not address current invasions. Focussing on species can be highly effective in reducing densities of a single species, but can simply clear the way for other species to invade. Integrated and strategic approaches are needed to deal with suites of co-occurring species in any given area, but if management is to be effective in those areas, pathways of introduction need to be managed and in most cases best practice species-specific control measures will need to be implemented.

The invasion process is commonly categorised in terms of an introduction-naturalisation-invasion continuum (Blackburn *et al*., 2011). There are four major invasion stages – pre-introduction, incursion, expansion, and dominance – that align with four management goals – prevention, eradication, containment, and impact reduction. The combination of the need to look at indicators for pathways, species and areas, as well as the need to look at pre-introduction, incursion, expansion and dominance, gives rise to the 3 × 4 framework. This framework was the basis of the draft National Strategy on Biological Invasions in South Africa, and is discussed in detail by Wilson, Panetta & Lindgren (2017). However, the development of indicators for all aspects of invasions at all invasion stages still requires some theoretical development. This report concentrates on indicators for the three aspects (pathways, species, and areas), and not on the four stages (pre-introduction, incursion, expansion, and dominance), although a future report may seek to develop the indicators needed to cover all components of the 3 × 4 framework.

There are, of course, many other ways of conceptualising or categorising biological invasions. Taxonomic, disciplinary or functional lines could also be used, e.g. by considering freshwater fish invasions and riparian plant invasions as separate problems. Alternatively, a status report could be divided into specific biomes, environments or realms. South Africa's National Biodiversity Assessment has, to date, taken this approach and is presented as a series of chapters based on 'realms' – freshwater, marine, and terrestrial. In terms of biological invasions, there is, however, no neat separation between aquatic and terrestrial environments, nor between fish, frogs, and ferns – the essence of the problem is the same. If propagule pressure can be reduced, will this reduce the likelihood of an invasion? What are the impacts? Is a species definitely alien? Management often needs to consider entire systems, e.g. simultaneously managing freshwater fish invasions and riparian plant invasions would lead to a more sustainable outcome than if either group was controlled on its own (Impson, Van Wilgen & Weyl 2013); and the same pathway (e.g. the pet-trade) can be responsible for introducing marine, terrestrial and freshwater organisms. So while it is important to be able to report along geographical or taxonomic lines, not least as this is frequently the level at which data are collected or management is implemented, it is important that such data can be aggregated to give higher level indicators. In this report, the indicators themselves are not split into geographical or taxonomic lines, but the report will consider groupings within each indicator as per the data sources themselves [e.g. the Southern African Plant Invaders Atlas (SAPIA) includes data on alien plants across all habitat types except marine and some coastal habitats].

For the report to be of value it should provide information that can be used to determine how effective interventions have been in reducing the size of current problems. The approach taken in this report is to assess the *effectiveness of interventions* (which is composed of both the *effectiveness of control measures* and the *effectiveness of regulations*) in terms of how they influence aspects of *pathways*, *species* or *areas*. Specifically indicators are presented for *inputs* (e.g. the amount of money spent), *outputs* (i.e. control measures that are in place), and the *outcomes* (i.e. how effective the control measures are). In this report, indicators are not, however, developed for: 1) the underlying processes required for those interventions; or 2) the ultimate impact of the interventions. Interventions require a suite of enabling processes (specifically: accessibility of data and information; organisational and human capacity; research; and public awareness and engagement), but as these are not directly related to outputs that affect outcomes they are not considered here. Developing indicators for these enabling processes might be a priority for future reports. Secondly, if the implications of any intervention for the broader South African community are to be assessed, there must be a link made to general environmental and socio-economic indicators, i.e. the impact. In this report, this link is not made explicit nor is an attempt made to develop indicators specifically for this (as it is more appropriate to co-opt existing sector-specific indicators). It is anticipated that developing the link between what is done in this report (i.e. assessing impact in terms of specific outcome indicators and changes to the indicators of the state of biological invasions) and broader societal indicators for impact will be a major focus of future reports.

In line with international proposals (GEO BON, 2015, Latombe *et al*., 2017), the status reported should be modular. If resources permit, high-level data can be collected without compromising the ability to compare with situations where fewer data or resources are available. For example, accurate distribution data are available for birds, but not for microbes (Chapter 4).

Sniffer dogs are frequently used to detect illegal imports, including alien species

2.3. CONFIDENCE LEVELS

Indicators are, of course, abstractions of the real world and the real world does not always fit neatly into these abstractions. There will be some uncertainty in any values presented whether because of how they were measured or that the subjects of measurement themselves are variable.

This report follows broad guidelines used in related environmental assessments and classifies confidence level of any of the assessments into three broad categories (Table 2.1).

TABLE 2.1 Guidance regarding the use of the confidence rating [adapted from Hawkins et al., 2015, modified from the EPPO pest risk assessment decision support scheme (Alan MacLeod 09/03/2011. revised 28/04/2011. copied from CAPRA, version 2.74; 2)]. Exact definitions are given for each indicator in Appendix 1.

CONFIDENCE LEVEL	DEFINITION
HIGH	There is direct relevant observational evidence to support the assessment; **AND** observations are at the relevant spatial or temporal scale; **AND** the data sources are reliable and of good quality; **AND** the interpretation of data and information is straightforward; **AND** data and information are not controversial or contradictory.
MEDIUM	There is some direct observational evidence to support the assessment, but some information is inferred; **AND/OR** observations are recorded at a spatial or temporal scale which may not be at the relevant scale but extrapolation or downscaling of the data is considered reliable, or to embrace little uncertainty; **AND/OR** the interpretation of the data is to some extent ambiguous or contradictory.
LOW	There is no direct observational evidence to support the assessment, e.g. only inferred data have been used as supporting evidence; **AND/OR** observations are recorded at a spatial or temporal scale which is unlikely to be relevant to the scale required, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties; **AND/OR** evidence is poor and difficult to interpret, e.g. because it is strongly ambiguous; **AND/OR** the information sources are considered to be of low quality or contain information that is unreliable.

2.4. INDICATORS USED IN THIS REPORT

In this section, the indicators used in this report are defined in the context of the overall reporting framework (Figure 2.1). A complete set of indicators for *pathways*, *species* and *areas*, as well as *interventions* (*effectiveness of control measures* and *effectiveness of regulations*) are presented in the sections that follow. Further detail on each indicator is provided in Appendix 1, including the intended use and interpretation of the indicator, the implications of a change in the indicator, and the recommended format of presentation. In addition, Appendix 1 provides information on source data, specifies the procedure to be followed when calculating the indicator's value, and identifies the units in which the indicator is expressed.

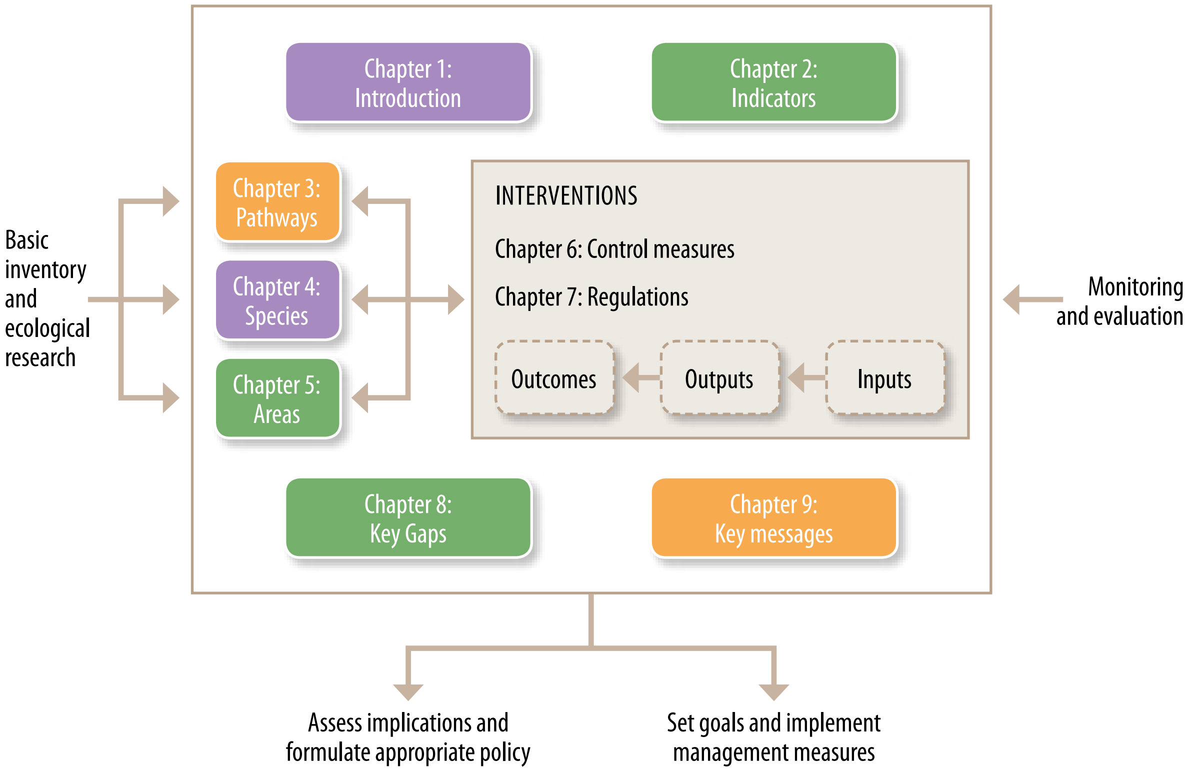


FIGURE 2.1 The structure used in this report. Indicators are developed in this chapter for each of the five subsequent chapters – pathways, species, areas, effectiveness of regulations, and effectiveness of control measures. The effectiveness of regulations and the effectiveness of control measures are considered jointly here as interventions, and are assessed in terms of indicators of inputs, outputs, and outcomes. In chapter 8 key gaps are identified and, in chapter 9, based on the insights from the other chapters, recommendations for policy makers and managers are developed. The indicators do not, however, cover everything in the report. In particular, there are several additional factors that must be reported on in terms of the regulations, but do not directly influence the indicators for the outcomes of the interventions and in and of themselves do not provide information as to whether interventions are succeeding or not. There are also several enabling processes that are not discussed in this report (accessibility of data and information; organisational and human capacity; research; and public awareness and engagement). See section 8.3 for a discussion on how they might be incorporated into future reports.

2.4.1. Pathways

This report considers four indicators for pathways (Table 2.2) that assess the prominence of the pathway and the rate at which taxa are introduced along the pathway, for both introduction into the country, and dispersal within the country: 1) *introduction pathway prominence*; 2) *introduction rates*; and the corresponding 3) *within-country pathway prominence*; and 4) *within-country dispersal rates*.

At a basic level, the indicators use the hierarchical scheme of pathway classification adopted by the Convention on Biological Diversity (CBD), based on six broad categories and 44 sub-categories (Appendix 2; Scalera *et al.*, 2016). If data are available, spatially explicit vectors can be used to facilitate precise response and management. Similarly at a basic level introduction rates are in terms of the number of alien species introduced, although ideally there would be estimates of colonisation and propagule pressure for each introduction event.

TABLE 2.2 Indicators for reporting on the status of introduction and dispersal pathways (indicator values are estimated in Chapter 3). For full details of how to calculate the indicators, see Appendix 1.

INDICATOR	METRIC BASIC		ADVANCED
1. Introduction pathway prominence	**1.1.** Five qualitative categories indicating the prominence of CBD pathway sub-categories (Not known; Pathway not present; Minor; Moderate; Major)	**1.2.** A ranked order of pathways in terms of their prominence	**1.3.** Spatially explicit vectors that detail the amount, number and value of goods or vessels moving into the country per pathway, with information on the sources, routes, destinations, and timings
2. Introduction rates	**2.1.** The total number of alien species introduced through each CBD pathway sub-category over all time	**2.2.** Five categories demonstrating changes over a recent period of time (e.g. since the 1980s or in the past decade) in the number of species introduced through each pathway (Not known; No introductions; Increase; Decrease; Minimal change)	**2.3.** Number of individuals of each species introduced through the pathways and place and date of introduction
3. Within-country pathway prominence	**3.1.–3.3.** As for 1. *Introduction pathway prominence*, for within-country dispersal rather than introductions		
4. Within-country dispersal rates	**4.1.–4.3.** As for 2. *Introduction rates*, for within-country dispersal rather than introductions		

2.4.2. Species

This report uses species as the primary biological unit in line with the majority of the taxa listed under the National Environmental Management: Biodiversity Act, Alien and Invasive Species Regulations (the NEM:BA A&IS Regulations). However, several taxa are listed at levels other than species, invasions can occur at the gene level (e.g. resulting in the loss of indigenous species through hybridisation), and fundamentally biological invasions are a population level phenomenon. These issues might be a focus for future reports.

The proposed system for global observation and monitoring of alien species identified three essential variables for monitoring species – alien status, occurrence and impact (Latombe *et al.*, 2017). In this report elements of determining alien status are combined with a very coarse categorisation for occurrence (5. *Number and status of alien species*). If a species is present and clearly alien, the next part of defining status is to determine where it is, and how common it is (indicators 6. *Extent of alien species*; and 7. *Abundance of alien species*). Finally, in direct alignment with the proposed global scheme is indicator 8. *Impact of alien species* (Table 2.3).

For the *Number and status of alien species*, at a basic level this is simply the number of invasive species (as these are the primary focus of most management efforts). At a more advanced level all alien species should be listed and placed into relevant categories along the introduction-naturalisation-invasion continuum (Blackburn *et al*., 2011), but in all cases there are two decisions to be made: 1) is a species alien or indigenous?; and if it is alien, 2) is it present in the region? The first part, i.e. determining nativity, is often fairly straight-forward, but in the case of cosmopolitan species it might be impossible to trace the indigenous range, and for other taxa, (microbes and fungi in particular) determining indigenous ranges requires extensive sampling and molecular analysis with little guarantee of success (Wood, 2017). Determining presence can be straightforward in many cases, but highly problematic in others. The minimum standards required for a species to be included on a list of alien species vary between lists, and in many cases no physical specimen is required. Similarly there is often, at least historically, no requirement or legal mechanism whereby deliberately introduced species needed to be recorded. Import permits alone are not sufficient proof of presence as permits can be issued, but not actually used. Moreover alien species, even those that have established, do not always persist (Simberloff & Gibbons, 2004). For example, *Tetrapygus niger* (black sea urchin) was recorded in South Africa in 2007, but the area where it was present has been transformed. Based on a recent survey, the species is considered to no longer be present in the country (Mabin, Wilson & Robinson, 2015). This points to the need to document when, where, and on what basis, the presence of a taxon was noted. Similarly, the evidence for declaring that a species is absent needs to be made clear. Such information is important for policy, as it is a key determinant when evaluating applications to import species.

By their nature, lists of alien species are dynamic as taxa are introduced, naturalise, become invasive, disappear from an area, or are eradicated. There are a few additional issues that mean lists change over time, e.g. cryptic taxa are identified as aliens, or there are taxonomic changes (Jacobs *et al*., 2017, Pyšek *et al*., 2013). Consequently, lists need to be dynamic, and changes need to be clearly documented based on defined minimum standards (Murray *et al*., 2017). The level of confidence that any particular species is still present should decline with time since the last specimen was collected or the last recorded field sighting.

In terms of alien species distributions, the *Extent of alien species* can be assessed using occupancy at broad spatial scales. At the broadest scale this will be occupancy at provincial, biome, primary catchment scale or marine ecoregion, but data are often available at a quarter-degree grid cell (~630–710 km^2 at the latitude of South Africa) and so this is used here. The measure of the *Abundance of alien species* will vary depending on the type of organism. For mobile taxa this might be an estimate of numbers of individuals, while for sessile organisms it might be a measure of how much of the area is occupied at a fine scale (i.e. condensed canopy area). These data are, of course, not always available or the data are insufficient to provide reliable estimates. Therefore a categorical approach might be needed (e.g. rare, occasional, or abundant). Data for extent and abundance come from physical collections, mapping (atlas) projects and dedicated surveys. Each method has its own strengths and biases (Robinson, Cumming & Erasmus, 2010), and therefore affect the confidence level with which estiamtes are given.

Finally, the *Impact of alien species* needs to be measured both in environmental and socio-economic terms. Recently, there has been substantial progress in developing consistent metrics that can be used to score the impacts of particular alien taxa, in particular through the Environmental Impact Classification for Alien Taxa (EICAT) scheme (Blackburn *et al*., 2014, Hawkins *et al*., 2015) that has recently been adopted by the IUCN and the more recent Socio-Economic Impact Classification of Alien Taxa Scheme (SEICAT; Bacher *et al*., 2018). EICAT provides a consistent method for rating impact as minimal, minor, moderate, major or massive, with interpretations provided for different impact mechanisms (for example competition, predation or herbivory, or chemical, physical or structural features of the ecosystem). The accurate assessment of species within this system requires confirmation that the species is alien, and the availability of adequate data to confidently place the species into one of the rating categories. SEICAT is similar in structure, with impacts measured in terms of how alien species affect what people do.

TABLE 2.3 Indicators used for reporting on the status of alien species (indicator values are estimated in Chapter 4). For full details of how to calculate the indicators, see Appendix 1.

INDICATOR	METRIC BASIC		ADVANCED
5. Number and status of alien species	**5.1.** Number of invasive species	**5.2.** Number of alien species in one of three categories (alien but not naturalised, naturalised but not invasive, invasive)	**5.3.** Number of species in each of the 12 different stages identified in the Unified Framework for Biological Invasions
6. Extent of alien species	**6.1.** Number of large-scale national subdivisions (provinces, primary catchments or bioregions as appropriate) occupied per species	**6.2.** Number of finer-scale national subdivisions (quarter-degree grid cells or hectads) occupied per species	**6.3.** Range size for each species (e.g. km^2 or ha)
7. Abundance of alien species	**7.1.** Categorical measure of abundance per species in one of five categories (absent, rare, occasional, abundant, not known)	**7.2.** Number of individuals for mobile organisms or condensed area occupied for sessile organisms	**7.3.** Abundance estimates divided into appropriate stage or age cohorts. At a basic level numbers of individuals which are reproductive or not
8. Impact of alien species	**8.1.** Categorical factor with eight levels. A single value is presented which is the maximum current recorded impact in South Africa in terms of either the Environmental Impact Classification of Alien Taxa (EICAT) or Socio-economic Impact Classification of Alien Taxa (SEICAT) schemes (Bacher *et al*., 2018, Blackburn *et al*., 2014)		**8.2.** The current and maximum ever recorded EICAT and SEICAT scores for each possible impact mechanism for each species in South Africa

2.4.3. Areas

There are a variety of ways to categorise areas. While administrative regions are useful for management, they do not necessarily follow biogeographical zones. But even biogeographical zones, as defined by the presence of indigenous species, are not necessarily useful or appropriate as the processes that set biogeographic boundaries can differ from those that determine spatial patterns for alien species (Rouget *et al*., 2015). As such, areas are often defined for practical planning reasons, e.g. municipalities or national parks, or a simple grid is used, e.g. quarter degree grid cells [QDGCs, often also (incorrectly) called quarter degree squares, QDSs]. In South Africa tertiary catchments are also frequently used (e.g. Roux *et al*., 2008), but while perhaps more ecologically relevant, this is not the scale at which data on biological invasions in the country has been collected. Therefore in this report two levels are considered: broad scale (provinces, biomes, marine regions, or primary catchments as appropriate) and QDGCs. These scales are largely dictated by the availability of data.

The first indicator is simply the total number of alien species in a given area (9. *Alien species richness*, Table 2.4). At a basic level this is the number of invasive species (as data are mostly collected on invasive species rather than those in captivity or cultivation and the invasive species are usually those of most direct concern). At more advanced levels, the number of alien species at different stages of the Unified Framework is reported on. The assumption is generally made that if a species is invasive in one area and recorded in another it is also invasive there, but this would require some refinement and ideally area-specific assessments of introduction status are required.

While *Alien species richness* provides a useful measure of the invasions, it does not take into account overall differences in species richness in an area. Therefore, Catford *et al*. (2012) recommend additional relative measures, codified here as 10. *Relative alien species richness* and 11. *Relative invasive abundance* (Table 2.4). The relationship between *Relative alien species richness and Relative invasive abundance* can indicate the presence of dominant invasive species and the trajectory of invasion over time (Catford *et al*., 2012). In this report, the distinction is made between *Relative alien species richness* and *Relative invasive species abundance*, as the former can give an indication of the potential size of future problems (taking all alien species into account), but the latter is a metric of the current status of invasions. At a basic level *Relative invasive abundance* is measured qualitatively (i.e. not known; invasive-free; minor; moderate; extensive; dominant), but where data allow a quantitative measure of the total abundance is preferred (e.g. percentage of cover, biomass, or numbers of individuals).

The importance of the *Impact of invasions* within a certain area will differ depending on the area-type. For example, in protected areas with high indigenous biodiversity, the degree of threat to indigenous biodiversity would be the main critical indicator, whereas in other areas reduction in ecosystem services (in terms of benefit flows and financial flows) or impacts on human livelihoods would be more important. There is no accepted, unified system for the classification of the impacts of all biological invasions on a particular area. Nonetheless, several studies have quantified the impact of particular invasions on the overall biodiversity of an area (e.g. Van Wilgen *et al*., 2008); and reductions in particular ecosystem services, expressed both in terms of benefit flows (e.g. the amount of water flowing from a catchment, or the number of livestock supported on a rangeland, Van Wilgen *et al*., 2008) or financial flows (the value of the benefits in monetary terms, De Lange & Van Wilgen 2010). Finally, the effects of invasive species can be assessed in terms of their impact on human livelihoods in a given area (Shackleton *et al*., 2007).

In the absence of other indicators, we propose to measure the *Impact of invasions* for particular areas of South Africa in terms of the reduction in water resources, grazing capacity and biodiversity (Table 2.4). Similar to the categories under the EICAT scheme, we propose that reductions in the service of < 2% are minor; 2–10% will be moderate; 10–50% will be major; and > 50% will be massive. These cut-offs are somewhat arbitrary and, unlike EICAT, they do not take the permanence of the change into account. We propose that a national status report should assess these reductions for particular ecosystem services for which at least some estimates have been made, or where models exist to make them. Based on an EICAT assessment, it should also be possible to convert information on species-impact status into the appropriate area-impact status for a target region. This is, however, clearly a topic where more work is required. It would be desirable to develop advanced indicators that could express the effects of reductions in ecosystem services in economic or social terms (De Lange & Van Wilgen, 2010), ideally again linking conceptually with the EICAT scheme.

TABLE 2.4 Indicators for reporting on the status of biological invasions in areas (indicator values are estimated in Chapter 5). The choice of the spatial unit varies, though generally it can be one of three levels: at a coarse scale (e.g. number of provinces / primary catchments or marine bioregions); at a quarter degree grid cell scale (QDGC); or at a scale relevant to regulations and management (e.g. national parks or municipal areas). For full details of how to calculate the indicators, see Appendix 1

INDICATOR	METRIC BASIC ······		······ ADVANCED
9. Alien species richness	**9.1.** The total number of invasive species per large-scale national sub-division (provinces, primary catchments or bioregions as appropriate)	**9.2.** The total number of invasive species per finer-scale national sub-division (quarter-degree grid cells or hectads)	**9.3.** The number of alien species in different stages of the Unified Framework per finer-scale national sub-division
10. Relative alien species richness	**10.1.** The proportion of invasive and indigenous species in a spatial unit that is invasive	**10.2.** The proportion of all species (indigenous and alien) that are at different stages of the Unified Framework per finer-scale national sub-division	
11. Relative invasive abundance	**11.1.** The proportion of the abundance (measured as cover, biomass, or number of individuals depending on the taxonomic group under consideration) that is invasive expressed at six levels for a given spatial unit (not known; invasive-free; minor; moderate; extensive; dominant)	**11.2.** A quantitative estimate of the percentage abundance that is invasive for a given spatial unit	
12. Impact of invasions	**12.1.** Factor with five levels of impact (not known; minor; moderate; major; massive)	**12.2.** The reduction caused by the invasions expressed quantitatively in the units in which the ecosystem service is measured	**12.3.** Net present monetary value of the reduction in the relevant ecosystem service or biodiversity indicators

2.4.4. Interventions (effectiveness of control measures and regulations)

While the above indicators cover current status in terms of the invasions themselves, the current status can only be understood in the context of whatever responses are or have been in place (be they control measures or regulations). For a report to be of most value, it should also assess the effectiveness of these measures, specifically the status of pathway management plans; species management programmes; and area management plans.

The key challenge here is to define indicators that would allow for an assessment of whether or not the policy and control measures are changing the status of biological invasions, i.e. the outcome (Figure 2.2). One of the main criticisms of the management of biological invasions in South Africa to date is that monitoring and reporting has focussed on inputs (e.g. amount spent and number of people employed) or outputs (e.g. extent of area treated, which is usually assessed uncritically in terms of the quality of the treatment) rather than outcomes (e.g. changes to the number and abundance of invasive species in an area).

This report focuses on inputs in terms of the 13. *Quality of the regulatory framework*; the 14. *Money spent*; and the 15. *Planning coverage* (Table 2.5). These form the basis for deciding which *pathways, species,* and *areas* need to be treated. At a basic level, the outputs are assessed in terms of whether the area that needs to be treated is being treated, and at an advanced level assessed in terms of the quality of the treatments (indicators 16–18). However, even a basic assessment of the outcomes (indicators 19–21; the *Effectiveness of pathway, species* and *area treatments*), requires some categorisation of whether the control is making a difference or not (and separately whether control measures are having any non-target negative consequences) (Table 2.5). The effectiveness of treatments should also be measured in terms of the impact on *pathway*, *species*, and *area* indicators and ideally (at an advanced level) the effectiveness of treatments are assessed in terms of the return on investment, linking back to the 14. *Money spent* input (Table 2.5). In future reports, it would be desirable to explicitly separate efforts at different invasion stages (pre-introduction, incursion, expansion, and dominance), as different management goals are appropriate at different invasion stages (see Section 2.1). For example for pathways it is important to get estimates of how much effort, where and when, should be placed in monitoring a given pathway Bacon, Bacher & Aebi 2012, Faulkner *et al.*, 2016b).

Ultimately, interventions to address the current and potential impact of biological invasions should be done in the broader context of South African society and the need to ensure a prosperous country for future generations. This report does not, however, consider the impact of interventions on other biodiversity and socio-economic indicators. This is an area where future collaboration will likely be particularly fruitful, in particular so that the report on the status of biological invasions will feed into other such processes (e.g. the National Biodiversity Assessments), and so that interventions can be adjusted to be appropriate in the context of South African society.

TABLE 2.5 Indicators for reporting on the effectiveness of interventions (indicator values are estimated in Chapter 6). For full details of how to calculate the indicators, see Appendix 1.

INDICATOR	METRIC BASIC ······ ADVANCED		
13. Quality of regulatory framework	**13.1.** Factor with four levels at a national scale (none; partial; substantial; complete)	**13.2.** As for 13.1. but for a range of different administrative entities, and incorporating an evaluation of inter-agency co-operation	
14. Money spent	**14.1.** Annual government expenditure at a national scale	**14.2.** Annual government expenditure separated into expenditure on the relevant components of pathways, species and areas	**14.3.** As for 14.2 including expenditure by private individuals/organisations, and detailed accounts of the sources of funding
15. Planning coverage	**15.1.** The proportion of each component (pathways, species, and areas) that has a regulatory requirement for a management plan that has a management plan in place	**15.2.** As for 15.1, but including an assessment of the quality of plans as gauged against a minimum set of criteria for adequate plans	**15.3.** The presence and quality of management plans for each component (pathways, species, and areas) that have been ranked in terms of their priorities

INDICATOR	METRIC BASIC ········ ADVANCED		
16. Pathways treated	**16.1.** Factor with five categories depending on the degree to which pathway sub-categories are subjected to a management intervention (not known; none; partial; substantial; complete)	**16.2.** Proportion of vectors that are subjected to a management intervention per pathway sub-category	**16.3.** As 16.2, with an assessment of the quality of the interventions (not known; inadequate; partially adequate; adequate)
17. Species treated	**17.1.** Proportion of regulated species that are being subjected to a management intervention	**17.2.** Five categories for the degree to which populations of an alien species identified as requiring management are actually being managed (not known; none; partial; substantial; complete)	**17.3.** As for 17.2, but with each intervention (per population or relevant area) assessed as not known; inadequate; partially adequate; adequate
18. Area treated	**18.1.** The proportion of areas that need to be managed that are being managed	**18.2.** As 18.1 with interventions assessed as (not known; inadequate; partially adequate; adequate)	
19. Effectiveness of pathway treatments	**19.1.** Number of pathways in six categories of control effectiveness (not known; counter-productive; none / ineffective; partial; effective; permanent) **AND** An assessment of any negative impacts of control	**19.2.** Quantitative measure of impact on relevant pathway indicators **AND** A formal environmental and social assessment of non-target impacts of the interventions	**19.3.** Return on investment expressed as a ratio of the amount spent on control to the value of avoided cost of impact for pathways treatments **AND** Non-target impacts as a cost
20. Effectiveness of species treatments	**20.1.** As for 19.1, but for species subcategories	**20.2.** As for 19.2, but for species indicators	**20.3.** As for 19.3, but for species treatments
21. Effectiveness of area treatments	**21.1.** As for 19.1, but for area subcategories	**21.2.** As for 19.2, but for area indicators	**21.3.** As for 19.3, but for area treatments

2.5. HIGH-LEVEL INDICATORS

This report proposes a total of 21 indicators (Tables 2.2–2.5). However, an additional set of high-level indicators are needed for the national suite of environmental indicators on which the Department of Environmental Affairs reports on a regular basis. Ideally the lower-level indicators should be of a nature that they can be aggregated to derive the higher-level indicator. Four indicators are proposed here in line with the *pathway, species, area, intervention* framework (Table 2.6).

TABLE 2.6 Proposed high-level indicators for monitoring the status of biological invasions at a country level. For full details of how to calculate the indicators, see Appendix 1.

INDICATOR	DESCRIPTION
A. Rate of introduction of new unregulated species (pathways)	This provides an indication of potential future biological invasions (i.e. species-based invasion debt). Species which have been introduced following a proper detailed and independently assessed risk analysis are not included. In this context new refers to new to South Africa, and unregulated refers to those taxa which were not legally imported to South Africa.
B. Number of invasive species that have major impacts (species)	The total number of alien species that have been reported to have a Major (MR) or Massive (MV) impact under either the EICAT or SEICAT schemes provides an indicator of the current size and complexity of the problem. A growth in the number of species would indicate an increase in consequences and management complexity.
C. Extent of area that suffers major impacts from invasions (areas)	The extent of invaded area that suffers major impacts is an indicator of the overall extent of impacts of biological invasions. Invaded areas are expected to deliver fewer or diminished ecosystem services, and/or to support lower levels of biodiversity.
D. Level of success in managing invasions (interventions)	The degree of success achieved by control measures will vary from place to place, and this indicator is intended to provide an assessment of overall control effectiveness across all projects. High levels of effectiveness would indicate that control measures are appropriate and that the goals of management are realistic and achievable. Low levels of effectiveness would indicate inefficiencies in management, or unrealistic expectations and goals, or both. It should trigger a thorough examination of the component projects with a view to re-allocating national-level resources to projects where the goals are more likely to be achieved, or to re-defining more realistic goals.

2.6. FRAMEWORK

The framework used in this report is shown in Figure 2.2, with further details in Appendix 1.

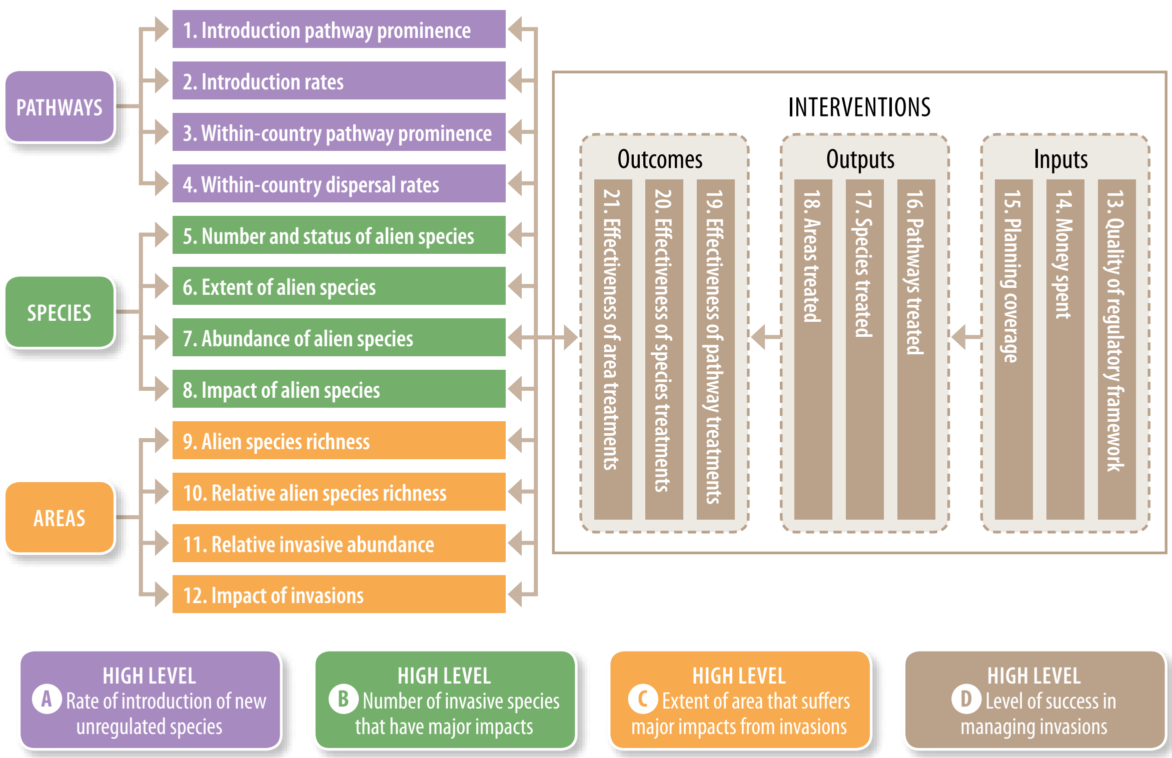
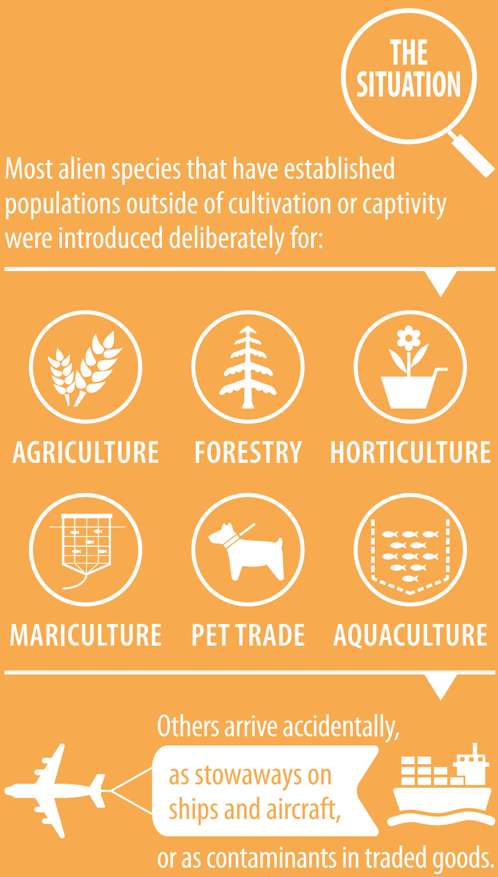


FIGURE 2.2 The 21 indicators and four high-level indicators used in this report. Details of the indicators are provided in Tables 2.2–2.6, with factsheets for each indicator in Appendix 1.

3
PATHWAYS OF INTRODUCTION

Lead authors:
Katelyn T. Faulkner,
John R. Wilson

Parthenium hysterophorus (famine weed) – Yercaud Elango



Chapter summary

This chapter reports on the status of how alien taxa are introduced to South Africa and how they are dispersing and spreading around the country. Four indicators were used to evaluate the pathways of introduction and dispersal: (1) *Introduction pathway prominence*; (2) *Introduction rates*; (3) *Within-country pathway prominence*; and (4) *Within-country dispersal rates*. An additional high-level indicator, the (A) *Rate of introduction of new unregulated species*, is also presented and discussed.

There are many different potential pathways of introduction to South Africa and the prominence of some of these pathways has increased markedly over time, in particular with increasing trade. The goods, people and transport vessels that are related to these pathways can enter the country through 72 official ports of entry.

Alien species are being introduced to South Africa through a wide variety of pathways, and although most alien taxa have been intentionally imported into the country, many have been accidentally introduced as commodity contaminants or as stowaways on transport vectors. In addition, some taxa have entered the Republic from neighbouring countries through natural spread over the 4862 km-long land borderline, but none have spread into the country through human-built corridors that connect previously unconnected regions (e.g. canals). Most alien taxa were originally imported intentionally for the ornamental plant trade and some have subsequently escaped from cultivation.

Overall the rate of introduction of new taxa appears to be increasing. For many pathways there has been an increase or no major change in introduction rate since the 1990s, and only a few pathways (e.g. introductions for fishing and aquaculture) are no longer responsible for the introduction of new alien taxa. Notably, however, it was not possible to ascribe > 50% of alien taxa to an introduction pathway.

South Africa's extensive and well-functioning transport networks facilitate the transportation of a large, and increasing, amount of goods and people; and so once an alien taxon has been introduced to South Africa, further dispersal or natural spread is highly likely. Taxa that are indigenous to the Republic can also be dispersed to parts of the country where they are not indigenous. Commodity contaminants or stowaways can be dispersed along the extensive transport networks, and there is also a thriving internal trade in species for a variety of purposes. Alien taxa may also spread naturally within the country, and utilise human-made corridors like tunnels and canals that connect previously unconnected regions.

For most of the pathways of introduction for which forecasts could be made, an increase in prominence is expected in the future. For some of these pathways control measures are not in place, and unless this changes, further increases in the rates of introduction of alien species are likely.

3.1. INTRODUCTION

The processes that lead to the introduction of alien species from one geographical location to another have been termed the 'pathways of introduction' (Richardson *et al.*, 2011a). These pathways are numerous and involve both the intentional and accidental introduction of alien organisms (Hulme *et al*., 2008). For example, biological control agents are intentionally introduced to manage invasive species from their indigenous range (Zimmermann, Moran & Hoffmann, 2004), while plant pests are often accidentally introduced when plants are imported from other countries (Kenis *et al*., 2007; Saccaggi & Pieterse, 2013; Saccaggi *et al*., 2016). In this chapter, the term 'pathways of introduction' refers to the processes that lead to the introduction of an alien organism to the country, while 'pathways of dispersal' refers to the processes that lead to the movement of an alien organism within the country after introduction.

As managing alien species once they have been introduced is difficult and costly (Hulme, 2006), it is often more efficient and cost-effective to prevent their introduction (Leung *et al*., 2002; Simberloff, 2006; Simberloff *et al*., 2013). To achieve this, information on how and/or why alien species are introduced is used to identify the pathways of introduction and dispersal, and prioritise these pathways for management (Hulme *et al*., 2008; Essl *et al*., 2015a; Saul *et al*., 2017). Adequate pathway-specific policies and interventions that target priority pathways must then be developed, implemented and enforced, and their effectiveness monitored (Hulme, 2006, 2015; Hulme *et al*., 2008; Essl *et al*., 2015a; Saul *et al*., 2017). For example, in South Africa permits are required when intentionally importing biological control agents (Klein *et al*., 2011), while imported plant products are inspected at ports of entry for contaminants (Saccaggi & Pieterse, 2013).

The importance of such action has been recognised by the Convention on Biological Diversity (CBD), and signatories, like South Africa, are required to identify, prioritise and manage their pathways of introduction [see Aichi Biodiversity Target 9 (UNEP, 2011)]. To help countries achieve this, the CBD has adopted a hierarchical pathway categorisation scheme (CBD, 2014; Essl *et al*., 2015a). This scheme recognises six pathway categories (release in nature, escape from confinement, transport - contaminant, transport - stowaway, corridor and unaided), which are divided into 44 subcategories (CBD, 2014; also see Figure 3.1). In the scheme a 'release in nature' refers to the intentional introduction of an alien organism into the natural environment for the purpose of human use (e.g. biological control agents for the control of alien plants, or trout for angling purposes). An 'escape from confinement' refers to the movement of an alien organism kept in confinement into the natural environment, and includes both the accidental and irresponsible release of live organisms (e.g. both escaped and unwanted pets). 'Transport – contaminant' involves the unintentional introduction of an alien organism with an intentionally imported commodity (e.g. pests on imported food, animals or plants); while 'transport – stowaway' refers to the introduction of an alien organism attached to transport vessels or their associated equipment and media (e.g. hull fouling marine species, hitchhikers in aeroplanes and marine organisms introduced with the release of ballast water by ships). 'Corridor' involves the natural spread of alien organisms into a new region through human-constructed transport infrastructure that connects previously unconnected regions (e.g. the movement of species through international canals that connect previously unconnected seas); while 'unaided' refers to the natural spread of an alien organism from a region where it was previously introduced, through the above mentioned pathways, to another region where it is not indigenous. The subcategories of the scheme (Figure 3.1) enable tailored regulations and interventions to be developed and implemented (Essl *et al*., 2015a; Saul *et al*., 2017).

The introduction and dispersal of alien species are influenced by a number of interacting variables (including the environment and species traits). In particular, trends in socio-economic factors (e.g. management interventions, fashions, economic conditions) play an important role in shaping the pathways of introduction and dispersal, and determining how they change over time (Hulme *et al*., 2008; Essl *et al.*, 2011, 2015a; Ojaveer *et al.*, 2017; Saul *et al.*, 2017; Seebens *et al.*, 2017; Zieritz *et al.*, 2017). For example, changes to global energy markets might result in an increase in the number of marine species introduced to the USA through the release of ballast water (Holzer *et al.*, 2017); and while acclimatisation societies facilitated the release of many alien species in New Zealand, Australia and the USA, a decrease in the public and scientific support for these societies during the twentieth century led to a decrease in these activities (Seebens *et al.*, 2017).

It is, therefore, important to understand the potential pathways of introduction and the role they play, as well as how important they might be for the introduction of alien organisms. The four indicators developed to track these factors are: (1) *Introduction pathway prominence*, (2) *Introduction rates*, (3) *Within-country pathway prominence*, and (4) *Within-country disper*sal rates (Table 2.2). *Introduction* and *Within-country pathway prominence* consider the size of the pathways of introduction and dispersal but do not take into account the importance of the pathways for the introduction or dispersal of alien organisms. *Introduction rates* and *Within-country dispersal rates* consider the importance of the pathways for the introduction and dispersal of new alien organisms. Information on how these indicators have changed over time and forecasts of future changes not only inform the development of policies and management strategies but are vital when evaluating the effectiveness of pathway-related control measures.

The status of the pathways of introduction in South Africa and how they have changed over time has been recently assessed using historical introduction data (see Faulkner *et al.*, 2016a). Building on this work, this report refines the analysis using the pathway categorisation scheme adopted by the CBD, and historical introduction and socio-economic data were obtained to populate the four indicators discussed above. These indicators were used to evaluate current pathway status and historical changes to the pathways, and where possible, socio-economic forecasts were obtained to get an indication of how these pathways might change in future. Finally, the effectiveness of pathway related control measures is evaluated and sources of uncertainty addressed (including knowledge gaps). The effectiveness of pathway related control measures and regulations are discussed in Chapter 6 and 7 respectively.

Facility for mass-rearing biological control agents – Kim Weaver

INCREASING HUMAN ROLE ↑

MECHANISM OF ENTRY	PATHWAY CATEGORY	PATHWAY SUBCATEGORY	IR	CHANGE IN IR	IPP	FORECAST	CONTROL
COMMODITY	Release in nature	Biological control	111	↓	Mod	↑	E
		Erosion control/dune stabilisation	68	NK	NK	NK	NK
		Fishery in the wild	15	✗	Maj	NK	E
		Hunting	30	↑	Mod	↑/↓	N/I
		Landscape/flora/fauna "improvement" in the wild	8	✗	PNP	–	P
		Introduction for conservation purposes or wildlife management	0	✗	NK	NK	NK
		Release in nature for use other than above	8	NK	NK	NK	NK
		Other intentional release	0	✗	NK	NK	NK
	Escape from confinement	Agriculture	91	NK	Maj	↑	NK
		Aquaculture/mariculture	12	✗	Min	↑	E
		Botanical garden/zoo/aquaria	3	✗	Min	NK	E
		Pet/aquarium/terrarium species	22	–	Min	NK	N/I
		Farmed animals	5	✗	Maj	NK	E
		Forestry	30	NK	Maj	NK	NK
		Fur farms	1	✗	Min	NK	E
		Horticulture	237	NK	Mod	↑	NK
		Ornamental purpose other than horticulture	1	✗	NK	NK	E
		Research and ex-situ breeding	4	NK	Min	NK	NK
		Live food and live baits	5	✗	NK	NK	E
		Other escape from confinement	72	NK	NK	NK	NK
	Transport – Contaminant	Contaminant nursery material	3	NK	Mod	NK	NK
		Contaminated bait	0	✗	NK	NK	NK
		Food contaminant	7	NK	Maj	NK	NK
		Contaminant on animals	9	–	Maj	NK	N/I
		Parasites on animals	13	–	Maj	NK	N/I
		Contaminant on plants	20	–	Mod	NK	N/I
		Parasites on plants	2	–	Mod	NK	N/I
		Seed contaminant	8	NK	Mod	NK	NK
		Timber trade	10	NK	Maj	NK	NK
		Transportation of habitat material	6	–	NK	NK	N/I
TRANSPORT VECTOR	Transport – Stowaway	Angling/fishing equipment	0	✗	Maj	↑	N/I
		Container/bulk	0	✗	Mod	↑	NK
		Hitchhikers in or on airplane	5	NK	Mod	↑	NK
		Hitchhikers on ship/boat	21	–	Mod	↑	N/I
		Machinery/equipment	0	✗	NK	NK	N/I
		People and their luggage/equipment	0	✗	Maj	↑	NK
		Organic packing material, in particular wood packaging	1	NK	NK	NK	NK
		Ship/boat ballast water	51	–	Mod	↑	N/I
		Ship/boat hull fouling	68	↑	Mod	↑	N/I
		Vehicles	1	NK	Maj	NK	N/I
		Other means of transport	0	✗	NK	NK	N/I
NATURAL SPREAD	Corridor	Interconnected waterways/basins/seas	0	✗	Min	–	N/I
		Tunnels and land bridges	0	✗	Min	–	N/I
	Unaided	Natural dispersal across borders of invasive alien species that have been introduced through pathways 1 to 5	9	–	Maj	↑	N/I

FIGURE 3.1 The current and forecasted status of the pathways of introduction and the effectiveness of control measures. IR: rates of introduction for the pathways (i.e. number of taxa introduced over all time), Change in IR: changes to the rate of introduction in the last full decade in comparison to that of the previous decade (NK: not known; ↑ increase; ↓ decrease; – minimal change; ✗ no introductions), IPP: introduction pathway prominence (NK: not known; PNP: pathway not present; Min: minimal; Mod: moderate; Maj: major), forecasted changes to introduction pathways (NK: not known; ↑ increase; ↓ decrease; – minimal change; ↑ / ↓ increase or decrease), and the effectiveness of control measures (NK: not known; N/I: none/ineffective; E: Effective; P: Permanent). The pathways were categorised using the scheme adopted by the Convention on Biological Diversity (CBD, 2014). For details see section 3.5 and Table A2.1.

3.2. DATA SOURCES

Introduction and *Within-country pathway prominence* were assessed using socio-economic information collected from a wide range of sources. Information on the pathways of introduction, date of introduction and region of origin for taxa introduced to South Africa were obtained from the dataset presented in Faulkner *et al.* (2015) and were used to assess *Introduction rates*. Information on the species dispersing through the pathways of dispersal was obtained from the literature and used to assess *Within-country dispersal rates*. Socio-economic data were obtained from a number of sources in order to forecast future changes to the pathways of introduction. All data sources are shown in Table 3.1.

TABLE 3.1 Data sources used in the assessment of the status of the pathways of introduction and dispersal for South Africa. Sources with an asterisk (*) contributed to the dataset presented in Faulkner *et al*. (2015).

DATA SOURCE	SCALE OF COVERAGE	DESCRIPTION	LEVEL OF CONFIDENCE BASED ON COMPLETENESS AND ACCURACY	INDICATOR INFORMED BY THESE DATA
ACSA passenger and aircraft statistics (Airports Company South Africa, 2017)	National	Socio-economic information on air traffic	High	**1.** Introduction pathway prominence **3.** Within-country pathway prominence
Agricultural Research Council-Plant Protection Research Institute (2017)	Continental	Information on the introduction and spread of *Spodoptera frugiperda* in Africa (note: given its recent introduction this species is not included in the species lists in Appendix 3)	Medium	**2.** Introduction rates
Appleton (2003)*	National	Historical introduction data for freshwater molluscs	Medium	**2.** Introduction rates
Bromilow (2010)*	National	Historical introduction data for plants	Medium	**2.** Introduction rates
CITES trade database (UNEP World Conservation Monitoring Centre, 2017)	Global	Socio-economic information on the number of animals imported for personal use, botanical garden/zoo purposes and scientific purposes	Low	**1.** Introduction pathway prominence
Cock *et al*. (2016)	Global	Information on insects released to biologically control other insects	High	**2.** Introduction rates
DAFF Diagnostic Import Interception Database (Department of Agriculture, Forestry and Fisheries, 2017)	National	Interception data for imported plants, food, seed and habitat material	Medium	**2.** Introduction rates
De Moor & Bruton (1988)*	Regional	Historical introduction data for freshwater fish, Ciliophora, Cnidaria and Platyhelminthes	Medium	**2.** Introduction rates
Dean (2000)*	Regional	Historical introduction data for birds, as well as information on dispersal for *Corvus splendens*	Medium	**2.** Introduction rates **4.** Within-country dispersal rates
Department of Agriculture, Forestry and Fisheries (2015)	National	Socio-economic information on seed imports and production	High	**1.** Introduction pathway prominence
Department of Agriculture, Forestry and Fisheries (2016a)	Continental	Information on the introduction and spread of *Tuta absoluta* in Africa	Medium	**2.** Introduction rates
Department of Agriculture, Forestry and Fisheries (2016b)	Continental	Information on the introduction and spread of *Tuta absoluta* in Africa	Medium	**2.** Introduction rates

DATA SOURCE	SCALE OF COVERAGE	DESCRIPTION	LEVEL OF CONFIDENCE BASED ON COMPLETENESS AND ACCURACY	INDICATOR INFORMED BY THESE DATA
Department of Home Affairs (2017)	National	Information for South African ports of entry	High	**1.** Introduction pathway prominence
Department of Transport (2016)	National	Socio-economic information on South African airports	High	**1.** Introduction pathway prominence
Dippenaar-Schoeman & Harvey (2000)*	National	Historical introduction data for Arachnida	Medium	**2.** Introduction rates
FAO (2016a)	Global	Socio-economic information on fishing	Medium	**1.** Introduction pathway prominence
FAOSTAT database of the Food and Agriculture Organisation of the United Nations (FAO, 2017)	Global	Socio-economic information on food imports and on the agriculture, livestock farming and forestry sectors	Medium	**1.** Introduction pathway prominence
FishstatJ database of the Food and Agriculture Organisation of the United Nations (FAO, 2016b)	Global	Socio-economic information on the fishing and aquaculture sectors	Medium	**1.** Introduction pathway prominence
Fur Free (2017)	National	Socio-economic information on fur farming	Low	**1.** Introduction pathway prominence
Germishuizen *et al.* (2006)*	National	Historical introduction data for plants	Medium	**2.** Introduction rates
Guimapi *et al.* (2016)	Continental	Information on the introduction and spread of *Tuta absoluta* in Africa	Medium	**2.** Introduction rates
Henderson (2001)*	National	Historical introduction data for plants	Medium	**2.** Introduction rates
Herbert (2010)*	National	Historical introduction data for terrestrial molluscs	Medium	**2.** Introduction rates
Hurley *et al.* (2012)	National	Information on the introduction and dispersal of *Sirex noctilio* within South Africa	Medium	**4.** Within-country dispersal rates
IMF trade forecast statistics (International Monetary Fund, 2016)	Global	Socio-economic information on the volume of imported goods	Medium	**1.** Introduction pathway prominence
Klein (2011)*	National	Historical introduction data for biological control agents released to control alien plant species	High	**2.** Introduction rates
Leibold & Van Zyl (2008)	National	Socio-economic information on fishing	Medium	**1.** Introduction pathway prominence
Lever (2005)	Global	Information on the spread of bird species within South Africa	Medium	**4.** Within-country dispersal rates
Long (1981)	Global	Historical introduction data for birds	Medium	**2.** Introduction rates
Long (2003)*	Global	Historical introduction data for mammals	Medium	**2.** Introduction rates
Martin & Coetzee (2011)	National	Information on the spread of aquatic plant species within South Africa	High	**4.** Within-country dispersal rates
Mead *et al.* (2011)*	National	Historical introduction data for marine taxa	Medium	**2.** Introduction rates
Measey *et al.* (2017)	Regional	Information on the dispersal and spread of amphibian species within South Africa	High	**4.** Within-country dispersal rates
Middleton (2015)	National	Socio-economic information on horticulture	High	**1.** Introduction pathway prominence
Moran, Hoffmann & Zimmermann (2013)	National	Information on the within-country dispersal of biological control agents	High	**4.** Within-country dispersal rates
OpenStreetMap contributors (2017)	Global	Spatial data on South Africa's road and rail networks	High	**3.** Within-country pathway prominence
Picker & Griffiths (2011)*	National	Historical introduction data for a wide variety of animals, including fish, birds, crustaceans, molluscs, insects and mammals. Information on the dispersal and spread of species within the country	Medium	**2.** Introduction rates **4.** Within-country dispersal rates

DATA SOURCE	SCALE OF COVERAGE	DESCRIPTION	LEVEL OF CONFIDENCE BASED ON COMPLETENESS AND ACCURACY	INDICATOR INFORMED BY THESE DATA
Plisko (2010)*	National	Historical introduction data for Annelida	Medium	**2.** Introduction rates
Richardson *et al.* (2003)	National	Socio-economic information on horticulture. Information on the spread of fish species	High	**1.** Introduction pathway prominence **4.** Within-country dispersal rates
Seebens *et al.* (2017)	Global	Information on global trends in the introduction of alien species	Medium	**1.** Introduction pathway prominence **2.** Introduction rates
South African Government (2017)	National	Socio-economic information on fishing	Medium	**1.** Introduction pathway prominence
StatsSA tourism and migration statistics (Statistics South Africa, 2017)	National	Socio-economic information on the number of people arriving in South Africa	Medium	**1.** Introduction pathway prominence
Taylor, Lindsay & Davies-Mostert (2015)	National	Socio-economic information on the hunting sector	Medium	**1.** Introduction pathway prominence **3.** Within-country pathway prominence
Transnet National Ports Authority (2014)	National	Socio-economic information on shipping	Medium	**1.** Introduction pathway prominence
Transnet National Ports Authority's Port statistics (Transnet National Ports Authority, 2017)	National	Socio-economic information on shipping	High	**1.** Introduction pathway prominence
United Nations Comtrade database (UN-Comtrade, 2017)	Global	Socio-economic data on live plant and vehicle imports	Medium	**1.** Introduction pathway prominence
Van Rensburg *et al.* (2011)*	National	Historical introduction data for freshwater fish, amphibians, birds, mammals and reptiles. Information on the fishing, hunting and aquaculture sectors and the within-country dispersal of fish	Medium	**1.** Introduction pathway prominence **2.** Introduction rates **3.** Within-country pathway prominence **4.** Within-country dispersal rates
Van Wilgen *et al.* (2010)	National	Socio-economic information on the import of animals as pets	Medium	**1.** Introduction pathway prominence
Visser *et al.* (2017a)	National	Information on the introduction of *Tuta absoluta* to South Africa	Medium	**1.** Introduction pathway prominence
Visser *et al.* (2017b)	National	Information on the current and historical introduction pathways for grasses	Medium	**1.** Introduction pathway prominence
WTO trade statistics (World Trade Organisation, 2017)	Global	Socio-economic information on merchandise imports	Medium	**1.** Introduction pathway prominence
WTTC's tourism and travel statistics (World Tourism and Travel Council, 2017)	Global	Socio-economic information on travel and tourism	Medium	**1.** Introduction pathway prominence
Zachariades *et al.* (2017)	National	Information on biological control agents released to control alien plants and future plans for these programs	High	**1.** Introduction pathway prominence **4.** Within-country dispersal rates
Zimmermann, Moran & Hoffmann (2004)	National	Information on biological control agents and their within-country dispersal	High	**4.** Within-country dispersal rates

3.3. STATUS OF THE PATHWAYS

3.3.1. Status of the pathways of introduction

Based on socio-economic data, many of the pathways of introduction appear to be playing an important role in South Africa and in many cases the prominence of these pathways has increased over time (see Figure 3.1 and Table A2.1). There are 72 official ports of entry through which people, goods and transport vessels can enter the Republic. Eight of these are maritime ports, ten are airports and 54 are land border posts (Figure 3.2). The number of people entering South Africa through these ports of entry has increased over time, and in 2016 over 21 million people entered the country (Figure 3.3). According to the World Tourism and Travel Council (2017), over 10 million of these were tourists. Tourism and travel is an important industry in South Africa and the contribution this sector has made to Gross Domestic Product (GDP) has increased over time (Figure 3.4). The quantity of food imported into South Africa through the ports of entry has also increased over time, and in 2013 over 7 million tonnes of food was imported (Figure 3.5). These pathways are examples of many that are playing a major and increasing role in South Africa, and as alien taxa could be transported into the country within the luggage of tourists, or as contaminants of imported food, these pathways, along with a number of others, might be playing an important and increasing role in the introduction of alien organisms.

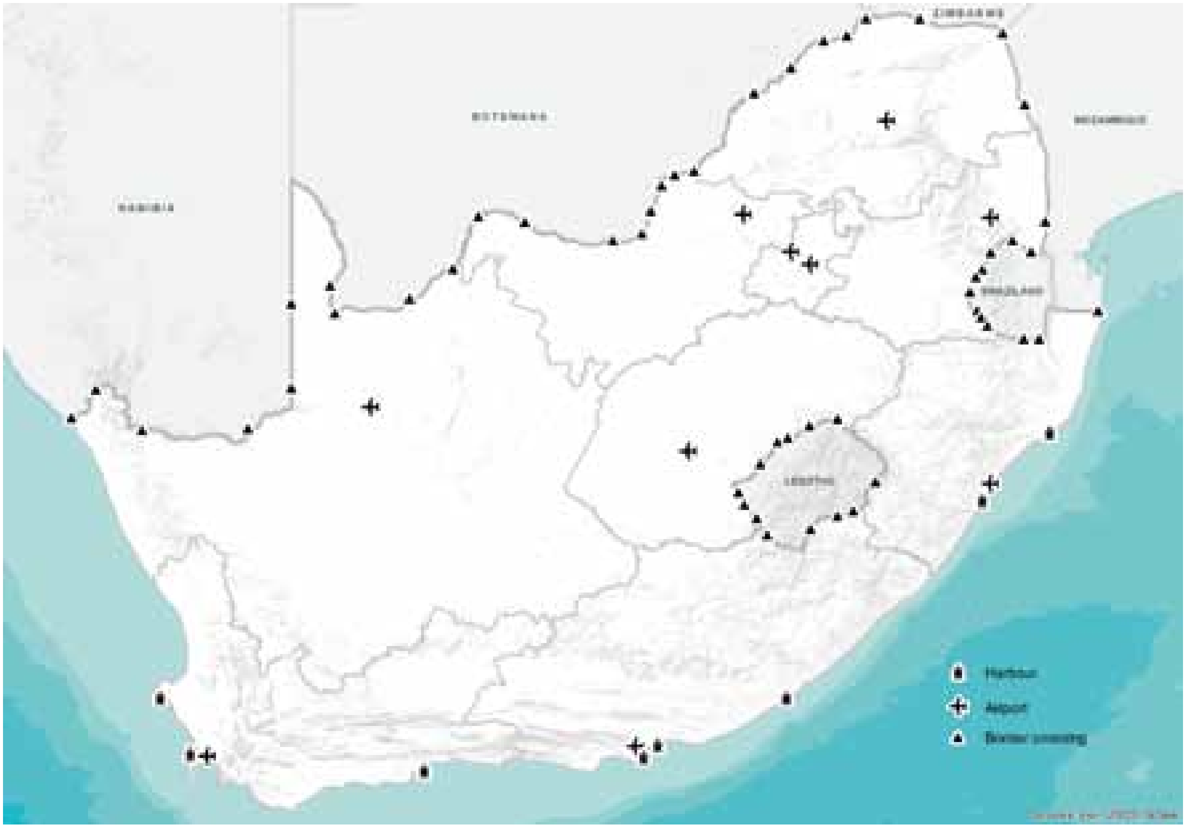


FIGURE 3.2 South African ports of entry. Any person, who wishes to enter into or depart from South Africa, can only legally do so through these ports. Information was obtained from the South African Department of Home Affairs (2017).

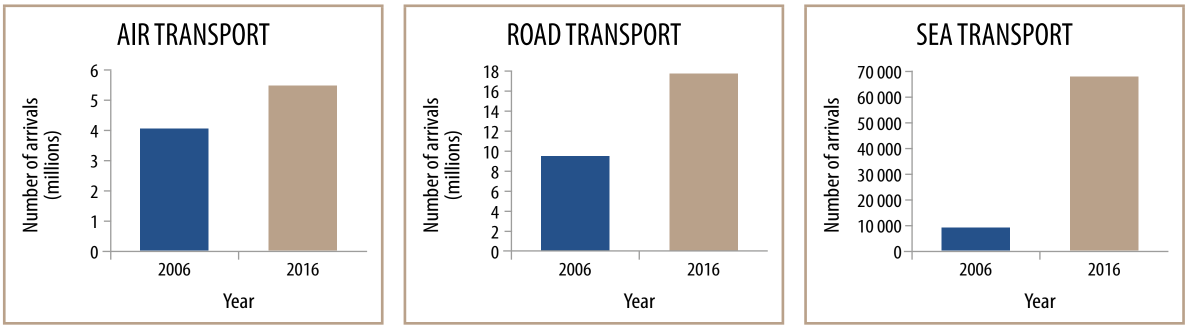


FIGURE 3.3 The number people arriving in South Africa by air, road and sea transport in 2006 and 2016. Data were obtained from Statistics South Africa (2017).

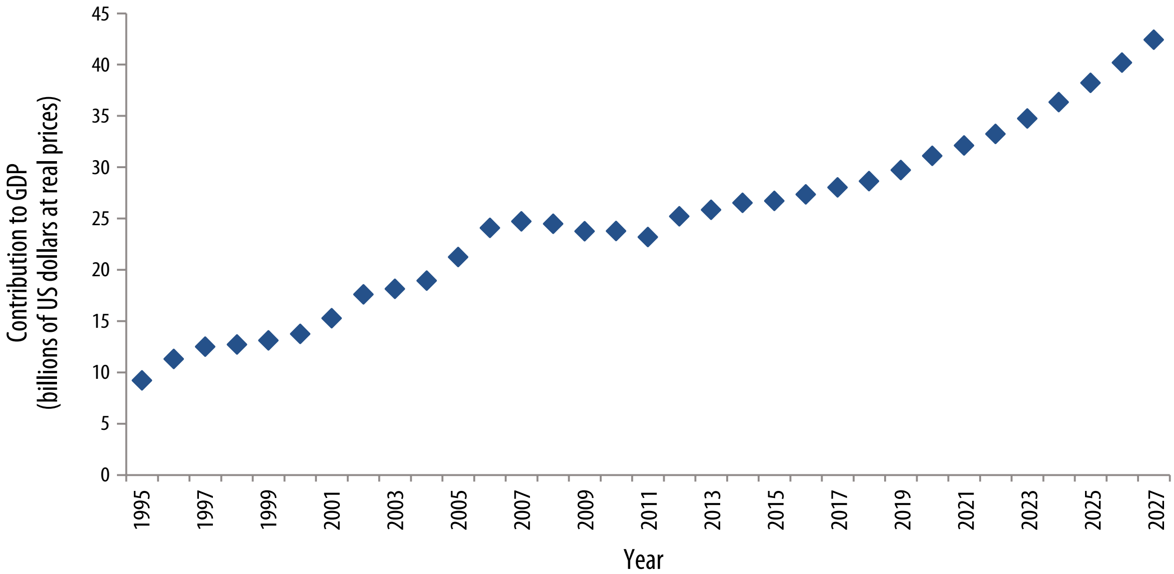


FIGURE 3.4 The contribution of travel and tourism to South Africa's Gross Domestic Product has increased over time and is expected to continue to increase in the future. Data were obtained from the World Tourism and Travel Council (2017).

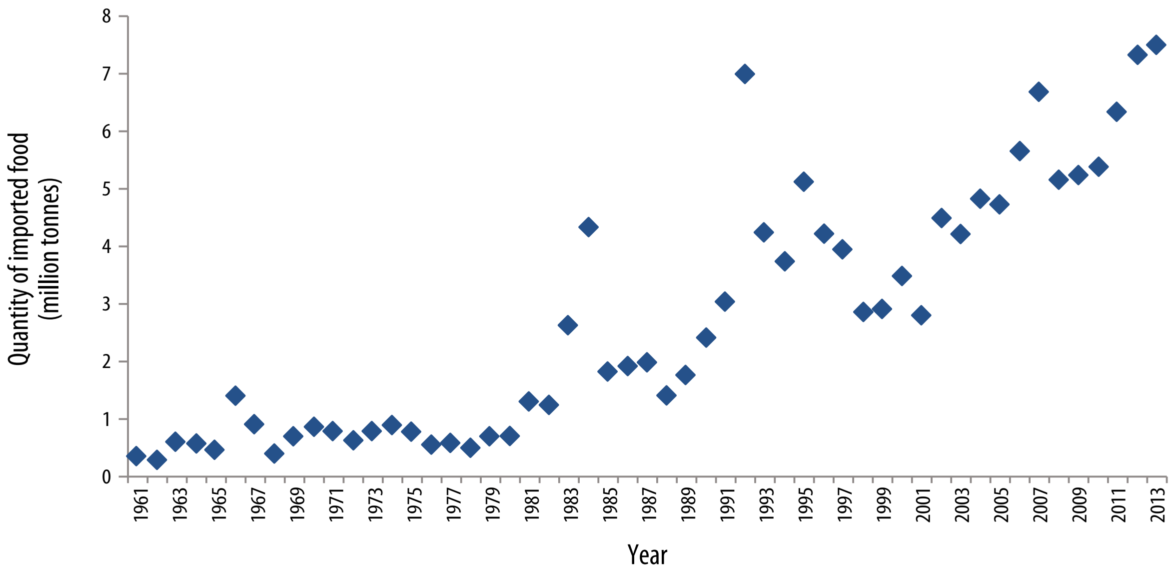


FIGURE 3.5 The quantity of food imported into South Africa has increased, particularly since 2000. Data were obtained from the Food and Agricultural Organisation of the United Nations (FAO, 2017).

As many introduction pathways are prominent in South Africa, it is not surprising that alien taxa have been intentionally and accidentally introduced to the country through a wide variety of introduction pathways. Although most alien taxa have been intentionally imported for the ornamental plant trade and then have escaped from gardens (Figure 3.1, Figure 3.6 and Figure 3.7), many have also been released for biological control or have been introduced for agriculture (Figure 3.1 and Figure 3.7). Although most alien taxa have been intentionally imported into the country, a large number have also entered the country accidentally (Figure 3.6). For example, many alien taxa have been introduced as contaminants on imported plants, or as stowaways on visiting ships (Figure 3.1 and Figure 3.7). Organisms that have been introduced to South Africa's neighbouring countries have also spread into the country; however, no alien taxa are known to have spread into South Africa through human-built transport infrastructure that connects previously unconnected regions (Figure 3.1 and Figure 3.6).

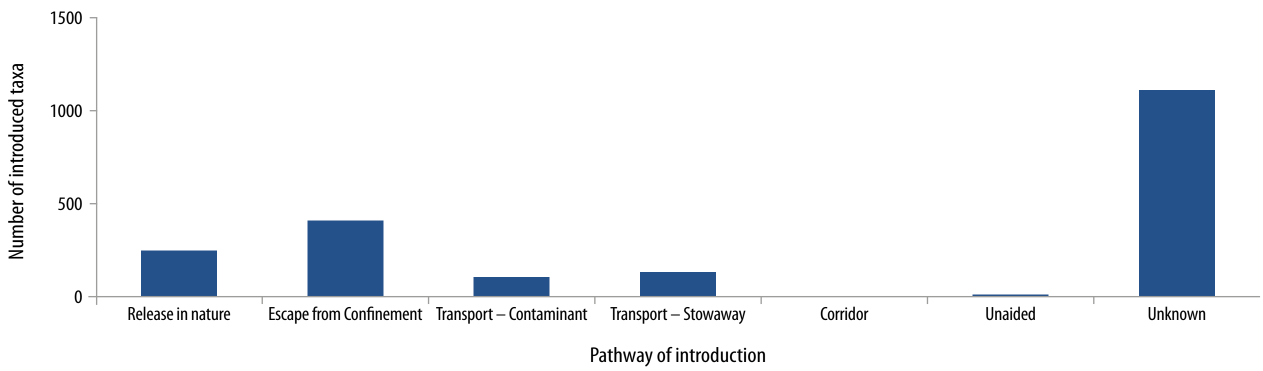


FIGURE 3.6 Number of alien taxa introduced to South Africa through the pathways of introduction (following the categorisation scheme adopted by the Convention on Biological Diversity), and the number of taxa for which pathway of introduction was unknown.

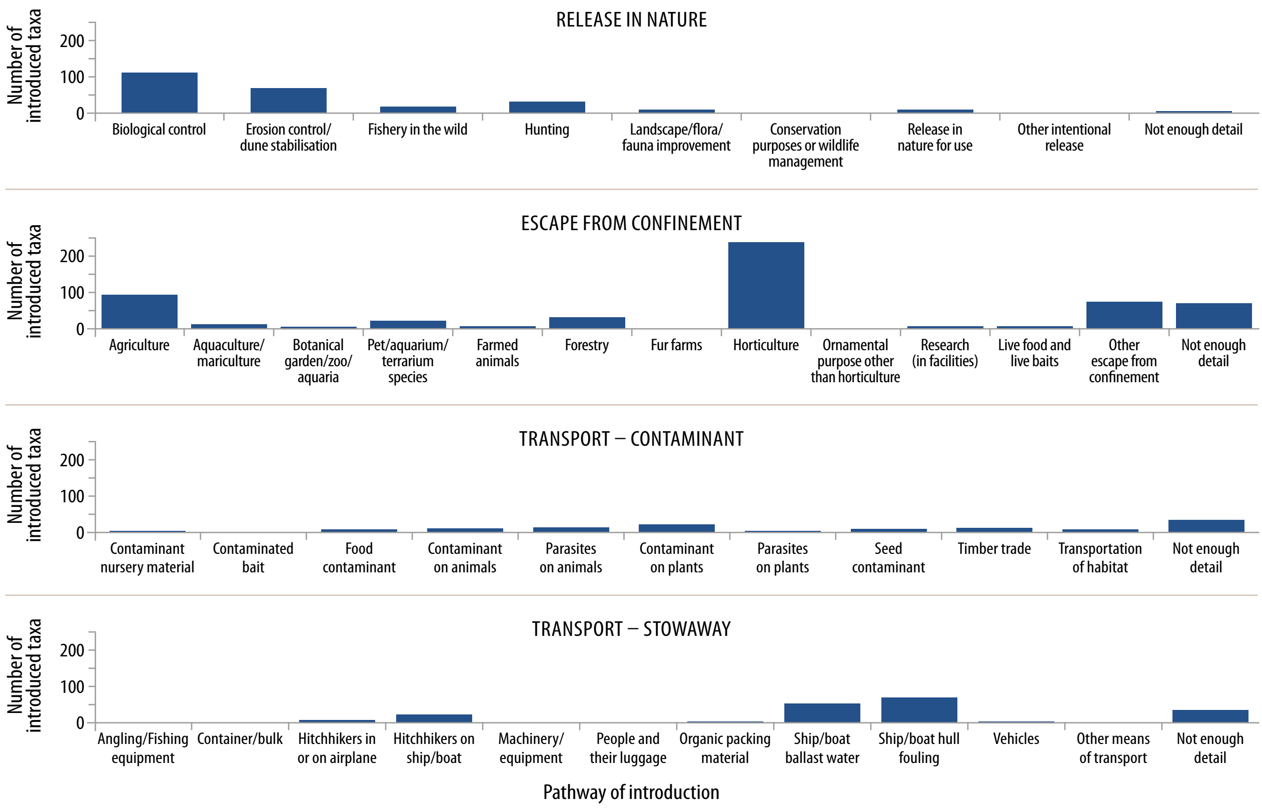


FIGURE 3.7 Number of alien taxa introduced to South Africa through the pathways of introduction, and the number for which designation at the pathway subcategory level was not possible due to insufficient information. The graphs show the results for the pathway subcategories of the (from top to bottom) 'Release in nature', 'Escape from confinement', 'Transport – Contaminant' and 'Transport – Stowaway' pathway categories. Results for the unaided pathway are not shown (see Figure 3.6 for the results of this pathway).

Although data were insufficient for many of the pathways of introduction, for some pathways data were sufficient to evaluate recent changes to the rate of introduction, and to assess the effectiveness of control measures. For eleven pathways, between 2000 and 2009 there was either a minimal change or an increase to the rate of introduction in comparison to that of the previous decade (Figure 3.1). Therefore, although control measures were enacted for some pathways in the 1980s, for many pathways the rate of introduction has not declined (Figure 3.1, also see Box 3.1 for an example). The rate at which alien taxa have been introduced to South Africa has declined for only one pathway: biological control (Figure 3.1). Regulatory process complications caused a decline in the number of taxa introduced for the biological control of invasive plants (Klein, 2011; Klein *et al.*, 2011), while the number of insects released to control insect pests has also declined since the 1980s (Cock *et al.*, 2016). Overall the introduction of biological control agents was, therefore, lower in the 1990s and 2000s than in the 1980s (see Figure A2.4). As the complications in these regulatory processes have since been resolved, and as biological control research and implementation for alien plants has recently increased (Zachariades *et al.*, 2017), it is likely there will be an increase in the release of biological control agents in the future (Figure 3.1). There have been no new alien taxa introduced for fishing or aquaculture since the 1980s (Figure 3.1; also see Figure A2.4 and Figure A2.5). While this decline might be due to the control measures that were implemented during this period [i.e. Animal Diseases Act (Act No. 35 of 1984)], changing fashions or other socio-economic factors could also have played a role. During the last full decade (2000–2009), the annual rate of introduction has fluctuated, with an average of 7 taxa introduced per year (Figure 3.8). Overall, and despite the control measures that are in place, the rate of introduction appears to be increasing (Figure 3.9).

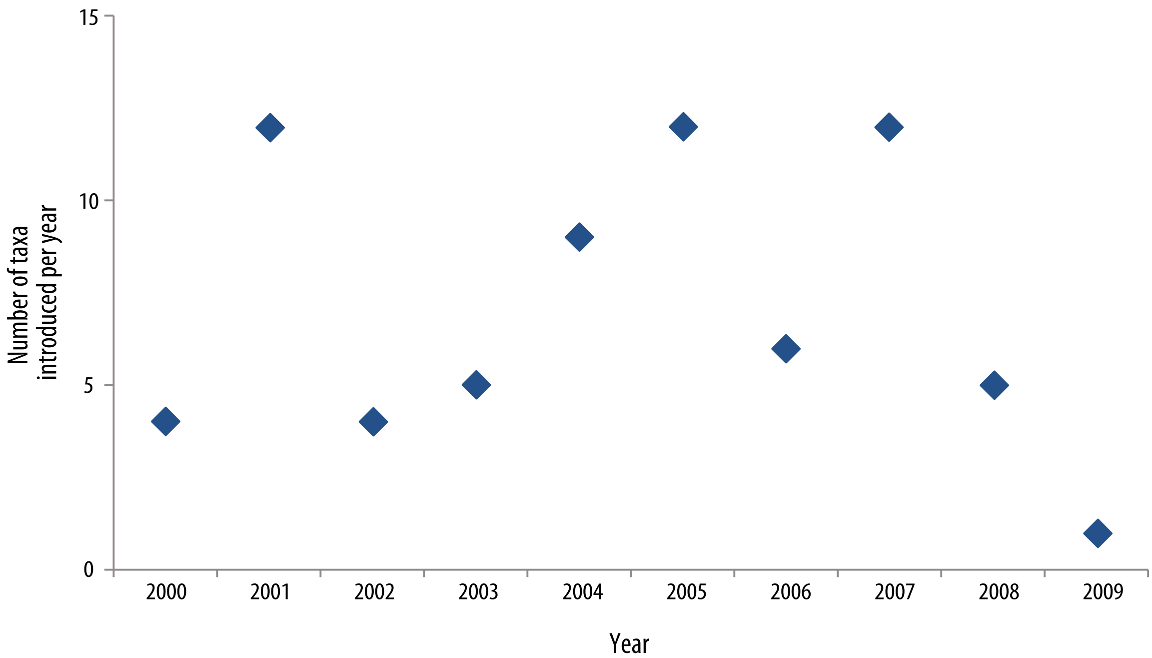


FIGURE 3.8 The number of taxa introduced to South Africa during each year in the last full decade.

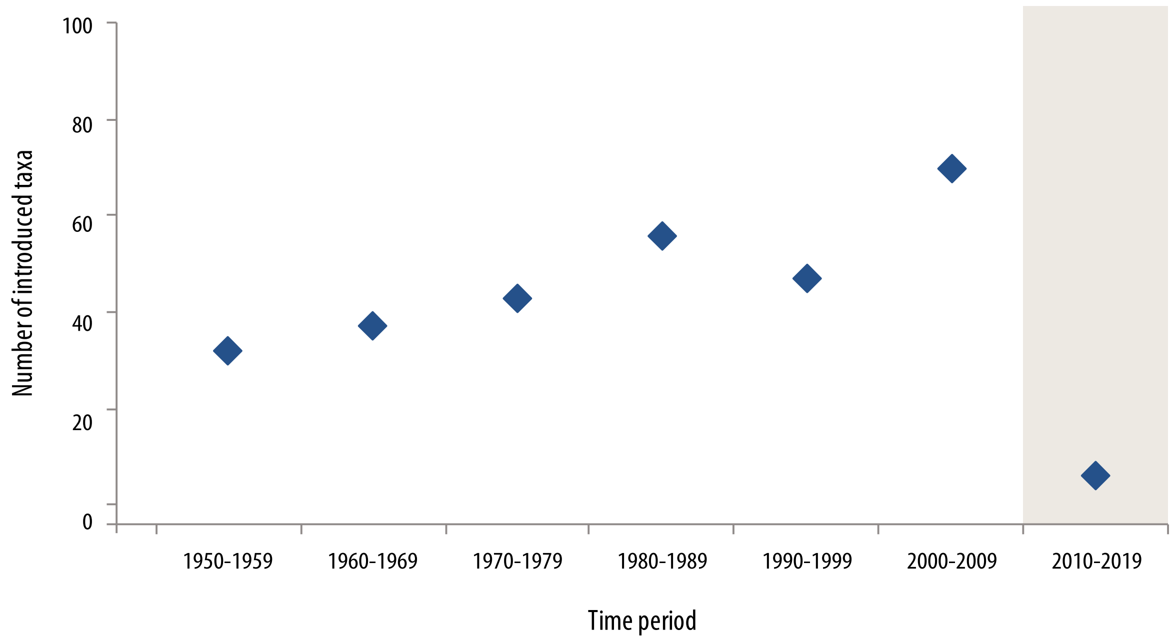


FIGURE 3.9 The number of taxa introduced to South Africa during each decade since the 1950s. Data for 2010 to 2019 were incomplete and are shaded in grey.

3.3.2. Status of the pathways of dispersal

Within-country pathway prominence is currently not known for all pathways of dispersal, in part as data are widely dispersed and owned by a number of different entities. South Africa, however, has extensive transport networks (Figure 3.10) that facilitate the movement of goods and people around the country. In line with international trade patterns, the volume of goods and the number of people moving around the country is expected to increase. For instance, the number of domestic airline passengers has increased over time – such that in the 2015/2016 financial year, there were over 13 million trips made on over 140 000 flights (Figure 3.11).

Importantly, not all of the species moving within the country are alien to the Republic, and species that are indigenous to one part of the country can also be transported and introduced to parts of the country where they are not indigenous (Measey *et al.*, 2017). Alien and indigenous species that are sold at pet stores (Figure 3.12) are often traded (e.g. through private or public sales on web-sites like Ebay) and moved around the country by members of the public (Martin & Coetzee, 2011, Measey *et al.*, 2017). Similarly alien and indigenous fish are often transported and introduced into new river systems by anglers (Picker & Griffiths, 2011). Many alien taxa have also become widely dispersed through natural spread [e.g. *Sturnus vulgaris* (the common starling) was introduced to the Western Cape and spread north (Picker & Griffiths, 2011)], but alien organisms are also transported as contaminants of commodities or as stowaways along the country's extensive transport networks (Figure 3.10). For example, *Sirex noctilio* (sirex woodwasp) was probably imported and transported around the country in infested timber (Picker & Griffiths, 2011; Hurley *et al.*, 2012). Organisms are also known to have spread within the country through human made transport infrastructure that connects previously unconnected areas. For example, fish species have dispersed along canals and pipes used to transfer water between river basins (Richardson *et al.*, 2003; Van Rensburg *et al.*, 2011).

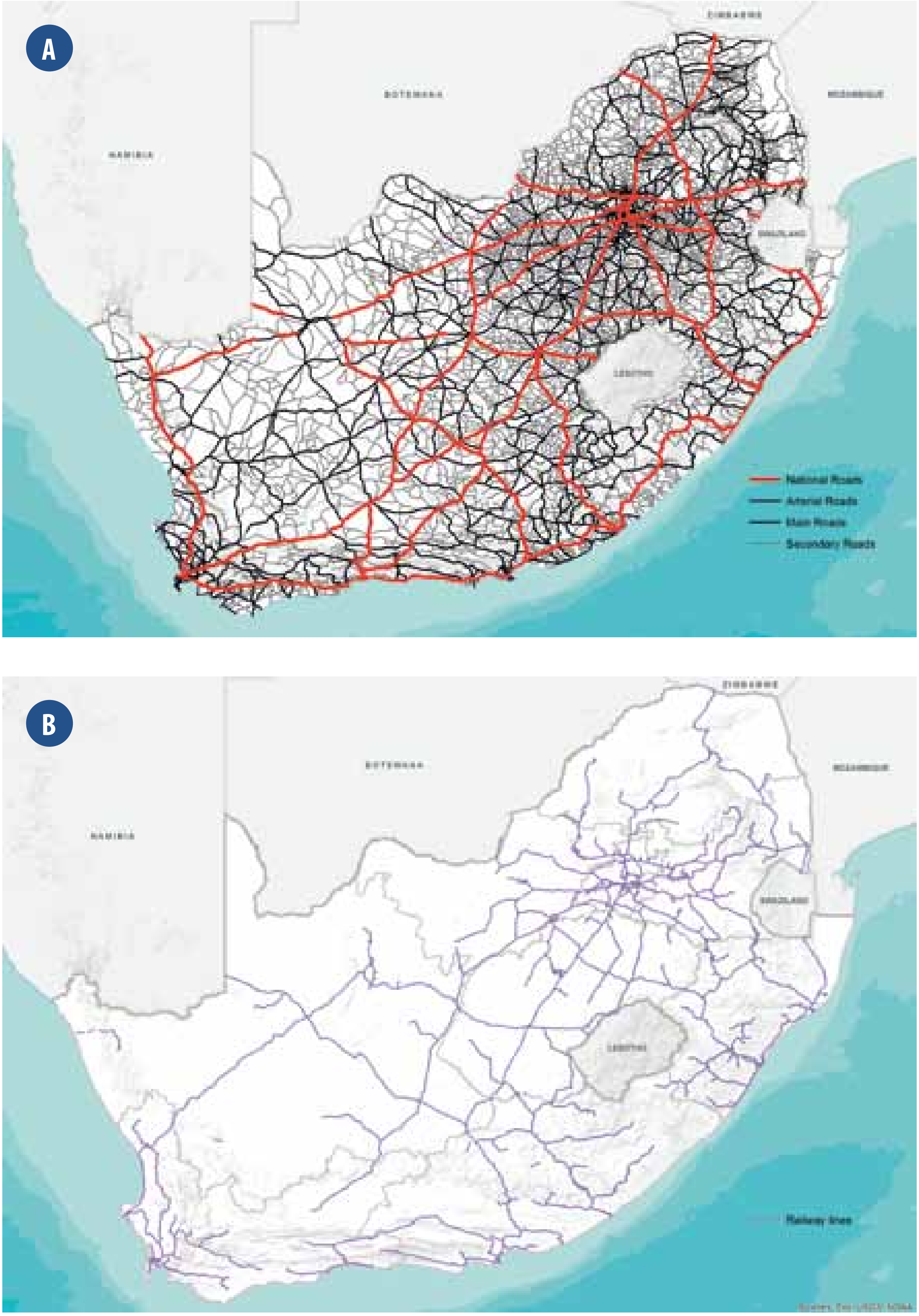


FIGURE 3.10 The South African (A) road and (B) rail networks. Data were obtained from OpenStreetMap contributors (2017). There is no expectation that these networks will expand significantly in the coming decades, although traffic volumes have increased, and continue to increase.

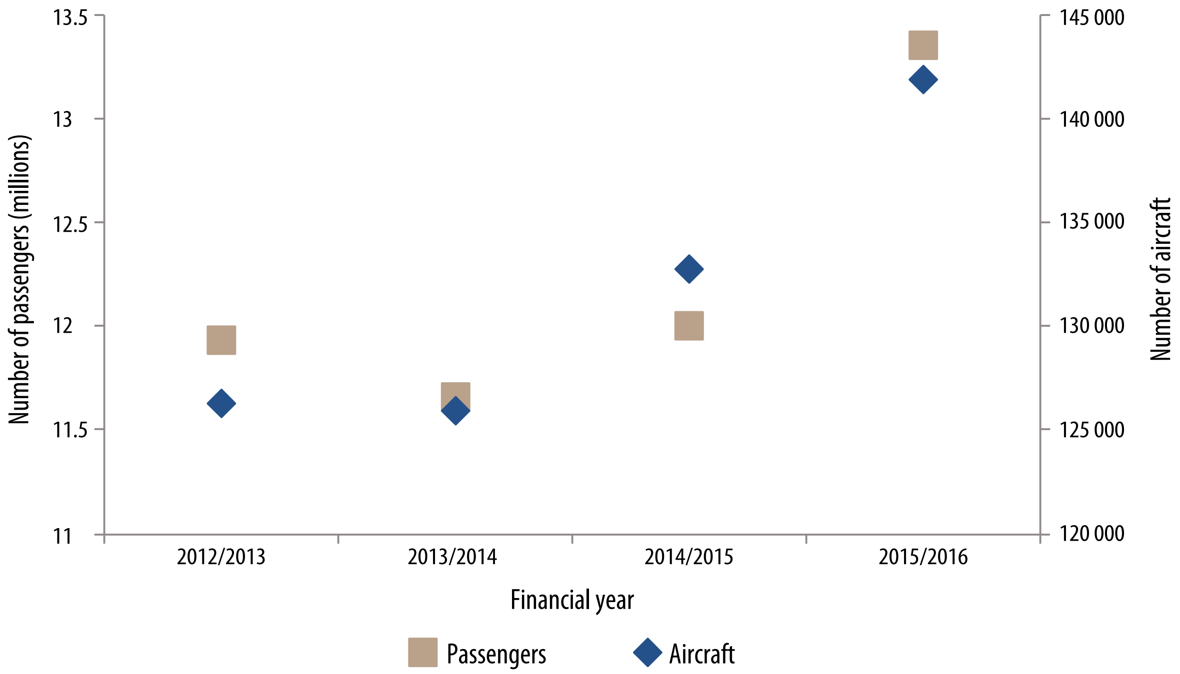


FIGURE 3.11 Domestic flights (as a within-country dispersal pathway) have been increasing in prominence recently. The total number of scheduled commercial domestic flights and passengers has increased since the 2012/2013 financial year (note neither axis starts at zero). These data were obtained from Airports Company South Africa (2017).

FIGURE 3.12 A tarantula sold in the pet trade. The pet trade has historically been responsible for the import, sale and distribution of many alien animal species, several of which have escaped and established populations outside of captivity. No alien tarantula species are known to be invasive in South Africa, and while the risks might be low, they should be analysed and, as appropriate, managed in partnership with the pet trade industry.

Photograph: C. Shivambu.

3.3.3. Future changes to the pathways of introduction

For some pathways of introduction, socio-economic forecast data could be obtained, and for most of these pathways an increase in pathway prominence is expected in the future (Figure 3.1). Of the pathways predicted to increase in size in the future, many involve the introduction of alien organisms as stowaways on transport vectors. For instance, the contribution of travel and tourism to South Africa's GDP is expected to increase (Figure 3.4). Unfortunately, control measures are not in place for most of these pathways (for an example see Box 3.2), and unless this changes, the predicted increase in the prominence of these pathways could result in an increase in the rate at which alien taxa are introduced as stowaways on transport vectors. As the amount of goods imported by mainland African countries is predicted to increase over the next few years (Figure 3.13), the number of taxa being introduced to Africa and then spreading into South Africa could also increase in the future (Figure 3.1). As such organisms can enter South Africa anywhere along the country's 4862 km-long land borderline, it is extremely difficult to prevent these introductions, and thus regional co-operation might be required (Faulkner *et al.*, 2017a).

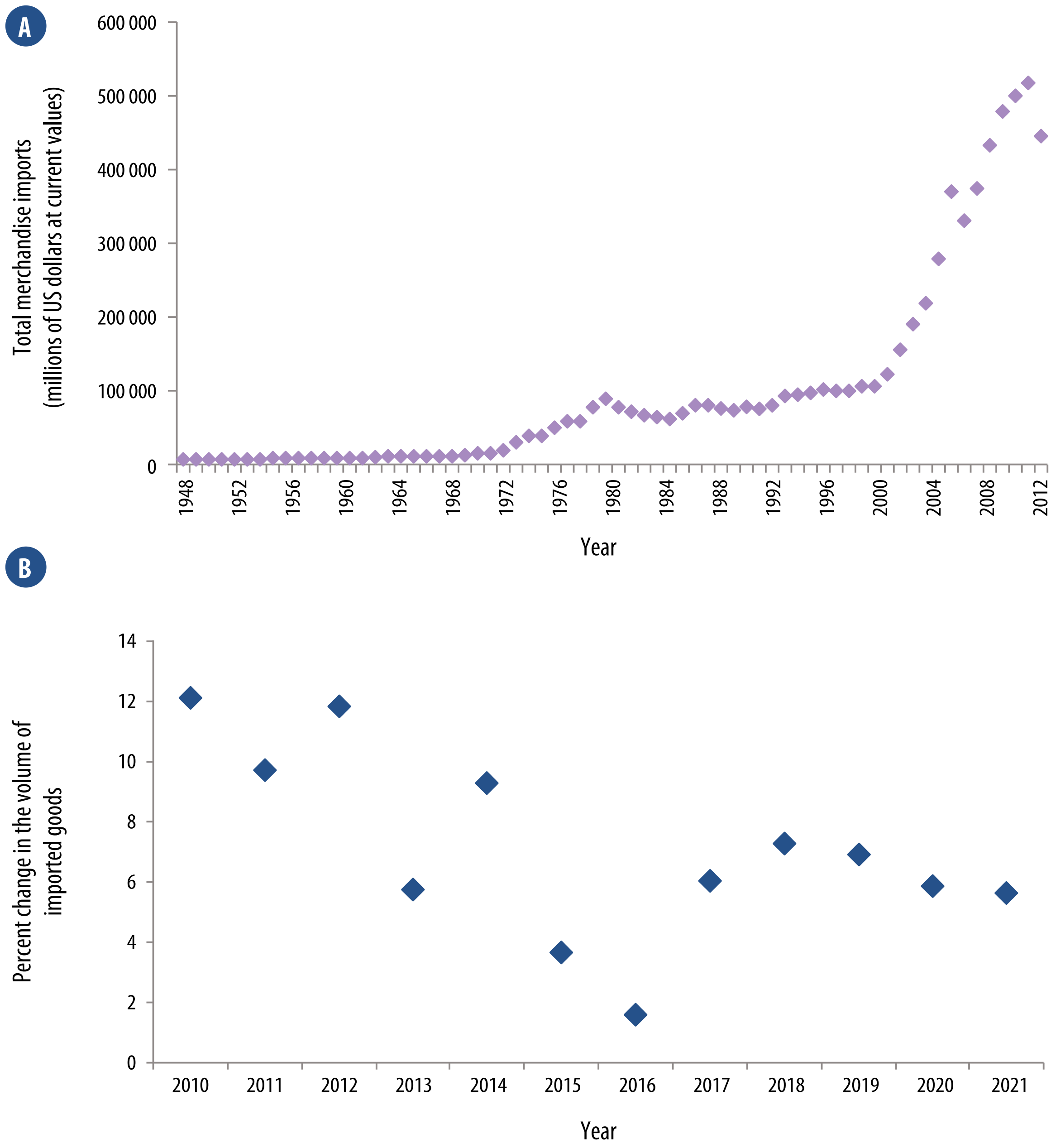


FIGURE 3.13 Trends in imports to mainland African countries (excluding South Africa). (A) The value of merchandise imports to mainland African countries has increased over time, and (B) the volume of goods imported into this region is expected to continue to increase in the order of 6% a year for the next four years. As other African countries see an increase in international trade, so the potential exposure of South Africa to new alien taxa arriving across the land borders or through natural spread increases. Data were obtained from the World Trade Organisation (2017) and International Monetary Fund (2016).

3.4 UNCERTAINTIES

Assessments of pathways of introduction are hampered by a number of uncertainties (Essl *et al.*, 2015a; Ojaveer *et al.*, 2017; Tsiamis, Cardoso & Gervasini, 2017). The pathways of introduction are often unknown, particularly for species that have been introduced accidentally, and the data that are available are often not of sufficient quality or detail to designate pathways of introduction with certainty (Essl *et al.*, 2015a; Ojaveer *et al.*, 2017; Saul *et al.*, 2017). In order to deal with this, certainty in pathway designations can be estimated. For many alien taxa in

South Africa, including insects and plants, pathway and date of introduction data are not available (Faulkner *et al.*, 2015). Indeed, pathway of introduction data were not available for 1090 of the alien taxa included in the assessment presented here (Figure 3.6), and of the 749 taxa for which pathway of introduction data were available, date of introduction data were insufficient for 402 taxa. Where it was possible to designate pathways of introduction, most designations were made with high certainty (Figure A2.8). But, there were instances where the data were of insufficient detail, and certainty was low or designations, particularly at the pathway subcategory level, could not be made (4 releases, 69 escapes, 32 contaminant and 33 stowaway introductions; see Figure 3.7). Furthermore, the increased level of detail provided by the CBD's categorisation scheme has led to an increase in uncertainty when designating pathways of introduction. This is because the differences between some of the pathway subcategories are unclear (Tsiamis, Cardoso & Gervasini, 2017). For instance, it was difficult to distinguish between the 'release in nature for use (other than the above, e.g. fur, transport, medicinal use…)' and the 'other intentional release' subcategories. Furthermore, some pathways appear to have not contributed to the introduction of alien species in South Africa, or appear to have recently become inactive (no recent introductions). While in some instances (e.g. introductions for fishing and aquaculture) this might be the case, for many of these pathways poor data quality means that these conclusions are likely incorrect. For example, it appears as though no new alien organisms have been recently introduced for horticultural purposes. However, as alien species dominate public and private gardens (Richardson *et al.*, 2003), and as South African consumers in the ornamental plant sector show a desire for new varieties of plants (Middleton, 2015), this is unlikely to be the case. This result is more likely due to the poor quality data available for this pathway (date of introduction data were not available for 210 taxa introduced for horticulture). Problems with data quality and availability may cause the importance of the pathways to be underestimated, while other uncertainties may lead to differing interpretations and errors. These factors pose a problem for decision making and management, and make it difficult to determine with confidence the effectiveness of control measures (see Figure 3.1).

3.5. SYNTHESIS AND INDICATOR VALUES

This chapter has highlighted that South Africa has a number of prominent pathways of introduction, and that alien taxa have entered the country through a wide variety of these pathways. Once introduced, these organisms are likely to disperse or spread widely. Some of the pathways that involve the intentional import of alien taxa are playing an important and increasing role in South Africa, and most taxa have been introduced intentionally through these pathways. A large number of alien taxa have been accidentally introduced to South Africa. The import of goods such as live plants and food has increased over time and although control measures are in place to prevent the accidental introduction of commodity contaminants, the rate at which alien taxa are being introduced through these pathways has not declined. In South Africa, the accidental introduction of alien taxa as stowaways on transport vessels is also playing an important role that is likely to increase in the future; unfortunately, control measures are not in place for many of these pathways. The natural dispersal of alien taxa into South Africa from our neighbouring countries will likely increase in the future, but preventing these introductions will be extremely difficult and to do so would require regional co-operation. Overall, the rate of introduction has increased over time and it appears that alien taxa will continue to be introduced at an increasing rate through a wide variety of pathways. Once introduced, these taxa can be dispersed with the aid of South Africa's extensive transport networks and can become widespread. Further research and better data are required to identify and prioritise these pathways and to develop and evaluate control measures.

Estimation of introduction pathway prominence: socio-economic data for the pathways of introduction were used by an expert to classify the size of the pathways into five categories of introduction pathway prominence. For 12 pathways (27.3%), introduction pathway prominence was not known as socio-economic data for these pathways could not be obtained. One pathway (2.3%) is no longer present due to changes in socio-economic factors. Seven pathways (15.9%) play a minor role in South Africa, but 12 (27.3%) have a moderate role, and a further 12 (27.3%) play a major role. However, as the data were evaluated by one expert, confidence in this assessment is medium.

Estimation of introduction rates and effectiveness of control measures: pathway and date of introduction data for alien species introduced to South Africa were used to estimate *Introduction rates*. As alien taxa can be introduced through more than one pathway, the number of taxa across the pathways might be greater than the number investigated. In some instances, pathway descriptions were vague and it was difficult to make definite categorisations. Furthermore, the similarity of some of the pathway subcategories (e.g. 'Contaminant nursery material' and 'Contaminant on plants') caused uncertainty. To account for this, certainty in the pathway assignments for each taxon was rated. In instances where pathway of introduction information was not available, or where insufficient information was provided, the pathway was classified as 'Unknown'. In some instances, there was insufficient information to assign pathways at the subcategory level (e.g. the pathway of introduction for many alien bird taxa was described as 'escape', with no further details provided). In these instances, a pathway category was assigned and the pathway subcategory was classified as 'Not enough detail provided'.

Excluded from the analyses were hybrid taxa, dubious records (e.g. the mollusc *Vertigo antivertigo* which has only been found as a subfossil (Herbert, 2010)), taxa that have not yet escaped from confinement, and those whose regions of origin extend into South Africa. Taxa with an uncertain region of origin were excluded unless currently believed to be alien to South Africa. Taxa which were listed as alien but for which no information on region of origin was provided were assumed to be alien and were included in the analyses.

The total number of taxa introduced through each pathway was calculated and used to estimate *Introduction rates*. Relatively few taxa have been introduced through most pathways, with only two pathways facilitating the introduction of over 100 taxa. For each pathway, the number of new taxa introduced during each decade from 1950 to 2020 was calculated. By comparing the rate of introduction in the last full decade (2000-2009) to that of the previous decade (1990-1999), recent changes to the rate of introduction were determined. There have been no introductions through 18 of the pathways (40.9%) since 2000. Although there have been no introductions through 14 of the pathways (31.8%) since 2000, as taxa have previously been introduced through these pathways and as the data appears to be insufficient, recent changes to the rate of introduction through these pathways were not known. While for one pathway (2.3%) the rate of introduction decreased by five or more taxa, for nine pathways (20.5%) there was minimal change to the rate of introduction (no change or a change of less than 5 taxa), and for 2 pathways (4.5%) the rate of introduction increased by five or more taxa. As pathway and date of introduction data are not available for many taxa, confidence in this assessment is low.

Estimates of recent changes to *Introduction rates* were used to evaluate the effectiveness of pathway-related control measures, which began to come into effect in the 1980s (e.g. Agricultural Pests Act (Act No. 36 of 1983); Conservation of Agricultural Resources Act (Act No. 43 of 1983); Animal Diseases Act (Act No. 35 of 1984)). Details on the calculations of these estimates are provided in Chapter 6.

Estimation of within-country pathway prominence: as socio-economic data related to the pathways of dispersal could only be obtained for a few pathways, *Within-country pathway prominence* was not assessed.

Estimation of within-country dispersal rates: as data on *Within-country dispersal rates* has not yet been collated and only a few examples were obtained, *Within-country dispersal rates* was not assessed.

Estimation of high level indicator – rate of introduction of new unregulated species: the data used to determine the rates of introduction were used to calculate the number of new taxa introduced to South Africa each year during the last full decade (2000-2009). The average rate of introduction for the decade was then calculated. 70 new taxa were introduced between 2000 and 2009, with an average introduction rate of 7 taxa per year. As pathway and date of introduction data are not available for many taxa and as it is likely that there is a substantial delay between introduction and detections, confidence in this assessment is low.

Forecasts of changes to the pathways of introduction: although future changes to introduction pathways are not directly addressed in the indicators, socio-economic data were used to make forecasts of how introduction pathway prominence might change in the future. Socio-economic forecast data were not available for 28 pathways (63.6%) and so future changes to the size of these pathways is not known. However in the future, twelve pathways (27.3%) are expected to increase in size, while there will be minimal change to the size of three pathways (6.8%). Future changes to the size of one pathway (2.3%) are very uncertain and there could be an increase or decrease in the size of this pathway.

TABLE 3.2 Values for the indicators for reporting on the status of the introduction and dispersal pathways, the level of confidence in each assessment and notes on the assigned confidence levels.

INDICATOR	VALUE BASIC •••••		••••• ADVANCED	LEVEL OF CONFIDENCE	NOTES
1. Introduction pathway prominence	**1.1.** Not known: 12 pathways Pathway not present: 1 pathway Minor: 7 pathways Moderate: 12 pathways Major: 12 pathways	**1.2.** Data not available	**1.3.** Data not available	**1.1.** Medium	Evaluation by one expert

INDICATOR	VALUE BASIC ••••••••••••••••••••••••••• ADVANCED			LEVEL OF CONFIDENCE	NOTES
2. Introduction rates	**2.1.** 0 taxa: 10 pathways 1 – 50 taxa: 27 pathways 51 – 100 taxa: 5 pathways > 100 taxa: 2 pathways	**2.2.** Increase: 2 pathways Decrease: 1 pathway Minimal change: 9 pathways No introductions: 18 pathways Not known: 14 pathways	**2.3.** Data not available	**2.1.** Low **2.2.** Low	Pathway and date of introduction data are not available or have not been collated for many alien taxa in South Africa
3. Within-country pathway prominence	**3.1.** Data not available	**3.2.** Data not available	**3.3.** Data not available	N/A	Data were only collected for a few pathways
4. Within-country dispersal rates	**4.1.** Data not available	**4.2.** Data not available	**4.3.** Data not available	N/A	Pathway and date of dispersal data have not been collated for alien taxa in South Africa
A. Rate of introduction of new unregulated species	**A.** 7 taxa per year			**A.** Low	Date of introduction data are not available for many alien taxa in South Africa

BOX 3.1 THE LIVE PLANT TRADE AS A PATHWAY FOR INTRODUCING CONTAMINANTS.

Live plants and their products are imported into South Africa for a number of uses. For example, as South African consumers in the ornamental plant sector show a desire for new varieties of plants, plants are often imported for this purpose (Middleton, 2015). Live plant imports to South Africa have increased over time and in 2016 these imports were valued at over 12 million US dollars (UN-Comtrade, 2017). To meet the requirements of the International Plant Protection Convention, South African phytosanitary policies require that all plant imports must be inspected in the country of origin, treated with pesticides and declared free of any organisms before import (Saccaggi & Pieterse, 2013). Despite this, organisms are often found on imported plants and plant products when inspected at South African ports of entry (Saccaggi & Pieterse, 2013). Additionally, over 20 species have been introduced as contaminants or parasites of plants, and the rate at which these organisms have been introduced has remained consistent over time (Figure 3.1; also see Table A2.1). For example, *Linepithema humile* (Argentine ant) is believed to have been introduced to South Africa as a contaminant of imported horse fodder (Picker & Griffiths, 2011). Once imported, plants are intentionally transported and sold throughout the country (Martin & Coetzee, 2011), and their contaminants are potentially transported with them. The live plant trade is, therefore, an important and potentially increasing pathway through which alien organisms are introduced to the country, but this trade also likely facilitates the dispersal of alien taxa within the country after introduction.

BOX 3.2 HULL FOULING AS A PATHWAY OF INTRODUCTION FOR MARINE ORGANISMS.


Photographer: T. Robinson

South Africa has eight major maritime ports (Richards Bay, Durban, East London, Ngqura, Port Elizabeth, Mossel Bay, Cape Town and Saldanha Bay), and in 2016 over 8000 ocean going vessels arrived at these ports (Transnet National Ports Authority, 2017). Ships can facilitate the introduction of alien taxa in a number of ways. Marine organisms can be transported within the ballast water carried by ships or can attach to ships' hulls. Through these pathways ships have facilitated the introduction of many marine taxa to South Africa (Figure 3.1). In September 2017, the International Maritime Organisation's (IMO) 'International Convention for the Control and Management of Ships' Ballast Water and Sediments' entered into force (IMO, 2004). This convention aims to prevent the transportation of aquatic organisms between regions, and under the convention all ships are required to manage their ballast water and sediments to a certain standard. South Africa has also drafted ballast water legislation (Marine Draft Ballast Water Bill), but this legislation has not yet been passed. Although there are, therefore, plans to manage the introduction of marine organisms through the release of ballast water by ships, there are currently no plans or management in place to prevent introductions through hull fouling. Over 60 alien taxa are believed to have been introduced to South Africa attached to the hulls of visiting ships, and the rate at which these introductions have occurred has increased over time (Figure 3.1; also see Table A2.1). Furthermore, to deal with increasing demand, all of South Africa's major ports, except Mossel Bay, will be upgraded and expanded in the future (Transnet National Ports Authority, 2014). This action could lead to an increase in the number of visiting ships, and unless additional biosecurity measures are put in place, the increased shipping intensity could result in an increase in the introduction of marine organisms through hull fouling. The threat posed by this pathway is, however, not simply in proportion to the number of visiting ships, and is higher for particular ports (Durban in particular) and for particular trade routes (routes from Asia) (Faulkner *et al.*, 2017b).

4

THE STATUS OF ALIEN SPECIES


Tephrocactus articulates (pine cone cactus) – SANBI

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Chapter summary

This chapter provides an overview of the status of alien species in South Africa based on data from a wide range of sources (atlas projects, expert assessments, lists, and published papers and reports).

Of the 2033 alien species recorded (or assumed to be present) outside of cultivation or captivity in South Africa, 775 are known to be invasive, 388 are known to be naturalised but not invasive, and 355 are present, but not naturalised. For the remainder (516 species), there is insufficient information to assign them to an introduction status category. Eight of the alien species recorded as present in the country are currently listed in the NEM:BA regulations as prohibited (i.e. species assumed to be absent from South Africa and which may not be imported).

Large numbers of alien species have relatively restricted distributions. Only in the case of plants and birds are there widespread species [e.g. found in at least a quarter (i.e. > 500) of the quarter-degree grid cells (QDGCs) of South Africa]. At least one alien reptile and two terrestrial invertebrate species are relatively widespread (> 100 QDGCs), although the data coverage is poor, so there is a low level of confidence in these estimates.

The only data available to estimate the abundance of alien species are those for terrestrial and freshwater plants. These estimates are very crude or over 20 years out of date, so the level of confidence in these estimates is very low. There are no comparable data for any other high-level taxa.

A systematic evaluation of the impacts of individual invasive species as per the recently developed international standards has not yet been conducted. However, 25 species were assessed by experts as having a severe impact, and 82 as having a major impact. Of these 107 species, most (80) are terrestrial or freshwater plants, eight are mammals, five each are freshwater fish, freshwater invertebrates and terrestrial invertebrates, two are amphibians, and there is one bird and one marine plant species.

Alien plants are the most diverse, widespread and damaging group of invaders in South Africa. Furthermore, it is clear that South Africa has a major alien plant invasion debt. Well over 100 new taxa have been recorded as naturalised or escapes from cultivation over the past decade, and the recorded range of almost all plants has increased significantly. This is a significant cause for concern, as it clearly indicates that problems associated with alien species are set to increase.

THE SITUATION

107 species have major impacts according to experts

most **(80)** are terrestrial or freshwater plants

8 are mammals | **1** marine invertebrate

5 each are freshwater fish, freshwater invertebrates & terrestrial invertebrates

2 are amphibians | **1** is a bird species

4.1. INTRODUCTION

This chapter provides an overview of the numbers, extent, abundance and impact of alien species in South Africa. The number of species was estimated using the list in the NEM:BA A&IS Regulations as a starting point, and adding other (unlisted) species that have been reported as naturalised in South Africa. The relevant indicators are the *Number and status of alien species* (i.e. whether they are known to be present in South Africa and their stage of introduction); the *Extent of alien species* (at national, provincial, biome or other scales); the *Abundance of alien species* status (in terms of their cover, biomass or population sizes); and the *Impact of alien species* (the degree to which the species has negative impacts). See Table 2.3 for further details.

Data were obtained from a variety of sources (Table 4.1). These data were of varying quality, and this affected the level of confidence placed in each indicator. In addition, the available data covered some, but not all, of the information needed to assign values to indicators, and for some indicators it is not yet possible to assign values due to a lack of data (Table 4.2).

TABLE 4.1 Sources of data used to assign values to species indicators, with levels of confidence based on the completeness and accuracy of data sets. Source Institutions for data: Animal Demography Unit (ADU); Centre for Invasion Biology (C•I•B); KwaZulu-Natal Museum (KZN Museum); Plant Protection Research Institute of the Agricultural Research Council (ARC-PPRI); South African Institute of Aquatic Biodiversity (SAIAB); South African National Biodiversity Institute (SANBI); South African National Parks (SANParks); Stellenbosch University (SU); University of Cape Town (UCT); University of KwaZulu-Natal (UKZN); University of Pretoria (UP). The numbering of indicators is based on Chapter 2: *5. Number and status of alien species; 6. Extent of alien species; 7. Abundance of alien species; 8. Impact of alien species.*

TAXON	SOURCE (SEE FOOTNOTE*)	TOTAL NUMBER OF SPECIES	DESCRIPTION	LEVEL OF CONFIDENCE BASED ON COMPLETENESS AND ACCURACY	INDICATOR INFORMED BY THESE DATA
All	Cape Nature	Totals provided for individual protected areas; no estimate of numbers across all protected areas	Lists maintained for individual protected areas	Moderate to low, depending on the protected area. Some protected areas have been poorly surveyed	5
All	Dr Llewellyn Foxcroft, (C•I•B/ SANParks); Foxcroft *et al.* (2017)*	869	Lists maintained by SANParks	High to low, depending on the park. Some are well-surveyed, others are data-poor	5, 6
All	Dr Michelle Greve (UP)	47	Database of alien species occurring on the Prince Edward Islands.	Moderate - conservative estimates as the invasion status of other alien species is unknown	5, 6, 8
All	Ezemvelo KZN Wildlife	Totals per protected area; no estimate of total across all protected areas	Lists maintained for individual protected areas	Moderate to low, depending on the protected area. Some protected areas have been poorly surveyed	5

TAXON	SOURCE (SEE FOOTNOTE*)	TOTAL NUMBER OF SPECIES	DESCRIPTION	LEVEL OF CONFIDENCE BASED ON COMPLETENESS AND ACCURACY	INDICATOR INFORMED BY THESE DATA
All	NEM:BA A&IS species list	556 taxa are listed, but the number of species is larger as the regulations sometimes include genera with several species.	Alien plant and animal species listed as invasive in the NEM:BA A&IS Regulations, or prohibited species found to be present in South Africa.	Moderate – many listed species are not assigned to the correct categories, are not invasive, or have not been recently recorded in South Africa	5
All	Zengeya *et al.* (2017)*	552	A simple scoring system was used to classify the alien species according to the relative degree of their benefits and negative impacts.	Low	8
Amphibians; Reptiles	Ditsong National Museum of Natural History Collection (Manamela, 2016)	49	Ditsong National Museum of Natural History Collection containing Herpetology, Mammal and Bird records from 1805 to 2008	Low – based on point data and does not include absence records	5, 6
Amphibians; Reptiles	Dr John Measey (C•I•B, SU); Kumschick *et al.* (2017); Measey *et al.* (2017); Bates *et al.* (2014); Minter *et al.* (2004)	44	Spatial database (Frog and reptile atlases) housed at the ADU, UCT	High for amphibians Moderate for reptiles	5, 6, 8
Animals	Picker & Griffiths (2017)*	571	Comprehensive listing of alien animal species in South Africa	Low	5, 6
Birds	Dr Rob Little (ADU/UCT)	49	Spatial database (Bird atlas) housed at the ADU, UCT	High – monitoring of distribution is frequent and the coverage is extensive	5, 6
Birds; Terrestrial invertebrates	Faulkner *et al.* (2017a)*	274	Description of how alien species might have been introduced to the region and spread between South Africa and elsewhere in Africa	Moderate	5, 6
Freshwater fish	Marr *et al.* (2017)*	27	Freshwater fish species introduced into the water courses of South Africa	Moderate	5, 8
Freshwater fish	SAIAB	Few	Assessments of species-specific impacts published in the scientific literature, and in theses	Low – very few species have been adequately studied	8
Freshwater invertebrates	Albany Museum (De Moor, 2015).	3	Specimen records held in the National Collection of Freshwater Invertebrates housed in the Albany Museum, Grahamstown, South Africa. 60 344 records with approximately 57 000 records georeferenced	Low, occurrence is based on the genera and not species	5

TAXON	SOURCE (SEE FOOTNOTE*)	TOTAL NUMBER OF SPECIES	DESCRIPTION	LEVEL OF CONFIDENCE BASED ON COMPLETENESS AND ACCURACY	INDICATOR INFORMED BY THESE DATA
Freshwater invertebrates; Terrestrial invertebrates	Global Biodiversity Information Facility (www.gbif.org)	1017	Occurrence data of invertebrates	Moderate – Data consistently updated on a regular bases	5, 6
Freshwater plants	Hill & Coetzee (2017)*	8	A review of the current status of aquatic weeds in South Africa, their socio-economic and environmental impacts and the benefits of their control	Moderate	5, 6, 8
Fungi; Terrestrial invertebrates	Zachariades *et al.* (2017)*; Klein (2011)	95	Assessment of the status of biological control as a management tool for suppression of invasive alien plants in South Africa; and a published review of biological control agents	High	5
Marine invertebrates	Iziko SA Museum: Marine invertebrate collection	20	The collection comprises ~130 000 lots of specimens (including un-accessioned material). Eleven hand-written catalogues exist for marine invertebrates dating back to 1871 and includes 76 184 entries	Low – database includes un-accessioned records	5, 6
Marine invertebrates; Marine plants	Dr Tammy B. Robinson (C•I•B/SU); Prof. Charles L. Griffiths (C•I•B/UCT); Ms S. Miza (SANBI)	93	List provided by experts	Low – based only on preliminary surveys and many species probably remain undiscovered or unrecognised as alien	5, 6, 8
Microbial species	Wood (2017)*	112	Preliminary listing of alien fungal species	Very low	5
Reptiles	Southern African Reptile Conservation Assessment (SARCA, Navarro 2015)	4	Distribution records for the reptiles of southern Africa, from literature and the SARCA Virtual Museum	Low – few records of alien reptiles were included in the assessment	5, 6
Soil biota	Janion-Scheepers *et al.* (2016)	103	Recently published review of soil biota	Low	5, 6
Terrestrial and freshwater plants	Bews Herbarium (UKZN)	168	Database of well-identified and fairly extensive invasive alien and problem plant collection of the Bews Herbarium, UKZN	High – based on published data	5, 6
Terrestrial and freshwater plants	Botanical Database of Southern Africa, BODATSA (Ranwashe, 2015)	401	BODATSA is a database that contains the official plant name data records. The data collected covers observational data, species checklists, specimen information, species description, literature and collector information from five herbaria. This is to maintain the most current scientifically accurate assessments of southern African plants	Moderate – based on regularly updated data	5, 6

TAXON	SOURCE (SEE FOOTNOTE*)	TOTAL NUMBER OF SPECIES	DESCRIPTION	LEVEL OF CONFIDENCE BASED ON COMPLETENESS AND ACCURACY	INDICATOR INFORMED BY THESE DATA
Terrestrial and freshwater plants	Southern African Plant Invaders Atlas (SAPIA); Henderson & Wilson (2017)*.	773	Atlas maintained by the PPRI-ARC	Moderate – based on roadside surveys of varying coverage	5, 6
Terrestrial and freshwater plants (grasses)	Visser *et al.* (2017b)*	256	Review of grasses as invasive alien plants in South Africa.	Moderate	5, 8
Terrestrial invertebrates (insects)	Albany Museum (Gess, 2015)	72	Database of the terrestrial insect collections of the Albany museum	Moderate – based on published data, however has not been updated	6
Terrestrial invertebrates (insects)	Dr Ruan Veldtman (SANBI)	9	List provided by expert	Low	5
Terrestrial invertebrates (insects)	Recently published comprehensive assessment of insect pests on crops and pastures in South Africa (Prinsloo & Uys 2015)	107	Prinsloo & Uys (2015) provided detailed accounts of 693 insect pests of cultivated plants and pastures in South Africa; of these, 107 (14.6%) were alien species	Low – the focus of this dataset was on pests of agricultural crops and pastures only. Alien status of species not explicitly included	5
Terrestrial invertebrates (molluscs)	David Kesner (SU)	16	Assessments of impacts as part of an ongoing study	Moderate	8
Terrestrial invertebrates (molluscs)	Prof Dai Herbert (KZN Museum)	39	Database and specimens curated by the KZN Museum	Low – records are accurate, but sampling intensity is low	5, 6, 8
Terrestrial plants	Clusella-Trullas & Garcia (2017) *	15	Impacts of invasive alien plants on abundance, richness and composition of several taxonomic groups of ectotherms	Low	8
Terrestrial plants (cacti)	Kaplan *et al.* (2017)*	31	An assessment of the status of cactus invasions in South Africa.	Moderate	5, 6

* Papers were part of the journal special issue that was produced as part of the status report process, see Box 1.3.

TABLE 4.2 Estimated completeness and accuracy of data required to assign values to alien species indicators in South Africa for different taxonomic groups. The taxonomic groupings are as per the NEM:BA A&IS Regulations. Levels of completeness are: High (information available for > 75% of species); Moderate (information available for 30–75% of species); Low (information available for < 30% of species). Levels of accuracy refer to available data, as follows: High (point distribution data available, or ecology and impacts well-documented); Moderate (quarter-degree grid cell distribution data available or superficial studies available on ecology and impacts); Low (no formal mapping or documented studies on ecology and impacts). N/A is not applicable.

INDICATOR	TAXON	COMPLETENESS	ACCURACY
Number and status of alien species	Amphibians	High	High
	Birds	High	High
	Freshwater fish	High	High
	Freshwater invertebrates	Low	Low
	Mammals	High	Moderate
	Marine fish	N/A	N/A
	Marine invertebrates	Low	Low
	Marine plants	Low	Low
	Microbes	Low	Low
	Reptiles	Moderate	Moderate
	Terrestrial and freshwater plants	High	Moderate
	Terrestrial invertebrates	Low	Low
Extent of alien species	Amphibians	High	Moderate
	Birds	Moderate	Moderate
	Freshwater fish	High	Low
	Freshwater invertebrates	Low	Low
	Mammals	Moderate	Moderate
	Marine fish	N/A	N/A
	Marine invertebrates	Low	Low
	Marine plants	Low	Low
	Microbes	Low	Low
	Reptiles	High	Moderate
	Terrestrial and freshwater plants	High	Moderate
	Terrestrial invertebrates	Low	Low
Abundance of alien species	Terrestrial and freshwater plants	Low	Low
	All other taxa	No data	No data
Impact of alien species	Amphibians	Moderate	Moderate
	Birds	Low	Low
	Freshwater fish	Low	Low
	Freshwater invertebrates	Low	Low
	Mammals	Low	Low
	Marine fish	Low	Low
	Marine invertebrates	Low	Low
	Marine plants	Low	Low
	Microbes	Low	Low
	Reptiles	Moderate	Moderate
	Terrestrial and freshwater plants	Low	Low
	Terrestrial invertebrates	Low	Low

4.2. THE NUMBER AND STATUS OF ALIEN SPECIES IN SOUTH AFRICA

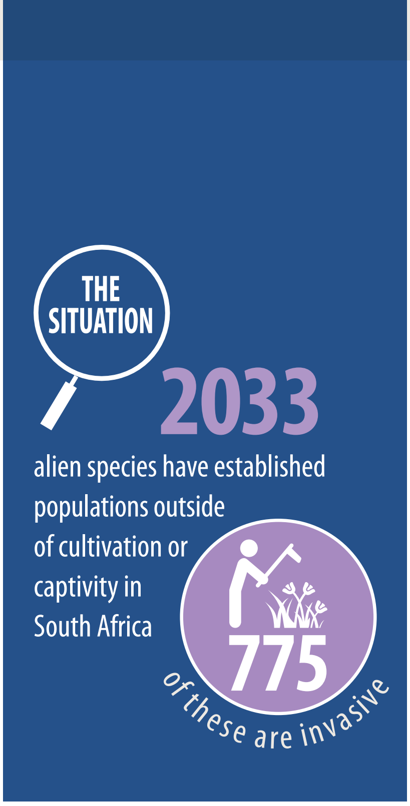
The introduction status of alien species can be assessed at different levels, depending on the availability of data (Table 4.3). For many species it was only possible to either determine whether or not it was present in South Africa, while for others it was possible to assess whether the species was absent, introduced but not naturalised, naturalised but not invasive, or invasive. There are very few studies on specific groups that provide data at the third and highest level of resolution, i.e. a breakdown of introduction status according to the unified framework of Blackburn *et al.* (2011), as was done, for example, by Jacobs *et al.* (2017). Full details of all species are provided in Appendix 3.

TABLE 4.3 The relationship between the three levels of resolution that can be used to describe introduction status. Species are placed as far along the introduction-naturalisation-invasion continuum as they can be with the available evidence (e.g. there has to be reported evidence that a species is invasive for it to be classed as such).

PRESENCE	BASIC INTRODUCTION STATUS	STATUS ADAPTED FROM THE UNIFIED FRAMEWORK FOR BIOLOGICAL INVASIONS (BLACKBURN ET AL., 2011)
ABSENT	Not present	**A0** (Never introduced beyond limits of indigenous range to the region in question, i.e. South Africa)
		A1 (Has been introduced beyond limits of indigenous range to South Africa, but no longer present)
PRESENT	Introduced but not naturalised	**B1** (in captivity or quarantine)
		B2 (in cultivation but no measures in place to prevent escape)
		B3 (released outside of captivity or cultivation)
		C0 (some escape from captivity or cultivation, but survival limited)
		C1 (escape and survival outside of captivity or cultivation, but no reproduction)
		C2 (escape, survival, and reproduction outside of captivity or cultivation, but not clear whether the population is self-sustaining)
	Naturalised but not invasive	**C3** (escape, survival, and reproduction outside of captivity or cultivation; population self-sustaining but not spreading)
	Invasive	**D1** (escape, survival, reproduction and spread outside of captivity or cultivation; though no evidence of reproduction post-dispersal)
		D2 (escape, survival, reproduction, spread, and subsequent reproduction outside of captivity or cultivation; though spread as yet limited to a few localities)
		E (invasive at multiple localities)

4.2.1. Number of alien species in South Africa

A total of 2033 alien species were found to be present in South Africa (Table 4.4). All of the species listed as prohibited in the A&IS Regulations were assumed to be absent from South Africa, except for eight prohibited species that are known to have been introduced. These include one bird, one reptile, two amphibians, one microbial species and three invertebrates.



4.2.2. Status of alien species in South Africa

Of the 2033 alien species recorded (or assumed to be present) outside of cultivation or captivity in South Africa, 775 are known to be invasive, 388 are known to be naturalised but not invasive, and 355 are present, but not naturalised. There are a further 516 species where there is insufficient information on which to assign them to one of the basic introduction status categories. For terrestrial and freshwater plants, the assessment relied heavily on the SAPIA dataset [see Henderson & Wilson (2017) for a recent analysis of the database]. Unless explicitly stated elsewhere, the assumptions were made that all taxa recorded in SAPIA were naturalised and all taxa in two or more quarter degree grid cells (QDGCs) were invasive. This is not strictly correct, as for a species to be recorded in SAPIA there is no formal assessment of naturalisation, or whether a population is invasive or not, but the assumption will hold for the majority of records. For the other taxa, the determination of a species as invasive was based on expert opinion where available, otherwise the species was not classed as naturalised or invasive (recorded as NA – Not Assessed – in Appendix 3).

About one third of the alien species found outside of captivity or cultivation in South Africa are known to have become invasive in South Africa. The proportion differed among taxa, with terrestrial, freshwater and marine plants having relatively high proportions (55 – 64%), while reptiles and microbes had no known invasive species (though in the case of microbes this is undoubtedly a classification error). The proportion of all introduced species (for example of a genus or family) that are invasive will be lower than the above estimates, because the estimates express the proportion in terms of species that are already present outside of captivity or cultivation. Reliable estimates of the proportion of species within a genus are only available for some genera of plants, where the proportion of introduced species that becomes invasive ranges from 2% to 22%. At least 36 species in the genus *Melaleuca* (bottlebrushes) have been introduced to South Africa, and 10 of these have naturalised, including 5 (14%) that are invasive (Jacobs *et al.* 2017). More than 80 species of the genus *Acacia* (Australian wattles) have been introduced to South Africa, and 18 (22%) have been recorded as naturalised (Richardson, Le Roux & Wilson 2015). At least 68 species of the genus *Pinus* (pine trees) have been introduced to South Africa, where eight species have become invasive (12%), and a further 26 species are regarded as potentially invasive (Van Wilgen & Richardson, 2012). Such analyses have the potential to inform risk analyses by identifying high-risk groups (Diez, Hulme & Duncan 2012), but should be moderated by an assessment of whether introduced taxa had an opportunity to become invasive or not (Moodley *et al.*, 2014).


Facility for mass-rearing biological control agents – Kim Weaver


Facility for mass-rearing biological control agents – Kim Weaver

TABLE 4.4 The number of alien species known to occur in South Africa, assigned to various categories of introduction status. The categories under "NEM:BA" refer to species listed in the Alien and Invasive Species Regulations under the National Environmental Management: Biodiversity Act; "context-specific" refers to species that are listed in different categories depending on their location or habitat. See Table 4.3 for definitions of status.

TAXON	LEGAL CATEGORY	STATUS				
		Occurs in SA, but insufficient data to assign status = NA	Present in South Africa, but not established outside of captivity or cultivation = B1, B2, B3, C0, C1, C2	Naturalised = C3	Invasive D1, D2, E	Total
Terrestrial and freshwater plants	Listed	29	4	34	315	382
	Unlisted	3	68	181	259	511
Marine plants	Listed	0	0	1	2	3
	Unlisted	0	0	2	3	5
Mammals	Listed	34	1	4	1	40
	Unlisted	2	0	0	0	2
Birds	Prohibited	0	1	0	0	1
	Listed	7	3	5	8	23
	Unlisted	41	8	13	6	68
Reptiles	Prohibited	0	1	0	0	1
	Listed	22	5	2	0	29
	Unlisted	81	16	0	1	98
Amphibian	Prohibited	0	2	0	0	2
	Listed	0	3	1	2	6
	Unlisted	0	11	1	1	13
Freshwater fish	Listed	2	7	6	0	15
	Unlisted	6	4	1	0	11
Terrestrial invertebrates	Prohibited	0	1	0	0	1
	Listed	13	2	8	0	23
	Unlisted	262	133	73	107	575
Freshwater invertebrates	Prohibited	0	0	0	1	1
	Listed	4	2	0	3	9
	Unlisted	1	2	2	14	19
Marine invertebrates	Prohibited	0	0	1	0	1
	Listed	0	0	3	9	12
	Unlisted	0	4	31	37	72
Microbial species	Prohibited	0	1	0	0	1
	Listed	7	0	0	0	7
	Unlisted	1	76	19	6	102
Total		**516**	**355**	**388**	**775**	**2033**

4.3. THE EXTENT OF ALIEN SPECIES IN SOUTH AFRICA

4.3.1. Number of broad-scale regions occupied per species

Distribution data were only available for 835 out of the 1941 terrestrial and freshwater species, and estimates of the extent of species are therefore restricted to this subset. Many species were relatively localised; for example about one third of all species were found in only one province (Figure 4.1). Some species were widespread, with over 40 species (about 5%) being found in eight or nine provinces (Figure 4.1).

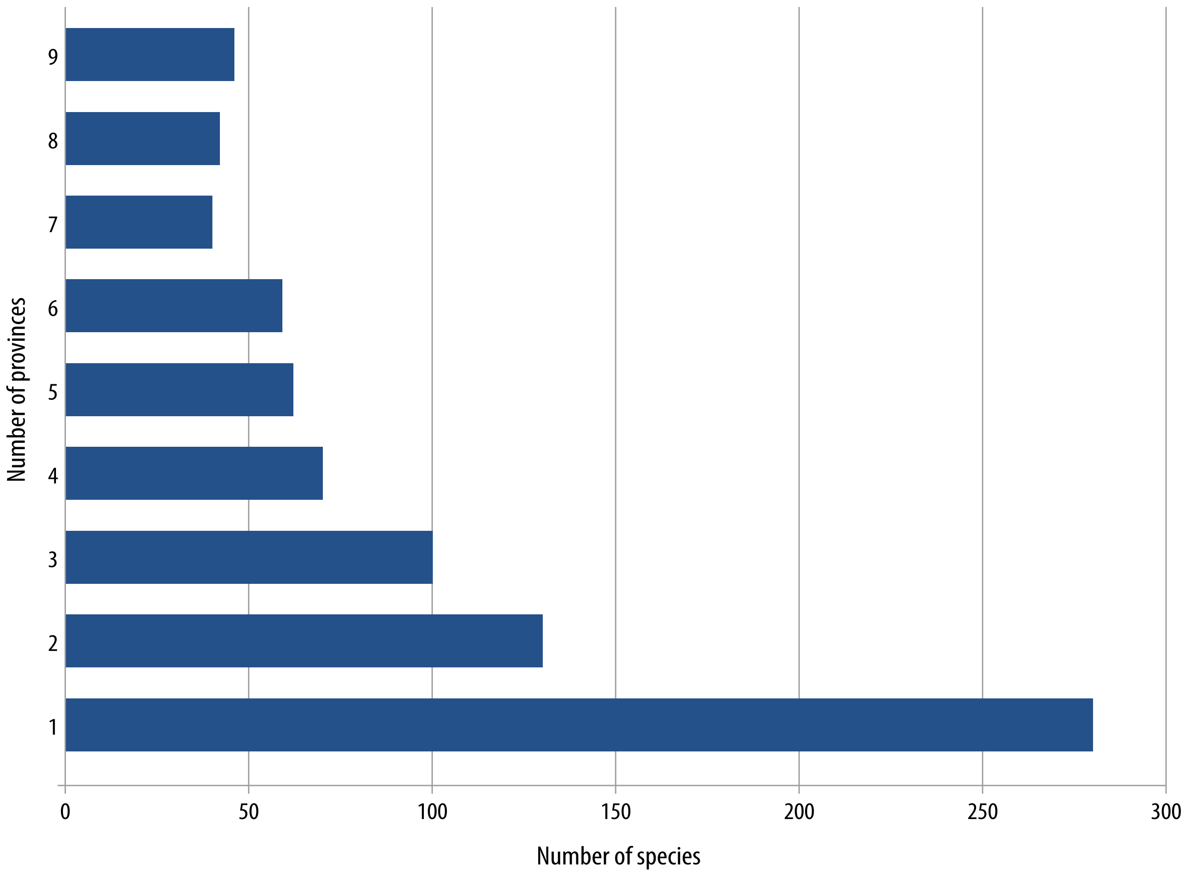


FIGURE 4.1 Extent of 835 alien species at a provincial scale in South Africa. About a third of all species are found in only one province, but there are more than 40 species that are found in all nine provinces.

Mapped distribution data for marine species were not available. Most alien marine species have only been recorded in harbours or marinas (Figure 4.2) which is arguably outside of captivity or cultivation, with some being associated with aquaculture facilities (within captivity or cultivation). Species that have been recorded outside of these human-dominated habitats are usually associated with a particular substrate (rocky or sandy intertidal zones, or estuaries), or may be pelagic species in coastal waters. Some species are known to be quite widespread, for example *Mytilus galloprovincialis* (Mediterranean mussel, see Box 4.1).

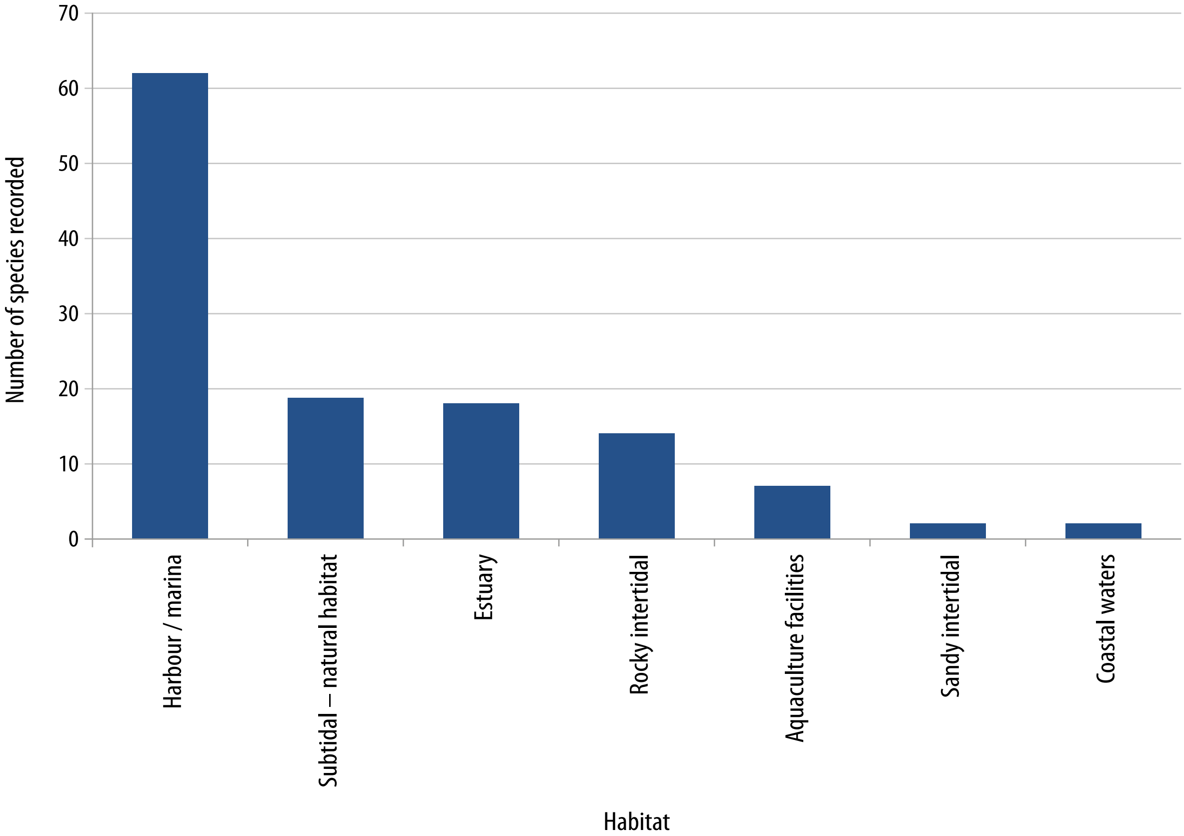


FIGURE 4.2 The numbers of alien marine species in South Africa associated with particular habitat types.

4.3.2. Number of quarter degree grid cells occupied per species

Quarter degree grid cells (QDGCs) provide the most convenient way to assess the extent of occurrence of alien species in South Africa, as most distribution data are available at that scale. There are 1 966 QDGCs in South Africa, and each cell measures 15 minutes of latitude by 15 minutes of longitude. The cells are approximately 676 km^2 in area (cells in the north of South Africa are approximately 11% larger than those in the south). Data on the extent are available for some, but not all, terrestrial taxa; essentially, these data only had a high degree of completeness and accuracy in the case of birds and terrestrial and freshwater plants (Table 4.2). Distribution data were not available at the scale of QDGCs for marine species.

Large numbers of species have relatively restricted distributions (Figure 4.3), and only in the case of plants and birds are there widespread species found in > 500 QDGCs. At least one alien reptile (*Python natalensis x molurus*, a hybirid of the Southern African and Burmese python) and two alien terrestrial invertebrate species (*Cornu aspersum*, the common garden snail and *Vanessa cardui*, the painted lady) are relatively widespread (occurring in > 100 QDGCs), although the data coverage is poor, so there is a low level of confidence in these estimates. Alien species in other taxa (amphibians, freshwater invertebrates and mammals) appear to be less widespread. There are no reliable data to illustrate the distribution of freshwater fish, fungi and microbial species at this scale.

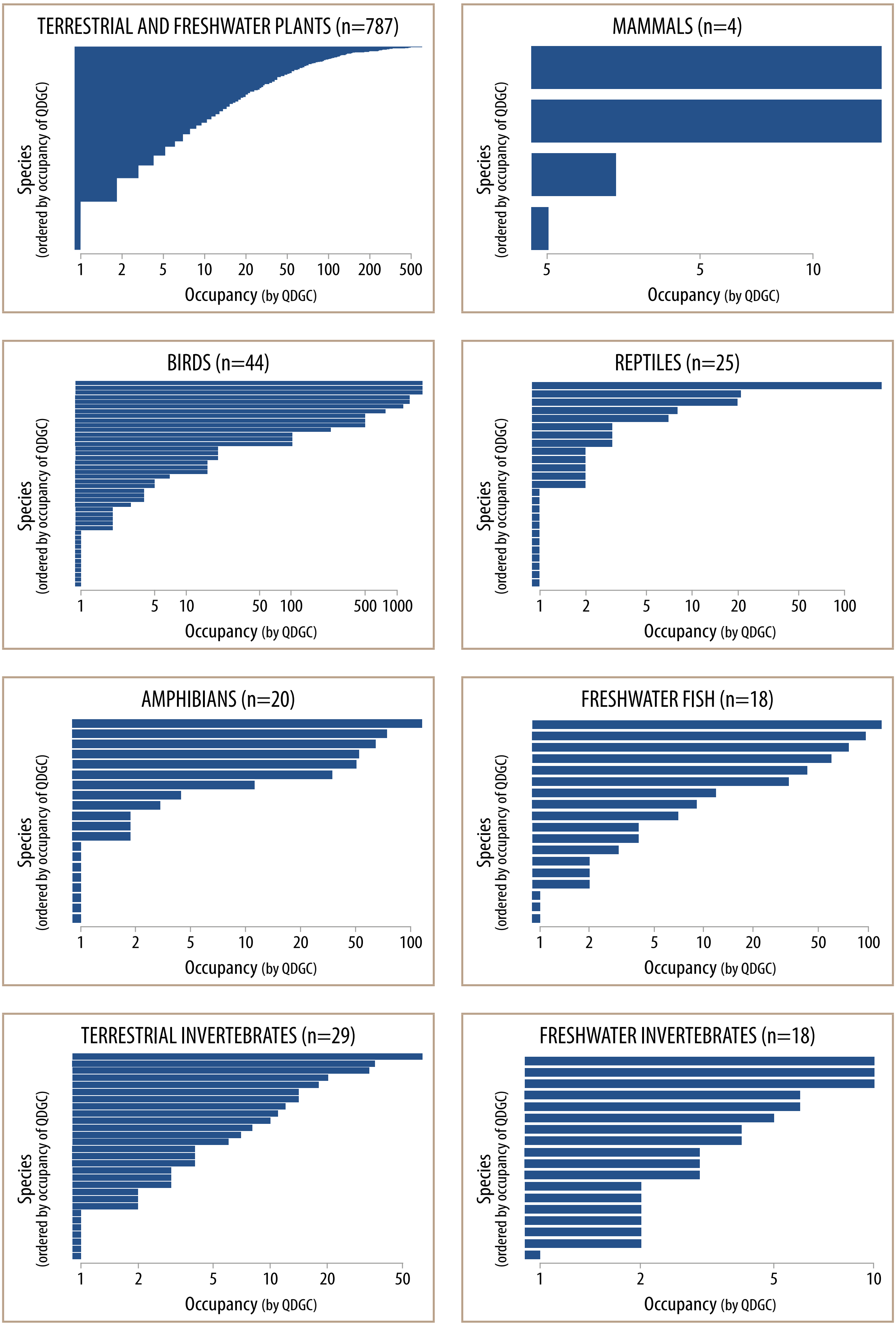
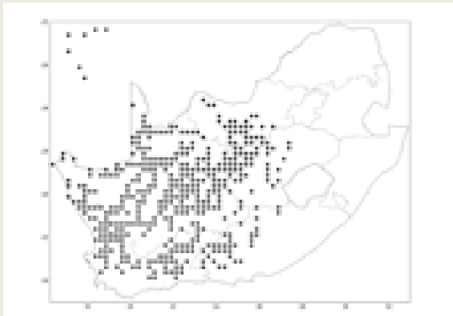


FIGURE 4.3 The distribution in alien range sizes for alien species in South Africa. Note the range sizes are plotted on a log scale. QDGC = quarter degree grid cell.

BOX 4.1 TEN EXAMPLES OF WIDESPREAD INVASIVE ALIEN SPECIES IN SOUTH AFRICA

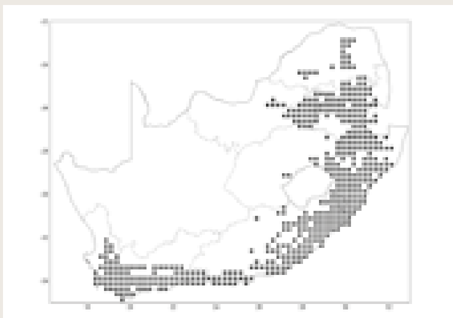
There are 556 alien taxa listed as invasive in South Africa's Alien and Invasive Species Regulations, and there are also many more invasive species that are not listed (Appendix 3). A relatively small subset of these species has become particularly widespread and often problematic, and hundreds of millions of rands have been spent annually on attempts to control some of them. A selection of ten of these species is presented here to illustrate the problem.

***Prosopis glandulosa* var. *torreyana* (honey mesquite):**
These trees were introduced from north and central America as a source of fodder for livestock in arid areas. They have subsequently invaded extensive areas in the karoo and arid savanna, where they impact negatively on biodiversity, rangeland condition and groundwater resources (Box 4.2). Because of their usefulness as a source of fodder, they are listed as category 3 (may be retained but not replaced) in the Northern Cape, but as category 1(b) elsewhere (must be controlled). Although there is some biological control available for this species, it is not effective. Endeavours to mechanically control the species have also not been effective, and it continues to spread.



Photograph: L. Otto. Map: L. Henderson.

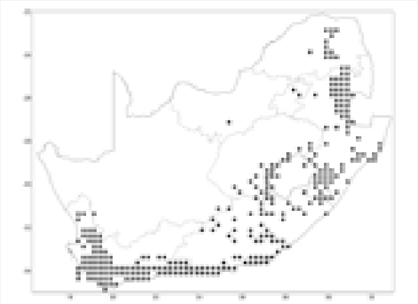
***Acacia mearnsii* (black wattle):**
These trees were introduced from Australia to provide a source of tannins from bark and for wood products. They have extensively invaded the relatively humid parts of South Africa, notably along rivers. They have negative impacts on water resources. Because of their commercial value, they are listed as category 2 (may be retained, and traded, with a permit, but should be controlled elsewhere). Biological control aimed at reducing seed production appears to be increasing in effectiveness, but soil-stored seed banks will probably persist for many years.



Photograph: SANBI. Map: L. Henderson

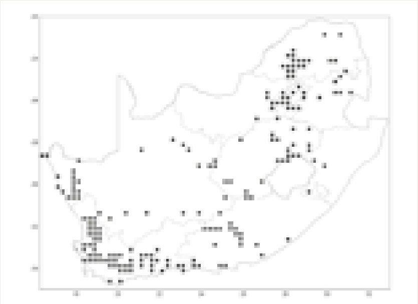
***Pinus patula, P. pinaster* and *P. radiata* (pine trees):**
These trees were introduced from Europe and North America as a source of timber. They have invaded extensively in the fynbos biome, where they impact negatively on water runoff from mountain catchments, reduce biodiversity and increase the intensity of fires. Because of their commercial value, they are listed as category 2 (may be retained, and traded, with a permit, but should be controlled elsewhere). Some progress has been made with regard to mechanical control in some areas, but at a broader scale these species continue to spread rapidly, and pose a major long-term threat to the integrity of fynbos ecosystems and the the ability of fynbos-clad catchments to deliver water runoff to dams. Biological control options have not yet been implemented for these species.

Photograph: SANBI. Map: L. Henderson



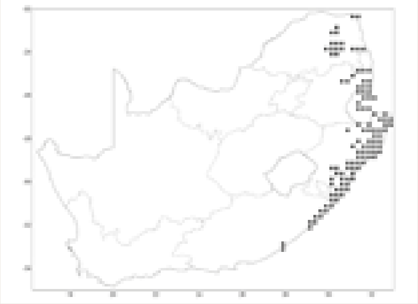
***Eucalyptus camaldulensis* (river red gum):**
These trees were introduced from Australia to provide a variety of useful products and services. They have become highly invasive along rivers in places throughout the country, where they often dominate the riparian vegetation. Eucalypts are known to use large amounts of water, so they probably reduce water levels in rivers, as well as reduce the biodiversity of natural vegetation. The species is listed as category 1(b) (must be controlled), but as category 2 (may be retained, and traded, with a permit) in a range of habitats including plantations, windrows, bee forage areas, woodlots and in gardens, to cater for various uses. The effectiveness of attempts to control this species has not been assessed, nor are there any biological control agents available for this species.

Photograph: H. Klein. Map: L. Henderson



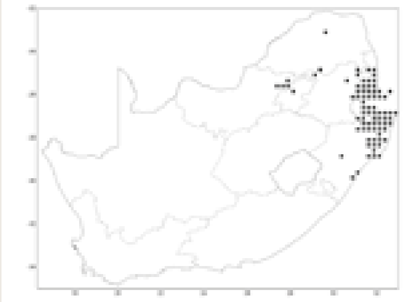
***Chromolaena odorata* (triffid weed):**
This shrub originates from north, south and central America, and was probably accidentally introduced to South Africa. It has spread along much of the KwaZulu-Natal Coast and the escarpment and lowveld of the Mpumalanga and Limpopo Provinces. It can form dense thickets and is regarded as an ecosystem transformer, almost certainly impacting negatively on range condition and biodiversity. It is placed in category 1(b) (must be controlled). There has been some success in reducing their populations in protected areas (see section 6.4.2). Biological control options are available, but their effectiveness has also not been assessed.

Photograph: T. Schoch. Map: L. Henderson



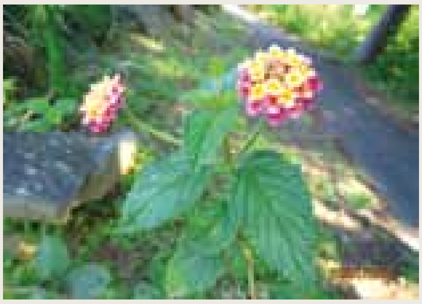
Parthenium hysterophorus (famine weed):
This annual herb is indigenous to tropical America, and has been present in South Africa for over 100 years. It has however only recently begun to spread rapidly, and it now occurs extensively in northern KwaZulu-Natal, Swaziland, and Mpumalanga. The species causes severe allergic reactions in many people who come into contact with it, as well as in livestock and wildlife. It has the potential to substantially reduce rangeland condition. It is placed in category 1(b) (must be controlled). Serious attempts to control this species have only recently begun. Indications are that mechanical control alone will not contain this species, but biological control options are being investigated, and they hold the potential to reduce spread rates and vigour.

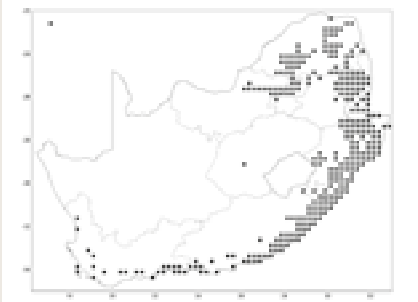
Photograph: SANBI. Map: L. Henderson



Lantana camara (lantana):
This shrub was originally introduced into South Africa from south and central America as a garden ornamental. It has extensively invaded the relatively humid parts of South Africa, where it can form dense thickets and transform ecosystems. The species presumably impacts negatively on biodiversity and is also poisonous. It is placed in category 1(b) (must be controlled). Much effort has been directed towards biological control of this species, where the level of control has been assessed as substantial.

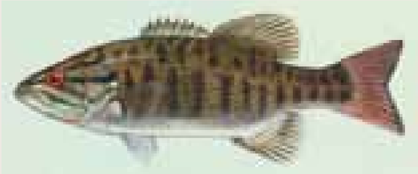
Photograph: SANBI. Map: L. Henderson

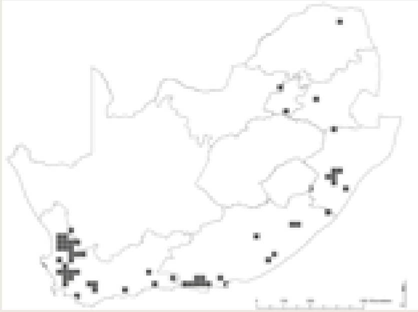




Micropterus dolomieu (small-mouth bass):
This species was imported from north America to provide freshwater angling opportunities. Anglers have introduced the species to several river systems, particularly in the Western and Eastern Cape Provinces. It preys on indigenous fishes and invertebrates and can change the structure of freshwater species communities. Its regulation is complex. It is placed in category 1(b) (must be controlled) in protected areas, and in category 2 or 3 in dams and rivers where it already occurs. Once established, control is not feasible except in small streams or dams where it may be possible to extirpate populations.

Photograph: R. Duane, U.S. Fish and Wildlife Service. Map: SAIAB.



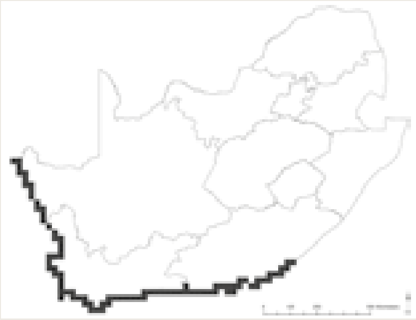


***Acridotheres tristis* (common mynah):**
This species was brought to Durban from Asia in 1888, from where it has spread to most of northeast South Africa. It favours urban environments (where populations can reach hundreds of thousands), but probably has negligible impacts on natural and rural habitats. It is listed as category 3 (does not require control, but may not be moved or traded). Large-scale control would probably be impossible, but occasional removal of isolated individuals has been carried out, for example in Cape Town and the Kruger National Park.

Photograph: R. Taylor. Map: ADU.

***Mytilus galloprovincialis* (Mediterranean mussel):**
This species was accidentally introduced from Europe to South Africa's west coast in about 1979, almost certainly by shipping. It spread rapidly to Namibia, and more slowly to the Eastern Cape. It now dominates most of the rocky shores of the west and south coasts, where it forms dense, multi-layered beds that monopolise space on intertidal rocks. It can be beneficial as a food source to both humans and animals (for example the African oystercatcher, *Haematopus ostralegus*). Listed as category 2 (cultivation and trade allowed with a permit). Its control would probably be impossible, given the wide range, prolific reproductive habits, and widely-dispersing larvae.

Photograph: S. Miza. Map drawn from data supplied by Dr T. Robinson.



4.4. ABUNDANCE OF ALIEN SPECIES

Two sources of data were available to estimate the *Abundance of alien species*, both relating to plants. The first is contained in the 1998 report of the Water Research Commission (Appendix 5 in Versfeld, Le Maitre & Chapman 1998). These estimates are very crude and 20 years out of date, so the level of confidence in these estimates is very low. There are no comparable data for any other high-level taxa. The second is the National Alien Invasive Plant Survey of the Agricultural Research Council (Kotzé *et al.*, 2010). This survey has a focus of those species targeted for control by the Working for Water programme (mainly trees and shrubs), and it excludes a very large proportion of arid South Africa. In addition, the methodology on which this survey is based has never been adequately documented, and therefore there can only be a low degree of confidence in the estimates at this stage. In addition, because of differences in methodology and sampling coverage, the findings of Versfeld, Le Maitre & Chapman (1998) and the National Alien Invasive Plant Survey are not comparable (Table 4.5).

TABLE 4.5 Invasive plant taxa listed as the most abundant in South Africa in terms of cover by Versfeld, Le Maitre & Chapman (1998), and by Kotzé *et al.* (2010). Species were ranked by condensed invaded area (mean % cover × area occupied). Condensed ha is the equivalent area occupied at a canopy cover of 100% (i.e. 50% cover on 10 ha = 5 condensed ha). Note that estimates from Kotzé *et al.* (2010) exclude almost all of the arid parts of South Africa.

TAXON	EXTENT (total invaded area in 1 000s of ha as estimated by Versfeld, Le Maitre & Chapman 1998)	ABUNDANCE (condensed invaded area in 1 000s of ha as estimated by Versfeld, Le Maitre & Chapman 1998)	ABUNDANCE (condensed invaded area in 1 000s of ha as estimated by Kotzé et al., 2010)
Acacia cyclops (rooikrans)	1 900	339	55
Prosopis species (mesquite)	1 800	173	Not estimated
Acacia mearnsii (black wattle)	2 500	131	474
Acacia saligna (Port Jackson)	1 900	108	50
Solanum mauritianum (bugweed)	1 800	89	40
Pinus species (pine trees)	3 000	77	133
Opuntia species (cacti)	1 800	75	95
Melia azedarach (syringa tree)	3 000	73	Not estimated
Lantana camara (lantana)	2 200	69	32
Hakea species (hakea)	700	64	36
Eucalyptus species (gum trees)	2 429	63	274
Chromolaena odorata (triffid weed)	534	43	102
Populus species (poplar trees)	1 305	15	58
Salix babylonica (weeping willow)	121	12	38

4.5. THE IMPACT OF ALIEN SPECIES

The impact of alien species in South Africa has, as in other countries, rarely been investigated, and where it has been done, the estimates are often in units that are not directly comparable. To alleviate the problem of comparing different types of impact measured in different ways, the Environmental Impact Classification for Alien Taxa (EICAT) Scheme (Blackburn *et al.*, 2014) has recently been adopted by the IUCN. A Socio-Economic Classification of Alien Taxa scheme (SECIAT, Bacher *et al.*, 2018) has also recently been developed. However, at the time of writing this report, these schemes had not yet been implemented in South Africa. The impact of some species has been formally assessed at a global scale (for example Evans, Kumschick & Blackburn 2016 for birds and Kumschick *et al.*, 2017 for amphibians). These assessments are not used here, as the specific impacts in South Africa would need to be assessed for a national-scale status report.

Therefore, for indicator *8 - Impact of alien species*, all species presently fall into the category of "not assessed". Conducting South African specific EICAT and SEICAT assessments is a priority for future reports (Chapter 8).

There was, however, a recent exercise in which experts were asked for their opinion on the impact of listed species (Zengeya *et al.*, 2017). In this study, the 552 species listed in the NEM:BA A&IS Regulations were scored by taxon-specific experts according to their ecological and their socio-economic impacts (separately for negative and positive impacts), on a scale from 1 to 10 using wording similar to the EICAT scheme. For the purposes of discussion, the scores in Zengeya *et al.* (2017) were grouped into five categories that correspond in spirit to the five categories of the EICAT and SEICAT schemes [1–2 is negligible impact ~ Minimal Concern (MC) under EICAT; 3–4 are a few impacts ~ Minor (MI); 5–6 is some impact ~ Moderate (MO); 7–8 are major impacts ~ Major (MR); and 9–10 are severe impacts ~ Massive (MV)], with each taxon assigned to a category according to the maximum impact scored (i.e. the higher of either the environmental or socio-economic impacts).

Using the scheme of Zengeya *et al.* (2017), 25 species were assessed as having a severe impact, and 82 as having a major impact (Table 4.6). Of these 107 species, most (80) are terrestrial or freshwater plants, eight are mammals, five each are freshwater fish, freshwater invertebrates and terrestrial invertebrates, two are amphibians, and there is one bird and one marine plant species.

The greatest impacts associated with invasive species in terrestrial habitats are due to invading plants (Table 4.7). Depending on the species, they can reduce rangeland condition and carrying capacity, reduce surface water runoff and groundwater recharge, increase fire hazards, and erode biodiversity. When introduced to offshore islands, they can imperil island fauna and flora (Box 5.3). In a review of the state of knowledge regarding the impacts of invasive plants in South Africa, Richardson & Van Wilgen (2004) concluded that, with the notable exception of the impacts of woody plants on water resources, very little was documented. Although there have subsequently been additional studies, the impacts of the vast majority of invasive species remains unstudied. One notable exception is provided by invasive trees in the genus *Prosopis* (mesquite trees), where at least ten separate studies have documented impacts on indigenous invertebrates, birds, mammals, trees and grasses, rangeland condition, groundwater recharge and human health in both biophysical and economic terms (Box 4.2). In some cases, indigenous knowledge systems provide valuable insights into impact. For example, Shackleton *et al.* (2017b) used semi-structured questionnaires to assess local perceptions associated with invasive cacti in Laikipia County, Kenya. This study was useful in identifying and ranking the main impacts associated with the species concerned, and this approach could be used more often in future to expand knowledge. Finally, some species can have both positive and negative impacts (Box 4.3), and these cases present special challenges when it comes to finding acceptable and sustainable approaches to their management.

In freshwater ecosystems, invasive fish and crustaceans, as well as the diseases they carry, can have large impacts on indigenous freshwater biota. Again, well-documented cases are rare, but a small number of robust studies exist. For example, Shelton, Samways & Day (2014) documented the impacts of *Oncorhynchus mykiss* (rainbow trout) in the rivers and streams of the Cape Floristic Region (CFR). They found mean densities of indigenous *Pseudobarbus burchelli* (Breede River redfin), *Sandelia capensis* (Cape kurper) and *Galaxias zebratus* (Cape galaxias), were 89–97% lower in invaded streams than in streams without trout. Furthermore, while indigenous fish were present at 100% of all sites without trout, they were not recorded at all at 58% of the invaded sites. The study concluded that alien trout have depleted the abundance of CFR-endemic fishes through size-selective predation.

Of the 93 alien marine species recorded, impact was assessed for only 12 species. As such, according to the scheme used here, 81 species are data deficient, 2 have few impacts, 7 have negligible impacts, 5 have some impacts and 2 have major impacts (T. Robinson & C. Griffiths unpublished data). Five species have economic or human health impacts, but these have not been formally assessed. *Mytilus galloprovincialis* (Mediterranean mussel) is believed to have the greatest impacts in South African marine environments. First recorded in the late 1970s, this species presently occupies more than 2000 km of coastline, occurring along the whole of the West Coast and as far east as East London (Robinson *et al.*, 2005). Within its range, this mussel impacts on a variety of indigenous species and ultimately has altered the structure of rocky shore communities. Along the West Coast *M. galloprovincialis* dominates primary rock surfaces at the expense of various competitively inferior indigenous mussel and limpet species (Branch & Steffani, 2004; Robinson *et al.*, 2007), while along the South Coast it co-exists with the indigenous mussel *Perna perna* (Linnaeus) (Bownes & McQuaid 2006). Interestingly, this mussel has also increased the diversity and abundance of indigenous fauna on invaded shores, as it forms complex mussel beds that increase habitat availability for indigenous biota (Robinson *et al*., 2007, Sadchatheeswaran, Branch & Robinson 2015). This change in habitat structure has significantly altered rocky shore communities. The five species that have some impacts are *Sagartia ornata* (brooding sea anemone), *Ficopomatus enigmaticus* (estuarine tube-worm), *Balanus glandula* (Pacific barnacle), *Semimytilus algosus* (pacific mussel) and *Ciona intestinalis* (sea vase). These invasions have resulted in population-level changes in indigenous species. The most recently arrived species, *S. algosus* is particularly concerning. This mussel was first detected along the West Coast in 2009 (De Greef, Griffiths & Zeeman 2013) but has recently crossed the biogeographic barrier of Cape Point and now occurs in False Bay (T. Robinson unpublished data). Laboratory studies have suggested that this mussel could survive along the South Coast (Alexander *et al.*, 2015) and this raises concerns that the full extent of the impacts of this alien are yet to be realised.

TABLE 4.6 The number of species known to occur in South Africa, assigned to various categories of impact status based on expert opinion of the impact in South Africa. The impact of biological control agents is positive, so they were not assigned to an impact status hence they were represented as NE (not evaluated). See text for definitions of impact status.

TAXON	IMPACT							
	DATA DEFICIENT	NEGLIGIBLE	FEW	SOME	MAJOR	SEVERE	NOT EVALUATED	TOTALS
Amphibians	15	1	2	1	2	0	0	21
Birds	0	5	5	8	1	0	73	92
Freshwater fish	1	0	5	9	4	1	6	26
Freshwater invertebrates	0	7	9	4	1	4	4	29
Mammals	0	4	16	11	8	0	3	42
Marine invertebrates	73	2	1	4	1	0	4	85
Marine plants	8	0	0	0	0	0	0	8
Microbial species	0	6	0	1	0	0	103	110
Reptiles	18	11	11	8	0	0	80	128
Terrestrial and freshwater plants	2	48	116	133	63	17	514	893
Terrestrial invertebrates	5	94	16	20	2	3	460	600
Totals	**122**	**178**	**181**	**199**	**82**	**25**	**1 247**	**2 034**

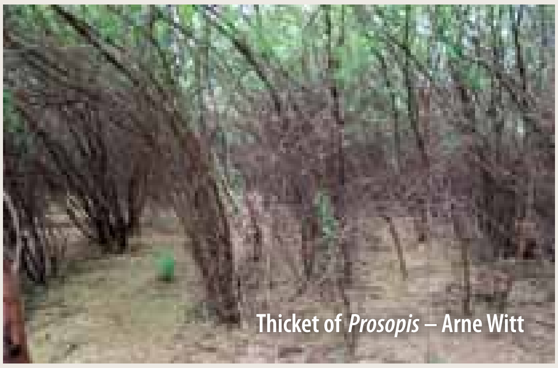
Twenty-five species were considered to have a severe impact (Table 4.7). Most of these (17 species) were plants, which included seven species of Australian trees and shrubs in the genus *Acacia*. The list also included some examples of severe impact by species in other high-level taxa, including one freshwater fish species, one amphibian species, three terrestrial mollusc species, and one terrestrial insect species.

TABLE 4.7 Invasive species assessed based on expert opinion to have severe impacts in South Africa. The regulatory category "context specific" applies to species that have been placed into various categories depending on their location.

TAXON	SPECIES	REGULATORY CATEGORY	EXTENT (QDGCs occupied)	EXAMPLES OF IMPACTS
TERRESTRIAL AND FRESHWATER PLANTS	*Acacia cyclops* (rooikrans)	1b	115	Forms closed-canopy stands, excluding most other species; disrupts natural sand movement in coastal ecosystems; increases fire intensity, leading to soil damage and erosion
	Acacia dealbata (silver wattle)	2	240	Forms closed-canopy stands, excluding most other species, especially in riparian areas; uses excessive amounts of water
	Acacia decurrens and hybrids (green wattle)	2	105	Forms closed-canopy stands, excluding most other species, especially in riparian areas; uses excessive amounts of water
	Acacia longifolia (long leaved wattle)	1b	53	Forms closed-canopy stands, excluding most other species; uses excessive amounts of water
	Acacia mearnsii and hybrids (black wattle)	2	369	Forms closed-canopy stands, excluding most other species, especially in riparian areas; uses excessive amounts of water
	Acacia melanoxylon (Australian blackwood)	2	124	Widespread invader in forests and forest ecotones. Excludes other species
	Acacia saligna (Port Jackson)	1b	126	Forms closed-canopy stands, excluding most other species
	Agrostis stolonifera (creeping bent grass)	Context specific	Offshore islands	Forms extensive clonal patches by means of long stolons, impacting on indigenous plant species on offshore islands
	Chromolaena odorata (triffid weed)	1b	110	Can dominate in grassland and savanna ecosystems, especially in disturbed areas, and reduces biodiversity and rangeland productivity
	Dolichandra unguis-cati (cat's claw creeper)	1b	44	A climbing vine that invades forests, woodlands and forest margins, smothering and collapsing trees
	Echium plantagineum (Patterson's curse)	1b	104	An invader of pastures and cultivated lands
	Eucalyptus camaldulensis (river red gum)	Context specific	136	Forms closed-canopy stands in riparian areas, excluding most other species; uses excessive amounts of water
	Hakea sericea (silky hakea)	1b	39	Forms closed-canopy stands in fynbos mountain catchments, and displaces most other species. Increases fire intensity, leading to soil damage and excessive erosion
	Lantana camara (lantana)	1b	312	Widespread invasive shrub that can dominate in savanna and grassland regions, and reduces biodiversity and rangeland productivity
	Prosopis glandulosa var. *torreyana* (honey mesquite)	Context specific	112	Many well-documented impacts on biodiversity, groundwater supplies, rangeland productivity and human livelihoods and health (see Box 4.2)
	Prosopis velutina (velvet mesquite)	Context specific	5	Many well-documented impacts on biodiversity, groundwater supplies, rangeland productivity and human livelihoods
TERRESTRIAL INVERTEBRATES	*Cornu aspersum* (common garden snail)	Unlisted	115	Pestiferous, documented for damage to commercial and ornamental crops, as well as domestic gardens
	Deroceras invadens (tramp slug)	Unlisted	10	Pest of garden vegetables
	Linepithema humile (Argentine ant)	1b	36	Disrupts seed dispersal mechanisms in fynbos, potentially leading to collapse of plant reproduction systems
FRESHWATER INVERTEBRATES	*Cherax quadricarinatus* (redclaw crayfish)	1b	3	Negatively impacts indigenous freshwater species. It also carries parasites which could have further impacts on indigenous species
	Schyzocotyle acheilognathi (Asian tapeworm)	Unlisted	5	A parasite introduced on alien fish that attacks indigenous fish species
	Pseudodactlogyrus anguillae (gill flukes)	Unlisted	2	A parasite introduced on alien fish that attacks indigenous fish species
	Procambarus clarkii (red swamp crayfish)	Prohibited	4	Physical damage to aquatic habitats; disrupts nutrient cycling; preys on indigenous species
FRESHWATER FISH	*Micropterus dolomieu* (smallmouth bass)	Context specific	60	Predatory fish that negatively impacts indigenous fish and freshwater invertebrates

BOX 4.2 *PROSOPIS* TREES IN SOUTH AFRICA: AN INVASIVE SPECIES WHOSE IMPACTS HAVE BEEN WELL DOCUMENTED.

Trees in the genus *Prosopis* (mesquite; Fabaceae) include several species and their hybrids that are among the world's most damaging invasive plants. Mesquite trees were introduced to South Africa to provide fodder and shade for livestock, but as elsewhere in the world they have become invasive, generating negative impacts. *Prosopis* is one of the few invasive alien taxa whose ecological and economic impacts have been well studied and documented.


Thicket of *Prosopis* – Arne Witt

Ten individual studies were conducted in Africa between 1996 and 2016, in which impacts of *Prosopis* were quantified. This knowledge was used to underpin an economic assessment of the net worth of the genus. The individual aspects studied, and the findings, are summarised here.

Dung beetle diversity: Invasion reduced the number of dung beetle species from 41 to 34, and reduced their density markedly. Large species, and rare species, showed the biggest declines.

Bird diversity: Bird communities in invaded sites were found to be less species-rich and less diverse; raptors were eliminated, frugivores became sparse and the number of insectivore species was halved in invaded sites. Other bird feeding guilds (nectarivores, seedeaters) were less affected.

Indigenous zebra species: In Ethiopia, invasion significantly reduced the cover of perennial grasses from 68% to 2%, increased soil surface exposure from 30% to 80%, and lowered the number of grass species from seven to two. This has particularly negative implications for the survival of an isolated population of the endangered Grevy's zebra (*Equus grevyi*).

Grazing capacity: Invasion by Prosopis with only 15% cover reduced grazing capacity by 34%, but clearing improved grazing capacity by 110% within 6 years.

Density and species richness of indigenous plants: Invasion reduced the density, richness and diversity of indigenous plants. For example, indigenous trees declined from eight to three species when invasions doubled in density, and the cover of indigenous perennial grasses and herbaceous plants declined from 15–20% to zero.

Inter-specific competition with indigenous trees: Invasive *Prosopis* and indigenous *Acacia erioloba* were found to compete for groundwater, increasing the likelihood of mortality in *A. erioloba* in times of stress.

Groundwater levels: Invasions by deep-rooted *Prosopis* trees reduced groundwater levels.

Economic consequences of invasion: The value of benefits of *Prosopis* was found to marginally exceed the cost of impacts, but this was predicted to change within a few years as *Prosopis* continues to spread, resulting in net negative impacts that will grow over time.

Health consequences: A study in Mali, West Africa, demonstrated that villages with *Prosopis* invasions supported three times more *Anopheles* mosquitoes, thus increasing the risk of contracting malaria.

Key references:
Muller *et al*. (2017); Shackleton *et al*. (2014); Wise, Van Wilgen & Le Maitre (2012).

BOX 4.3 EXAMPLES OF CONFLICT SPECIES THAT CAN BE SIMULTANEOUSLY BENEFICIAL AND HARMFUL

Alien species can simultaneously bring many benefits and cause substantial environmental harm, very often leading to conflicts over their management. The impacts grow over time as invasions spread, and as societal perceptions of the value of alien species change as understanding grows and as values shift. The management of these "conflict" species is particularly challenging, and requires trade-offs if benefits are to be maximised and harm minimised. Some of the prominent conflict species in South Africa are described here.

Pine trees (*Pinus* species) were planted extensively in South Africa after the 1930s to provide timber. Planted pines have invaded the adjacent fynbos in the Cape Floristic Region. Invasion by alien pine trees was recognized as a problem as early as the 1940s, and coordinated attempts to clear these invasions began in the 1970s, but despite this, invasions are growing. Both the need to prevent water and biodiversity loss and to stimulate economic growth are becoming more acute, leading to polarized views regarding the advantages and disadvantages of pines. To date, suitable compromises have not been found, nor do they seem possible.


Photographer: B. van Wilgen

Rainbow trout (*Oncorhynchus mykiss*) were deliberately introduced to South Africa to create self-sustaining populations outside of captivity or cultivation. Trout introductions support recreational and commercial fisheries that contribute to the economy. These intentional introductions continue to occur despite changing views on the stocking of non-indigenous species due to their demonstrated ecological impacts. A major problem with managing invasive trout is that once established, control is extremely difficult. Implementing management interventions is also complicated by the economic contributions of angling and aquaculture, and by resistance from anglers who actively support continued stocking. Attempts by government to add trout to the list of regulated species have failed to date, and a management impasse continues.


Photographer: Cape Nature

Mallards (*Anas platyrhynchos*), have been widely introduced into South Africa, where feral mallards interbreed with the indigenous Yellow-billed Duck (*Anas undulata*). Attempts to remove mallards by the City of Cape Town were effectively halted because the arguments for the campaign (genetic contamination of a single indigenous species) were less convincing to the public than arguments for the widespread ecological impacts of more damaging invasive species.


Photographer: S. Turner

Cacti are among the most dominant invasive plant groups in South Africa, where they impact negatively on biodiversity, ecological functioning and agricultural productivity. Cacti are also important ornamental plants, and around 300 species of cacti are imported to South Africa annually, and the trade in these plants contributes to the economy. A management framework has been developed in which four strategic objectives were proposed:

(1) all invasive and potentially invasive cactus species should be prevented from entering the country, (2) new incursions of cactus species must be rapidly detected and eradicated, (3) the impacts of invasive cacti must be reduced and contained, and (4) useful cacti (both invasive and non-invasive species) must be utilised sustainably to minimise the risk of further negative impacts.

4.6. SYNTHESIS AND INDICATOR VALUES

The analysis of the number of alien species and their introduction status in South Africa is based on the 2 034 species listed in Appendix 3. Because introduction status is not recorded explicitly in databases, it was necessary to make several assumptions, and these need to be tested in future reports. For many taxa, it was not possible to assign species to a category of introduction status due to a lack of information. However it is clear that South Africa has a major invasion debt. Well over 100 new alien plant taxa have been recorded as escaped from cultivation in the past decade, and the recorded range of almost all invasive plants has increased significantly (Henderson & Wilson 2017). This is a major cause for concern, as it clearly indicates that the problems associated with alien species are set to increase.

Estimates of species extent were limited to 835 taxa for which reliable distribution data were available. Levels of confidence in these estimates are moderate for terrestrial and freshwater plants and for birds, but low for other taxa. This can form the basis for tracking changes in range over time.

There are no recent reliable estimates of alien species abundance. For alien plants, there are estimates made by Le Maitre, *Versfeld & Chapman* (2000), but these are crude and more than 20 years out of date. Estimates made by Kotzé *et al.* (2010) do not cover the whole country, are restricted to certain taxa, group some species by genus or family, and there is uncertainty regarding the methodology employed. It is therefore not possible at this stage to provide estimates of individual species abundance.

Finally, the issue of quantifying the impacts of alien species remains a challenge. For the vast majority of species, no studies document impacts, and there have been almost no formal assessments of impact using either the EICAT or SEICAT schemes at the scale of South Africa. This assessment therefore had to rely on expert opinion to assign species to categories of impact. This, however, is not suitable for presenting as an indicator, as the methodology is not repeatable. Formal assessments are required for the next report if trends in impact are to be tracked. In the meantime, this report does not assign values to impact indicators in Table 4.8, although the estimate based on expert opinion is presented in the high-level indicators in Table 6.9.

TABLE 4.8 Indicators used for reporting on the status of alien species. For full details of how to calculate the indicators, see Appendix 1.

INDICATOR	METRIC BASIC ••••••••		••••••••• ADVANCED	LEVEL OF CONFIDENCE	NOTES
5. Number and status of alien species	**5.1.** Number of invasive species: 775	**5.2.** Number of alien species in categories Alien but not naturalised: 355 Naturalised but not invasive: 388 Invasive: 775 Not assessed: 516	Number of species in each of 12 stages No data	Low	Status not explicitly or consistently recorded in databases, so assumptions were used. These numbers focus on alien species outside of captivity or cultivation (this was not captured consistently). A census of all aliens is needed
6. Extent of alien species	**6.1.** Extent of species per province (based on 835 species of known extent). (see Figure 4.1)	**6.2.** At a quarter-degree grid cell scale, many species have a limited distribution, with some being relatively widespread (see Figure 4.1; and Figure 4.3).	**6.3.** Range size for each species No data	Moderate for terrestrial and freshwater plants and birds; low for all other taxa	Plants and birds are conspicuous and the relevant atlases are regularly updated
7. Abundance of alien species	**7.1.** Categorical measure of abundance No data	**7.2.** Number of individuals or area occupied No data	**7.3.** Abundance estimates by stages or age cohorts. No data	N/A	There are only abundance data for alien plants, but these are crude and 20 years out of date
8. Impact of alien species	**8.1.** Number of species in impact categories No data	**8.2.** Detailed impacts per species for a range of impact mechanisms No data		N/A	Species have been placed into impact categories based on expert opinion, and these are presented in the text , but no species have been formally assessed according to EICAT or SEICAT guidelines
B. Number of species with major impacts	107 species			Not applicable	Based entirely on expert opinion, and so does not represent an appropriate base-line

5

THE STATUS OF INVADED AREAS

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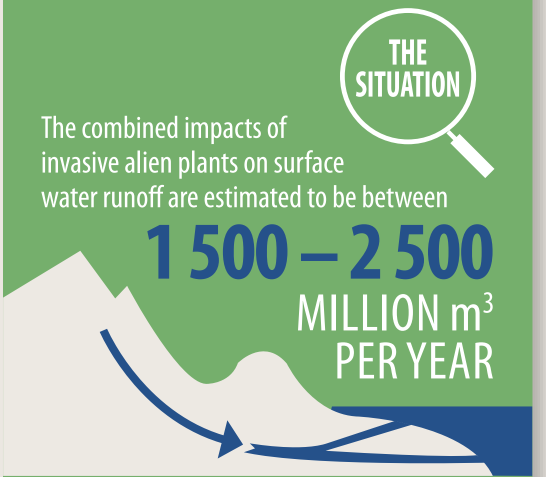


Chapter summary

This chapter provides a review of the status of invaded areas at provincial, biome, catchment and quarter-degree grid-cell scales, where data allow.

Invasive species richness at a provincial scale in terrestrial and freshwater ecosystems was highest in the relatively humid coastal provinces (Western and Eastern Cape and KwaZulu-Natal) and lower in the arid interior provinces (Northern Cape, Northwest and Free State). Marine invasive species richness was highest in the Western Cape.

Invasive plant species richness was highest in the Savanna, Grassland, Indian Ocean Coastal Belt and Fynbos biomes, and lower in the arid biomes. There were only 6 invasive bird species, which were widespread across most biomes, except the Desert biome. There were insufficient data to assess the richness of other groups at a biome scale.

Alien species richness provides an indication of the diversity of issues that need attention, but it is not a measure of how large the invasions are – this would require estimates of cover, biomass or population size. There are no reliable estimates of these measures, but crude estimates made in 1998 confirmed what is generally accepted – the Western Cape is the most invaded province, followed by Mpumalanga, Northern Cape and KwaZulu-Natal. These estimates are more than 20 years out of date, and data from an atlas project suggests both the extent of invasions, and the relative dominance of species, have changed considerably since then.

At a national scale, the combined impacts of invasive alien plants on surface water runoff have been estimated at between 1 444 to 2 444 million m^3 per year. Primary catchments most affected (> 5% reduction in mean annual runoff) are in the Western and Eastern Cape, and KwaZulu-Natal. If no remedial action is taken, reductions in water resources could rise to between 2 589 and 3 153 million m^3 per year, about 50% higher than estimated current reductions.

Invasive alien plant infestations are estimated to have reduced the potential for South Africa to support grazing stock by just over 1%, though this varies between biomes. If no remedial action is taken, however, impacts are projected to become much larger (up to a 71% loss of grazing in some biomes).

Reductions in biodiversity intactness in South Africa's terrestrial biomes were highest (3%) in the fynbos biome. Under a scenario where invasive alien plants are allowed to reach their full potential, biodiversity intactness is predicted to decline dramatically, by around 70% for the Savanna, Fynbos and Grassland biomes, and even more (by 87% and 96%) for the two Karoo biomes.

Invasion of natural ecosystems by alien plants can change the structure and biomass of vegetation, adding fuel and supporting fires of higher intensity. Increased fire intensity can in turn increase the damage done by fires, as well as the difficulty of controlling fires. Although there is very little in the way of documented impacts in South Africa, these effects have clearly been shown in a limited number of studies.

Estimating the level of invasion by alien species in particular areas could only be made with a low degree of certainty, given the relative lack of reliable and comprehensive data on invasive species. The same applies to impacts. However, based on a few existing studies, it appears that impacts are currently relatively low (with the exception of water resources), but that they are set to grow rapidly as invasive species enter a phase of exponential growth.

5.1. INTRODUCTION

This chapter provides a review of the status of invaded areas at several scales – at a broad scale (provincial, biome and primary catchment: 1 000–400 000 km^2); at a quarter-degree grid cell scale (QDGC, 630–710 km^2); and at scales specific to administrative regions (e.g. municipalities or protected areas: 28–20 000 km^2).

A variety of data sources were used to provide information on the spatial occurrence and abundance of alien (and for some purposes indigenous) taxa (Table 5.1). Taxa were defined as alien based on the lists and data sources presented in Chapter 4. However, cases of taxa which are alien to one area of South Africa and indigenous to another might occur in the spatial occurrence data if the database that was used recorded such taxa as alien (e.g. alien to a particular national park). In order to calculate *Relative alien species richness*, checklists of indigenous taxa were consulted [for birds, BirdLife South Africa (www.birdlife.org.za/); for plants, the Botanical Database of Southern Africa (BODATSA, Ranwashe 2015)]. Taxa for which spatial data were available, but that were not either in the lists of alien taxa or in the checklists of indigenous taxa were excluded from the analysis (this included some cosmopolitan species).

Data are presented as per the groupings used in the NEM:BA A&IS Regulations – amphibians; birds; freshwater fish; freshwater invertebrates; mammals; marine invertebrates; marine plants; reptiles; terrestrial invertebrates; and terrestrial and freshwater plants.

TABLE 5.1 Sources of data used to assign values to indicators for the status of biological invasions in particular areas, with levels of confidence based on completeness and accuracy of data sets. QDGC is quarter-degree grid cell (630–710 km^2 for South Africa). The indicators informed by these data are 9. *Alien species richness;* 10. *Relative alien species richness;* 11. *Relative invasive abundance;* 12. *Impact of invasions.*

DATA SOURCE	SCALE OF COVERAGE (geographical and organismal)	DESCRIPTION	LEVEL OF CONFIDENCE BASED ON COMPLETENESS AND ACCURACY	INDICATOR INFORMED BY THESE DATA
Animal Demography Unit (ADU; www.adu.uct.ac.za)	National Amphibians, Mammals, Reptiles, Terrestrial invertebrates (butterflies)	Atlases of occurrences at QDGC scale	High for birds and amphibians; moderate for reptiles and butterflies	9, 10
Cape Nature (www.capenature.co.za)	Protected areas in the Western Cape All taxa	Lists of invasive species per protected area	Moderate to low, depending on the protected area	9, 10, 11
Dr David Le Maitre (Council for Scientific and Industrial Research, CSIR). Le Maitre *et al.* (2016)	National Plants	Estimates of modelled impacts of invasive plants on water resources at primary and quaternary catchment level	Moderate	12
Ezemvelo KwaZulu-Natal Wildlife (www.kznwildlife.com)	Protected areas in KwaZulu-Natal All taxa	Lists of invasive species per protected area	Moderate to low, depending on the protected area	9, 10

DATA SOURCE	SCALE OF COVERAGE (geographical and organismal)	DESCRIPTION	LEVEL OF CONFIDENCE BASED ON COMPLETENESS AND ACCURACY	INDICATOR INFORMED BY THESE DATA
Global Biodiversity Information Facility (GBIF; www.gbif.org)	National (and international) All taxa	A global online repository of biodiversity data, collected at a range of scales.	Low	9, 10
KwaZulu-Natal Museum (www.nmsa.org.za/)	National Terrestrial invertebrates; (Molluscs)	Spatial data on the distribution of alien terrestrial mollusc species	Low	9, 10
Picker & Griffiths (2011; 2017)	National All animals	A reference book based on a variety of sources	Low (for most taxa) to High depending on the taxonomic group	9
South African Institute for Aquatic Biodiversity (SAIAB)	National Freshwater fish	Atlas at QDGC scale	Low	9, 10
South African National Parks (SANParks; Foxcroft *et al.*, 2017)	Protected areas in South Africa All taxa	Lists of invasive species per protected area	Moderate to low, depending on the protected area	9, 10
Southern African Bird Atlas Project 2 (SABAP2, Brooks, 2017)	National Birds	Atlas at QDGC scale	Moderate	10
Southern African Plant Invaders Atlas (SAPIA; see Henderson & Wilson, 2017)	National (including neighbouring countries) Plants	Atlas of alien plant species occurrence outside of captivity or cultivation. Data can be aggregated to a QDGC scale	High	9, 10
Van Wilgen *et al.* (2008)	Terrestrial biomes Plants	Estimates of impacts of invasive alien plants on livestock production and biodiversity intactness at terrestrial biome scale	Moderate	12

5.2. ALIEN SPECIES RICHNESS

5.2.1. Invasive species richness per large-scale national sub-division

Invasive species richness at a provincial scale in terrestrial and freshwater ecosystems was highest in the relatively humid coastal provinces (Western and Eastern Cape and KwaZulu-Natal) and lower in the arid interior provinces (Northern Cape, Northwest and Free State) (Table 5.2a). Marine invasive species richness was highest in the Western Cape.

Data on invasive species richness that could be accurately grouped according to biome were only available for birds and plants (Table 5.2b). The six invasive bird species were found in most biomes, except the desert. Invasive plant species richness was highest in the Savanna, Grassland, Indian Ocean Coastal Belt, and Fynbos biomes, and lower in the arid biomes.

TABLE 5.2A Invasive species richness per province. These estimates are based on 538 species for which distribution data were available (out of 775 species regarded as invasive). See Table 5.1 for a list of the data sources used, note that these data are incomplete. N/A is not applicable (inland provinces do not have marine areas).

TAXON	PROVINCE								
	EASTERN CAPE	FREE STATE	GAUTENG	KWAZULU-NATAL	LIMPOPO	MPUMALANGA	NORTH WEST	NORTHERN CAPE	WESTERN CAPE
Amphibians	2	1	1	2	2	2	1	1	1
Birds	6	6	6	6	5	6	6	6	5
Freshwater fish	6	3	1	3	2	3	3	3	6
Freshwater invertebrates	0	0	1	2	0	2	1	0	1
Mammals	1	1	0	1	0	1	1	1	1
Reptiles	0	0	0	0	0	0	0	0	0
Terrestrial invertebrates	4	2	3	3	1	1	2	3	5
Terrestrial and freshwater plants	348	172	247	448	235	279	193	130	325
Total terrestrial and freshwater organisms	367	185	259	465	245	294	207	144	344
Marine invertebrates	38	N/A	N/A	40	N/A	N/A	N/A	13	68
Marine plants	2	N/A	N/A	3	N/A	N/A	N/A	0	4
Total marine organisms	**40**	**N/A**	**N/A**	**43**	**N/A**	**N/A**	**N/A**	**13**	**72**

TABLE 5.2B Invasive species richness per biome for a range of taxa. See Table 5.1 for a list of the data sources used.

TAXON	BIOME								
	ALBANY THICKET	DESERT	FOREST	FYNBOS	GRASSLAND	INDIAN OCEAN COASTAL BELT	NAMA-KAROO	SAVANNA	SUCCULENT KAROO
Amphibians	1	0	1	2	2	2	1	2	1
Birds	6	3	5	5	6	6	6	6	5
Freshwater fish	5	1	1	6	6	1	1	6	1
Freshwater invertebrates	0	0	0	1	1	2	0	2	0
Mammals	1	0	0	1	1	1	1	0	1
Reptiles	0	0	0	0	0	0	0	0	0
Terrestrial invertebrates	3	0	1	5	4	2	1	4	3
Terrestrial and freshwater plants	175	17	87	245	348	273	119	384	75
Total terrestrial and freshwater organisms	**191**	**21**	**95**	**265**	**368**	**287**	**129**	**404**	**86**

5.2.2. Invasive species richness per finer-scale national sub-division

Recorded alien animal species richness was only available at a half-degree grid cell scale, and then only for all species and not for the subset of invasive species. Alien animal species richness is highest close to Cape Town and high along the southern and eastern coastal areas, and in Gauteng (Figure 5.1A). Invasive bird species richness at a QDGC scale also tends to be highest around major urban centres (Cape Town, George, Durban, Johannesburg, Pretoria, and Bloemfontein, Figure 5.1B). Invasive plant species richness is highest in Gauteng, along the escarpment of the Mpumalanga and Limpopo Provinces, and in parts of the KwaZulu-Natal and Western Cape Provinces (Figure 5.1C) while data for the Northern Cape Province suggest that the arid interior of the country has relatively fewer species. These patterns in *Alien species richness* likely contain some sampling bias (e.g. Gauteng has been well sampled for alien plants), but the very arid regions likely do have lower *Alien species richness* both due to a general lower capacity to support species (i.e. lower indigenous species richness), and due to introduction dynamics (aliens species are often initially introduced to major urban centres, and human-mediated dispersal is much greater between these areas).

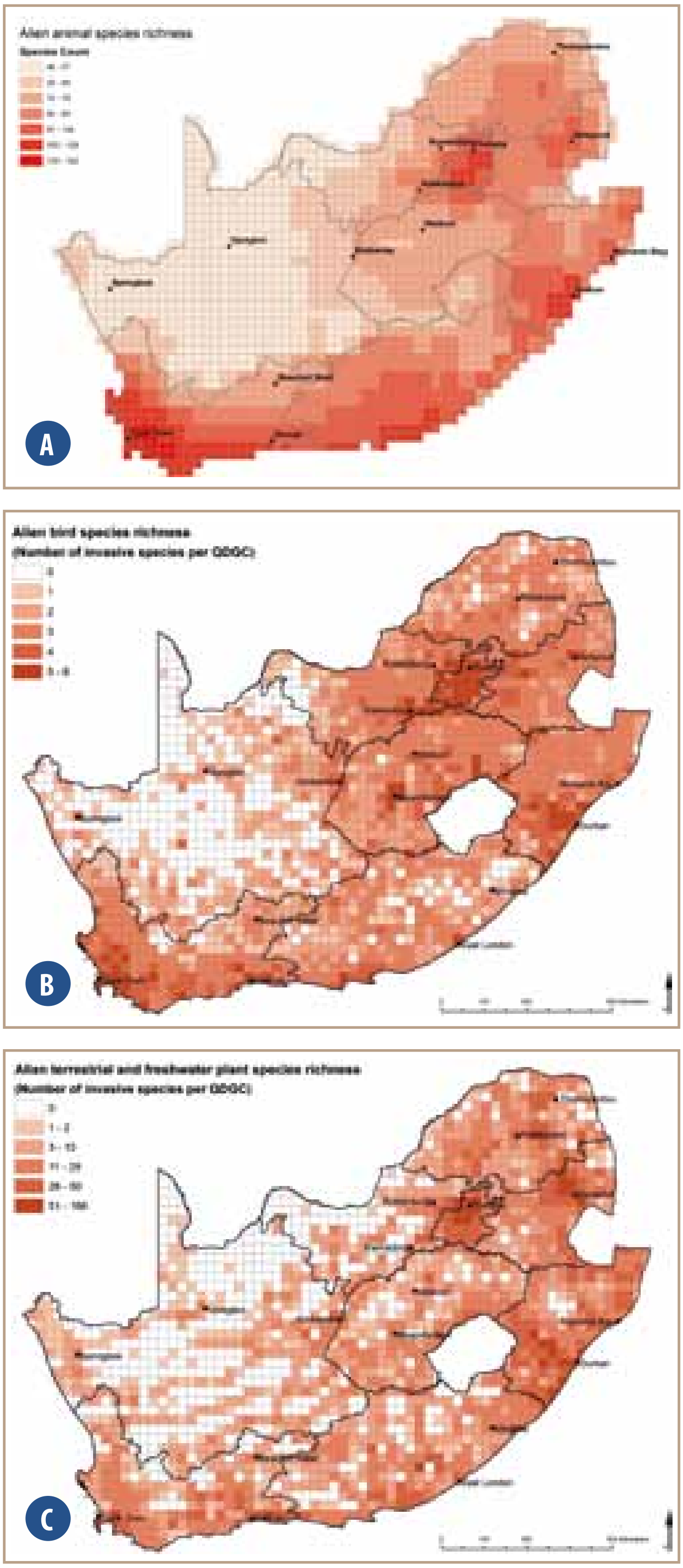


FIGURE 5.1 Alien species richness outside of cultivation or captivity for: (A) all animals at a half degree square (based on 242 species). Coastal cells that straddle marine and terrestrial habitats include species from both habitats. Reproduced from Picker & Griffiths (2017) based on data from Picker & Griffiths (2011). (B) Invasive birds at a quarter degree grid cell (QDGC) scale (based on six species). Data from the Southern African Bird Atlas Project 2 (accessed May 2017). (C) Invasive terrestrial and freshwater plants at a QDGC scale (based on 773 species). Data from the Southern African Plant Invaders Atlas, accessed May 2016).

When invasive species richness per QDGC is compared across provinces or biomes, the patterns are slightly different. While the Indian Ocean Coastal Belt has the third highest invasive plant species richness (a total of 273 plant species, Table 5.2b), it has the highest median invasive plant species richness per QDGC (20 species per QDGC). This is indicative that the scale of the problem in this region tends to be higher as there are more widespread invaders. However, and unsurprisingly, the arid biomes still have low invasive species richness per QDGC (Figure 5.2).

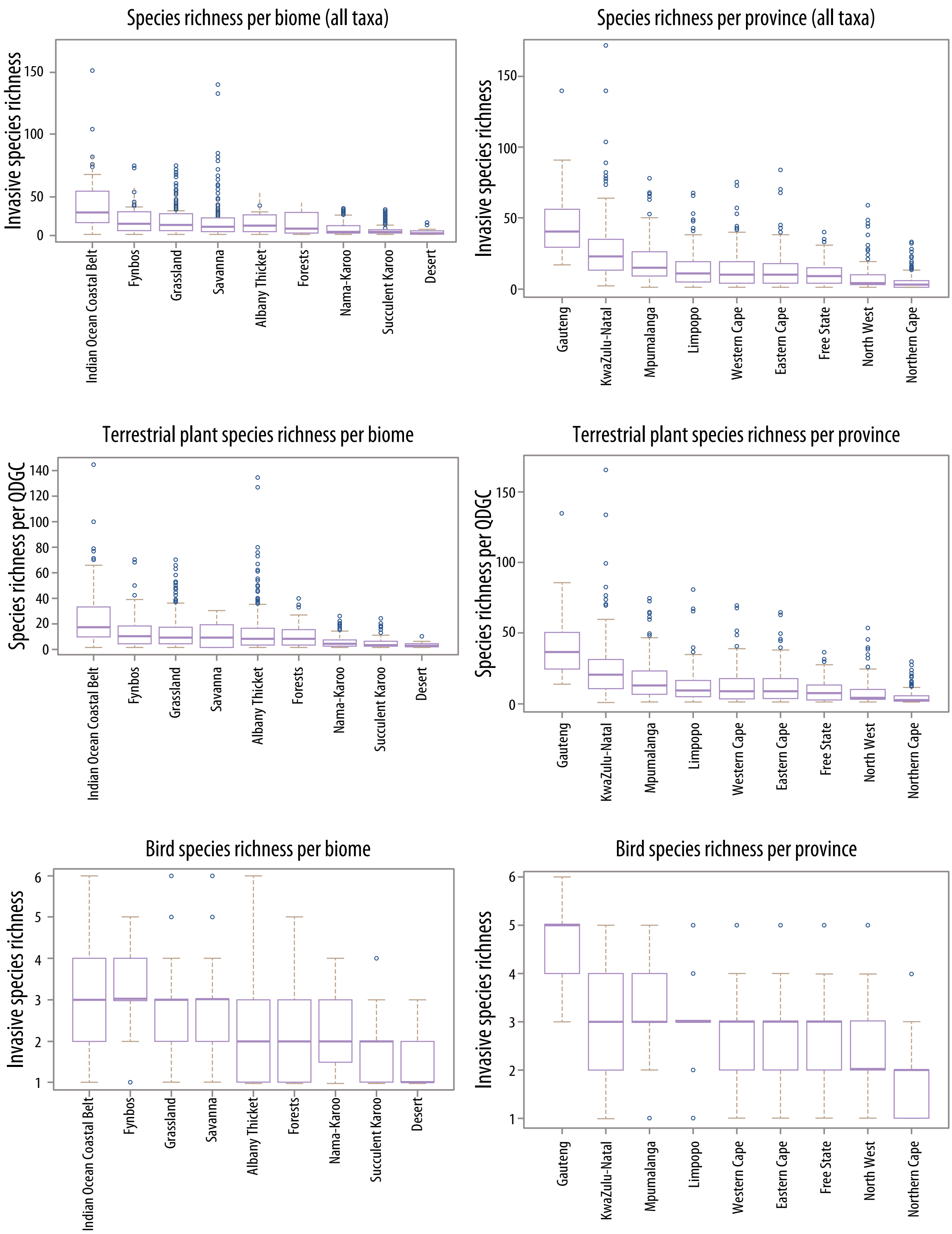


FIGURE 5.2 Median invasive species richness for different taxa at a quarter degree grid cell scale for provinces and terrestrial biomes in South Africa. The plot shows the median, upper and lower quartiles, and range of the data. Circles indicate outliers.

5.2.3. Alien species richness at different stages of the Unified Framework for Biological Invasions

If the size of the future problems on biological invasions is to be estimated, then spatial data on the number of species at different stages along the introduction-naturalisation-invasion continuum would be required (i.e. area-based invasion debt). However, the introduction status of all alien species is not known for any groups.

5.3. RELATIVE ALIEN SPECIES RICHNESS

Estimates of *Relative alien species richness* at provincial scales could only be made for invasive taxa for which reliable distribution data were available (plants and birds). Relative invasive bird species richness per province ranged from 1.0% in Limpopo to 1.6% in the Free State. Relative invasive plant species richness per province ranged from 7% in the Northern Cape to 25% in the Northwest. Note that the number of indigenous plant species is based on BODATSA, which has incomplete records.

This indicator will be of value to management when used in concert with *Alien species richness* and *Relative invasive abundance* at an appropriate scale, e.g. per protected area, or management zone, and as tracked over time. However, these data are not available at present.

5.4. RELATIVE INVASIVE ABUNDANCE

There are no reliable estimates of invasive plant species cover or biomass per province (Box 5.1). Crude estimates made by Versfeld, Le Maitre & Chapman (1998) confirmed what is generally accepted, namely that the Western Cape is the most invaded province, followed by Mpumalanga, Northern Cape and KwaZulu-Natal. Approximately 28% of the area of the Western Cape was invaded by alien plants at a range of cover classes, with the most important taxa being wattles (genus *Acacia*), pines (genus *Pinus*) and hakeas (genus *Hakea*). Approximately 16% of the area of the Mpumalanga was invaded by alien plants at a range of cover classes, with the most important taxa being wattles (genus *Acacia*), *Lantana camara* (lantana) and *Solanum mauritianum* (bugweed). Invasions in the Northern Cape Province were dominated by mesquite trees (genus *Prosopis*), which accounted for almost all of the invasions that covered 14% of the province at the time. In KwaZulu-Natal, where invasions covered 9% of the province, the most important contributing taxa were wattles (genus *Acacia*), *Chromolaena odorata* (triffid weed), cacti (in particular the genus *Opuntia*) and *Solanum mauritianum* (bugweed). Other provinces were all estimated to have less than 3% cover by invasive alien plants (with the admission that the Eastern Cape Province was substantially under-sampled by Versfeld, Le Maitre & Chapman (1998). These estimates, besides being crude, are more than 20 years out of date, and both the extent of invasions and the relative dominance of species, have changed considerably since then (Henderson & Wilson, 2017). A more recent estimate by Kotzé *et al.* (2010) confirmed *Acacia mearnsii* (black wattle) as the most abundant invasive alien plant species, followed by gum trees (*Eucalyptus* species), pine trees (*Pinus* species) and *Chromolaena odorata* (triffid weed, see Table 4.5). However, the study by Kotzé *et al.* (2010) only targeted alien plant species of interest to the Working for Water programme (mainly trees and shrubs), excluded a very large proportion of arid South Africa, and is based on methodology that has not been adequately documented. As a result, there can only be a low degree of confidence in the estimates at this stage.

5.5. IMPACT OF INVASIONS

While the impacts of individual invasive species have been quantified in a number of cases, i.e. *Alien species impact*, such studies are rare (Box 4.2). Fewer studies have attempted to quantify the combined impacts of co-occurring invasive species on a particular area, i.e. *Impact of invasions*. In South Africa, some work has been done to quantify the impacts of invasive plants on selected ecosystem services or ecosystem intactness, either at a biome scale (for water resources, livestock production from natural rangelands, and for biodiversity intactness, Van Wilgen *et al.*, 2008), or at a catchment scale for water resources (Le Maitre *et al.*, 2000; 2016). The findings of these studies are summarised below.

5.5.1. Impacts on surface water runoff and groundwater by primary catchment

The adverse impacts of alien plant invasions on water flows have provided a strong argument for the control of invasive plants (Le Maitre *et al*., 1996; Van Wilgen, Cowling & Burgers 1996). Le Maitre, *Versfeld & Chapman* (2000) estimated that the total reduction in runoff due to invading alien plants was about 3 300 million m^3 per year, or about 7% of the country's mean annual runoff. About a third of this estimated water use, by volume, was accounted for by invasive plants in the Western Cape, followed by KwaZulu-Natal (17%), the Eastern Cape (17%) and Mpumalanga (14%). This section summarises current estimates of the impacts on water flows for primary catchments and biomes and highlights the species with the greatest impacts. The reductions take the form of changes in runoff from invaded dryland areas due to increased evaporation, and evaporation of groundwater from invaded river floodplains (riparian invasions) and from invaded areas with groundwater in aquifers accessible to root systems (groundwater). The total reduction is expressed as a proportion of mean annual runoff because all these reductions ultimately result in a reduction in surface water runoff as measured in rivers.

Le Maitre *et al.* (2016) subsequently used new information on the distribution of invasive alien plants, and improved flow reduction models, to put forward a revised estimate of 1 444 million m^3 per year, or 2.9% of the naturalised mean annual runoff (less than half of the 3 300 million m^3 per year estimated in 2000). Two main factors accounted for the difference between the estimates of Le Maitre, *Versfeld & Chapman* (2000) and those of Le Maitre *et al*. (2016). The first was a decrease in the estimated unit-area flow reduction to 970 m^3 per ha per year compared with 1 900 m^3 per ha per year estimated in 1998, largely due to refinements of the models. The second was the use of a smaller estimated invaded area (alien plants that covered 1 million ha compared to the 1.76 million ha used in the 2000 assessment). This was due to the use of a new alien plant distribution data set (Kotzé *et al.*, 2010) that excluded South Africa's arid interior and thus the entire Nama Karoo, almost all of the Succulent Karoo and Desert biomes, about a third of the Savanna, and half of the Grassland biome. This meant that the 2016 figure for water use by invasive plants was an under-estimate.

In addition, the revised estimate was also considered to be an underestimate by Le Maitre *et al.* (2016) because the extent and impacts of riparian invasions had been underestimated. The estimate of Le Maitre *et al.* (2016) of 1 444 million m^3 per year was based on the mapped data showing that only 4–6% of invasions of some of the major contributing taxa (*Acacia mearnsii*, black wattle, *Eucalyptus*, gum trees, *Populus*, poplar trees, and *Salix*, willows) were found in riparian zones (where water use is higher). However, the actual proportion of these taxa in riparian zones is probably much higher, and this could increase the estimate by as much as 70%, from 1 444 to 2 444 million m^3 per year.

Impacts on surface water runoff by primary catchment: The largest reductions (over 5% of mean annual runoff) were in the Western Cape (catchments G, H and K), the Eastern Cape (catchments K, M and R), and KwaZulu-Natal (catchment U) (Table 5.3). Only about 5% of the Orange River system (catchment D) was mapped, as was only about 33% of the Vaal River system, so the total reductions in these catchments were significantly underestimated. The main difference from the 2000 estimate is the much greater estimated reductions in catchments in the Eastern Cape (where alien plant invasions were inadequately accounted for in the 2000 estimate).

TABLE 5.3 The estimated extent of reductions in surface water runoff due to invasive alien plants in South Africa's primary catchments. Table adapted from Le Maitre et al. (2016). Condensed ha is the equivalent area occupied at a canopy cover of 100% (i.e. 50% cover on 10 ha = 5 condensed ha). See Figure 5.3 for the location of primary catchments.

PRIMARY CATCHMENT	RIVER SYSTEMS	ESTIMATED INVASION LEVEL (CONDENSED HA)	ESTIMATED REDUCTION (MILLIONS OF m^3)	ESTIMATED REDUCTION (% OF MEAN ANNUAL RUNOFF)
A	Crocodile-Limpopo	86 510	24.44	1.06
B	Olifants-Letaba	123 328	61.79	2.13
C	Vaal	138 557	64.25	1.53
D	Orange	54 383	31.57	0.46
E	Olifants-Doring	4 825	3.65	0.31
F	Namaqualand coast	795	0.00	0.02
G	Berg-Agulhas	92 970	111.36	6.04
H	Breede-Goukou	45 164	126.21	6.11
J	Gouritz	25 438	11.69	1.86
K	Hartenbos-Kromme	60 951	102.51	8.43
L	Gamtoos	24 228	10.86	2.09
M	Swartkops	23 662	11.64	6.46
N	Sundays	39 906	0.89	0.34
P	Bushmans	12 432	3.31	1.99
Q	Great Fish	30 385	4.83	0.90
R	Keiskamma-Nahoon	45 414	42.92	7.41
S	Great Kei	59 130	46.58	4.49
T	Umbashe-Umzimvubu	220 942	321.96	4.51
U	uMzimkulu-uMvoti	111 698	154.35	5.03
V	Thukela	81 139	100.87	2.60
W	uMfolozi-Pongola	154 984	148.66	2.31
X	Incomati	58 025	59.19	1.90
Total		**1 494 867**	**1443.56**	**2.88**

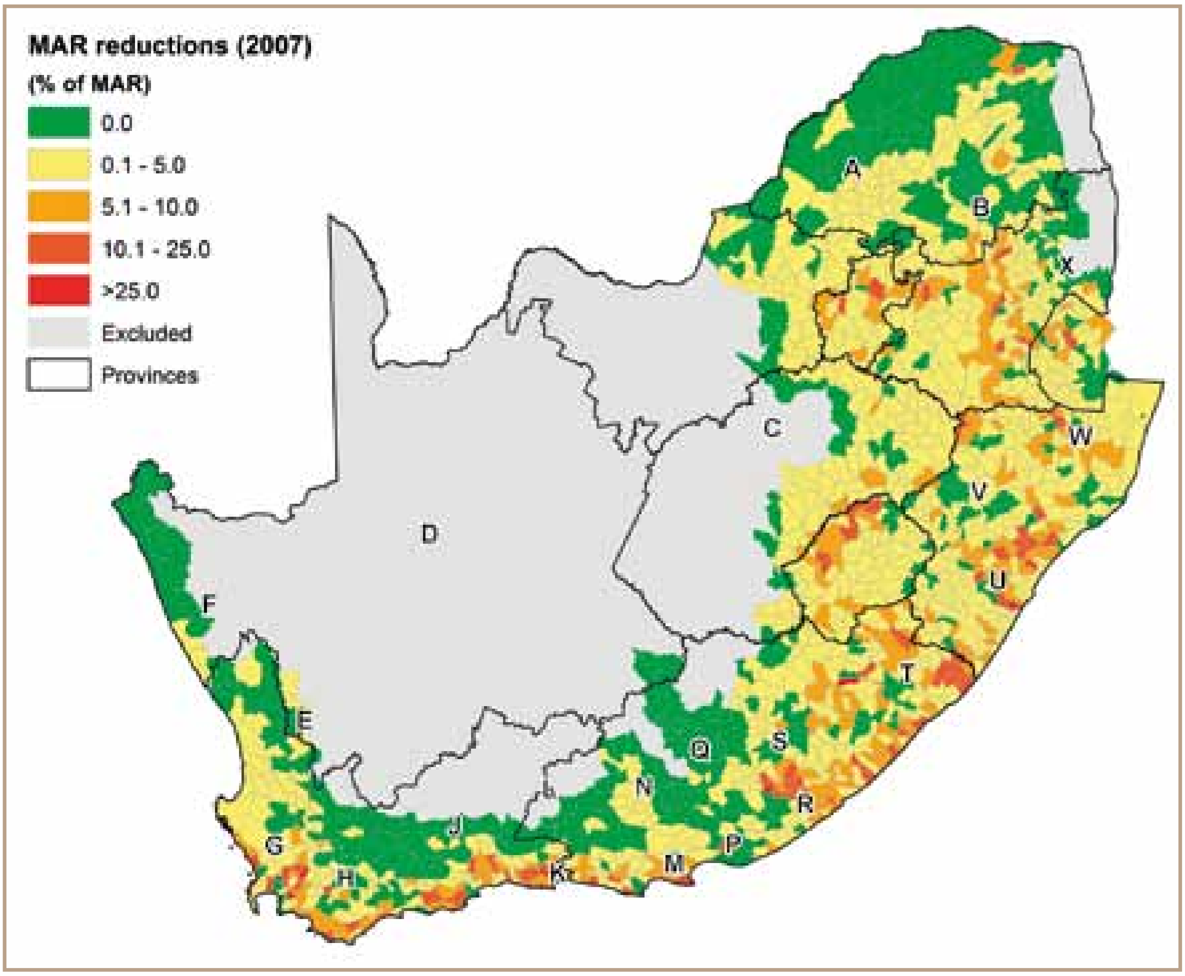


FIGURE 5.3 Estimates of the reductions in mean annual runoff (MAR) due to invasive alien plants in the quaternary catchments of South Africa. Capital letters refer to primary catchments. The quaternary catchments that were completely excluded are shown in grey; many others were only partially mapped; the Kruger National Park was also excluded. Map: D Le Maitre unpublished data.

Impacts on surface water runoff by biome: Although some biomes were excluded or only partially mapped by Kotzé *et al.* (2010), the data show that while the Grassland Biome and the wetter areas of the Savanna Biome (i.e. excluding the Kalahari) have the most extensive invasions, the most heavily invaded ones are the Indian Ocean Coastal Belt and Fynbos. The invasions and impacts for the Forest biome (Table 5.4) are overestimated, due to mapping scale mismatches. This means that the greatest percentage reductions are found in the Indian Ocean Coastal Belt and in the Fynbos biome. However, the volume of the reduction for the Grassland is of particular concern because the surface runoff from this biome is critical for water supplies to Gauteng, the EThikweni Region and Mangaung, as well as for power generation and much of the irrigated agriculture in South Africa.

TABLE 5.4 The estimated impacts on the annual surface water runoff of all invasions in the biomes included in the landscape mapping for the RSA by Kotzé et al. (2010). MAR = mean annual runoff.

STATISTIC	BIOME					
	ALBANY THICKET	FOREST	FYNBOS	GRASSLAND	INDIAN OCEAN COASTAL BELT	SAVANNA (wetter areas only)
Total reduction (million m^3/yr)	23	12	365	621	113	309
MAR (million m^3/yr)	659	66	5 213	16 709	1 509	7 726
Reduction (% MAR)	3.48	18.36	6.99	3.72	7.52	4.00

The available estimates of the impact of invasive plants on surface water runoff from catchments therefore are underestimates and, at best, coarse approximations, due to the issues regarding the accuracy of the mapping and the number of assumptions and extrapolations that had to be made. Further research is needed to provide better estimates of the impacts.

In the 2016 estimate, the taxon with the greatest estimated impact was wattles (*Acacia mearnsii*, black wattle, *A. dealbata*, silver wattle, and *A. decurrens*, green wattle) which accounted for 34% of the reductions, followed by *Pinus* species (pine trees) (19.3%) and *Eucalyptus* species (gum trees) (15.8%) (Table 5.5). Nearly 70% of the wattle invasions, 60% of gum trees, 40% of pines and most of the poplar and willow invasions are in the Grassland biome and explain why estimated reductions in this biome are so hig. *Prosopis* (mesquite) invasions in the Northern Cape were mapped in 2007 (Van den Berg 2010) and this information was used to estimate a reduction of about 9 million m^3/yr, most of this being in the Orange River catchment (Le Maitre *et al.*, 2013).

TABLE 5.5 A comparison of the estimated extent and impact of invasions by different taxa on the mean annual surface water runoff in South Africa (Middleton & Bailey 2008) based on the landscape mapping for the RSA by Kotzé et al. (2010). Condensed ha is the equivalent area at a canopy cover of 100% (i.e. 50% cover on 10 ha = 5 condensed ha)

	ESTIMATED CONDENSED AREA (HA)	ESTIMATED REDUCTION (MILLION M3)	ESTIMATED REDUCTION (MM RAINFALL EQUIVALENT)
Acacia cyclops **(rooikrans)**	54 679	28.95	53
Acacia mearnsii **(black wattle)**	474 489	483.23	102
Acacia melanoxylon **(Australian blackwood)**	2 796	18.07	646
Acacia saligna **(Port Jackson willow)**	50 052	11.66	23
Agave **spp. (Century plants)**	11 341	0.89	8
Arundo donax **(giant reed)**	3 202	1.59	50
Atriplex nummularia **(old man saltbush)**	5 862	0.94	16
Caesalpinia decapetala **(Mauritius thorn)**	8 830	10.95	124

	ESTIMATED CONDENSED AREA (HA)	ESTIMATED REDUCTION (MILLION M3)	ESTIMATED REDUCTION (MM RAINFALL EQUIVALENT)
***Cereus jamacaru* (queen of the night)**	10 948	0.13	1
***Cestrum* spp. (cestrums)**	7 217	19.27	267
***Chromolaena odorata* (triffid weed)**	101 992	100.29	98
***Eucalyptus* spp. (gum trees)**	273 573	217.37	79
***Hakea* spp. (hakeas)**	36 344	72.20	199
***Jacaranda mimosifolia* (jacaranda)**	4 200	1.76	42
***Lantana camara* (lantana)**	32 328	40.29	125
***Melia azedarach* (seringa)**	14 224	7.34	52
***Opuntia* spp. (cacti)**	95 010	7.70	8
***Pinus* spp. (pine trees)**	132 937	272.31	205
***Populus* spp. (poplars)**	58 082	26.89	46
***Prosopis* spp. (mesquite)**	5 232	1.95	37
***Psidium guajava* (guava)**	6 354	7.16	113
***Rosa rubiginosa* (eglantine)**	11 801	8.75	74
***Salix babylonica* (weeping willow)**	37 555	22.48	60
***Senna didymobotrya* (peanut butter cassia)**	11 586	13.84	119
***Sesbania punicea* (red sesbania)**	1 683	2.22	132
***Solanum mauritianum* (bugweed)**	40 413	58.20	144
***Tamarix chinensis* (Chinese tamarisk)**	2 137	7.13	334
Total	**1 494 867**	**1 443.56**	**97**

Projected invasions: The initial estimates of the costs of control and the impacts of invasions were based on an increase of 5% per year (e.g. Le Maitre *et al.*, 2002) but a synthesis of the information on spread suggests a rate closer to 10% (Van Wilgen & Le Maitre 2013). Projections of the impacts based on increases in invasions in the area of the catchments under natural vegetation show that the impacts are likely to become substantially greater. At an expansion rate of 5%, and densification of 1%, the total reduction would increase to 2 589 million m^3/yr (5.2% of MAR) in 25 years (i.e. in about 2032). At 10% the projected reductions in 25 years will be about 3 153 million m^3/yr (6.3% of MAR). The increases in the percentage reductions occur throughout the mapped area but are greatest in the higher rainfall parts of the Eastern Cape, Kwa-Zulu-Natal and the Western Cape. The simple spread model did not allow invasions in a catchment to spread to adjacent ones that were not initially invaded so the estimated impacts probably are conservative.

These findings have significant implications for water security within and downstream of these invaded areas, highlighting the need to focus investment in areas where it will yield the greatest long-term benefits.

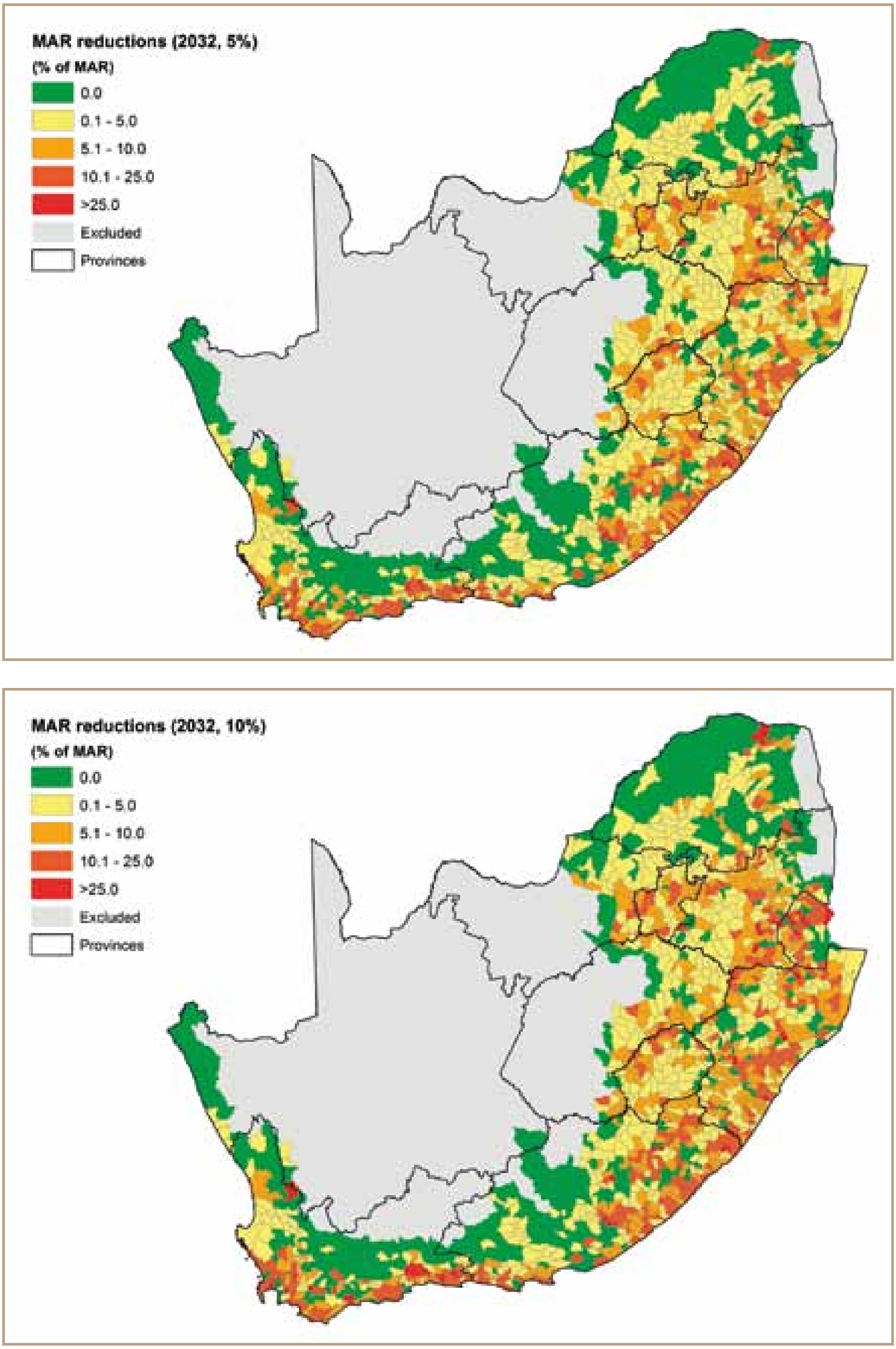


FIGURE 5.4 Projected reductions in the mean annual runoff (MAR) in 2032, at different rates of spread of invasive alien plants (assumed to be 5% in upper map and 10% in lower map). Map: D Le Maitre unpublished data.

The productivity of rangelands is under serious threat from a large number of invasive plants that could potentially halve the production of livestock from natural rangeland areas.

5.5.2. Impacts on rangeland productivity by biome

The impact of invasive alien plants on grazing potential was assessed for the Fynbos, Grassland, Succulent Karoo, Nama Karoo and combined Savanna and Thicket biomes by Van Wilgen *et al.* (2008). They used estimates of the mean livestock production to represent the potential of un-invaded vegetation to support livestock production, and maps of the extent of invasion by alien plant species to estimate reductions in livestock production in each biome. They estimated that current reductions in the potential of biomes to support grazing stock, as a result invasive alien plant infestations, amounted to between 200 (in the Nama Karoo) and 74 500 (in the Fynbos) large stock units. This amounted to just over 1% of the potential number of livestock that could be supported by these ecosystems. However, they also estimated that these impacts could increase to 71% of the potential, if infestations of invasive alien plants were allowed to reach their full potential. They noted that "while the errors in these estimates could be large, the predicted impacts are of sufficient magnitude to suggest that, even with significant over-estimates, there is cause for serious concern; for example, even if the levels of impact are one tenth of those predicted, they would result in significant losses of benefit".

5.5.3. Impacts on biodiversity intactness by biome

The impact of invasive alien plants on biodiversity intactness was also assessed for the Fynbos, Grassland, Succulent Karoo, Nama Karoo and combined Savanna and Thicket biomes by Van Wilgen *et al.* (2008). Biodiversity intactness (Scholes & Biggs, 2005) estimates the impact of land-use changes (in this case invasion by alien plants) on populations of plants, mammals, birds, reptiles and frogs in a given area, and was designed to provide an easy-to-understand measure of the state of biodiversity for policy-makers and the public. A previous study by (Biggs, Reyers & Scholes 2006) had estimated that the biodiversity intactness index range from 71% to 89% for the five biomes analysed. These estimates took the conversion of natural landscapes by means of agriculture, forestry or urban development, as well as land degradation into account, but they did not account for the impacts of invasive alien plants. When the additional impacts of invasive alien plants were considered, estimates of the current levels for the biodiversity intactness index only declined in the Fynbos biome (from 73% to 70%). It was concluded (Van Wilgen *et al.*. 2008) that this reflected the fact that the fynbos biome had the highest levels of alien plant infestations, probably due to the considerably longer period of colonial settlement in the fynbos. Under a scenario where invasive alien plants are allowed to reach their full potential, however, the values were predicted to decline dramatically, to around 30% for the savanna, fynbos and grassland biomes, but to even lower values (13% and 4%) for the two karoo biomes, suggesting significant potential declines in biodiversity of > 90% in places.

5.5.4. Impacts on fire regimes

Invasion of natural ecosystems by alien plants can change the structure and biomass of vegetation, adding fuel and supporting fires of higher intensity.

Increased fire intensity can in turn increase the damage done by fires, as well as the difficulty of controlling fires. Although the principles behind this phenomenon have been understood for some time (Brooks *et al.*, 2004), there is very little in the way of documented impacts in South Africa. Van Wilgen & Richardson (1985) found that invasion of Fynbos shrublands by the shrubs *Hakea sericea* (silky hakea) and *Acacia saligna* (Port Jackson willow) increased fuel biomass by between 50 and 60%, but that this could not be shown to increase fire intensity in an existing fire behaviour prediction model. These authors concluded that shortcomings in the model prevented the accurate simulation of high intensity fires which were known to occur in invaded stands under severe fire weather conditions. Such fires vigorously consume the increased biomass of shrub crowns, and are difficult to control. Later work demonstrated that physical damage to the soil can occur after fire in invaded areas, resulting in increased erosion after fire. For example, 6 tonnes of soil per hectare was lost following fires in pine plantations compared to 0.1 tonnes per hectare following fire in adjacent Fynbos in the Western Cape (Scott, Versfeld, Lesch 1998). While pine plantations are not strictly equivalent to invaded sites, the comparison is valid as plantations are normally established in Fynbos sites with almost no soil. A further study (Van Wilgen & Scott, 2001) compared soil damage following fires in vegetation invaded to different degrees on the Cape Peninsula. This study found a relationship between the degree of invasion and the physical damage to the soil, especially between sites that were uninvaded, or lightly invaded, compared to heavily invaded sites. Invasions of fire-prone areas by large trees and shrubs can therefore be expected to result in severe soil damage and erosion.

5.5.5. Impacts on marine habitats

As the most widespread and abundant marine invaders [*Mytilus galloprovincialis* (Mediterranean mussel), *Semimytilus algosus* (pacific mussel) and *Balanus glandula* (Pacific barnacle)] occur on rocky shores, this habitat is considered to be highly impacted. These impacts are focused on the west and south coasts where these species occur, and rocky shores along the east coast are not affected in the same way. Because of the impacts associated with *Ficopomatus enigmaticus* (estuarine tube-worm) in estuaries, this habitat is considered to be moderately impacted, while harbour environments experience low impacts. These results should be carefully considered because they represent the impacts of only 14% of marine alien species. These estimates might change once impacts of more species are understood.

5.6. SYNTHESIS AND INDICATOR VALUES

There are relatively reliable data on species richness for invasive plants at national, provincial and biome scales. While some conservation agencies have provided information about the extent to which protected areas under their management have been invaded by alien species, there has not been any consistent monitoring of alien species within a standardised set of spatial units in South Africa, despite the existence of several attempts to map the extent of invasions (Box 5.1). It is still not possible to provide estimates of *Relative invasive abundance* for most areas (e.g. Van Wilgen *et al.*, 2016).

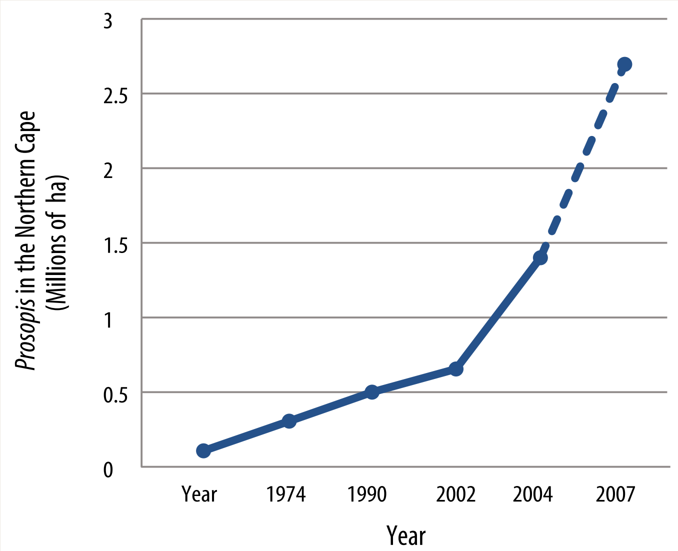
Estimating the level of invasion by alien species in particular areas could only be made with a low degree of certainty, given the relative lack of reliable and comprehensive data on invasive species. Even at the scale of protected areas, information on the level of invasions is at best scattered and incomplete. Only South African National Parks and two of the nine provincial conservation agencies (Cape Nature and Ezemvelo KwaZulu-Natal Wildlife) were able to provide lists of invasive species in protected areas under their jurisdiction, despite a long-standing legal requirement to develop such lists (Box 5.2). The level of completeness of these lists also varies.

There are few data on impacts. However, based on the existing studies, it appears that impacts are significant (in particular on water resources), are set to grow rapidly as invasive species enter a phase of exponential growth, and the widespread negative impacts currently observed are a small fraction of what they will be if invasions were left unchecked.

TABLE 5.6 Indicators used for reporting on the status of invaded areas. For full details of how to calculate the indicators, see Appendix 1.

INDICATOR	METRIC BASIC		ADVANCED	LEVEL OF CONFIDENCE	NOTES
9. Alien species richness	**9.1.** Invasive species richness: Between 177 and 577 invasive species per province	**9.2.** Invasive animal species richness: 46–162 per half-degree-grid cell; Invasive bird species richness: 0–6 per QDGC; Invasive plant species richness: 0–165 per QDGC	**9.3.** Number of alien species at different introduction stages per finer-degree national subdivision: Data not available	**9.1.** Moderate **9.2.** Low for animals; moderate for birds and plants	
10. Relative alien species richness	**10.1.** Relative invasive plant species richness per province ranged from 7% in the Northern Cape Province to 25% in the Northwest Province; no data for other taxa		**10.2.** Richness of alien species to indigenous species at different introduction stages per finer-degree national subdivision: Data not available	Low	Distribution data for indigenous species are incomplete
11. Relative invasive abundance	**11.1.** Relative abundance in broad categories: No data		**11.2.** Proportion of abundance due to invasive species: No data	N/A	Abundance data are not available for either alien or indigenous taxa
12. Impact of invasions	**12.1** Fynbos: major, massive and moderate impacts on water resources, rangeland productivity and biodiversity intactness respectively Grassland: moderate and minor impacts on water resources, and rangeland productivity respectively Savanna: Minor impacts on water resources	**12.2.** Surface water runoff reduced by between 1 and 321 million m^3 per primary catchment Range productivity reductions are between 200 and 74500 large livestock units per year per terrestrial biome. Biodiversity intactness reduced by between 0 and 3% per biome	**12.3.** Estimated annual losses due to impacts on water resources, rangeland productivity and biodiversity amount to ZAR 5864, 337 and 428 million respectively.	Low	Estimates based on Van Wilgen *et al.* (2008) for 12.1 and 12.2, and on De Lange & Van Wilgen (2010) for 12.3
C. Percent of area experiencing major impacts	**C.** 1.4%			Low	Based on the only available estimate of dense ("condensed") cover invasive alien plants in South Africa

BOX 5.1 MAPPING THE EXTENT AND ABUNDANCE OF INVASIVE SPECIES IN SOUTH AFRICA



Estimates of the combined impact of invasive species on the areas that they invade have to be based on reliable information about the area occupied by these species. Distribution data therefore need to be collected, stored, updated and periodically assessed in order to be able to estimate impacts on invaded areas. There are several examples of attempts to collect distribution data on invasive species in South Africa.

In 1993, the Council for Scientific and Industrial Research initiated a project to map invasive alien plants in South Africa, with the goal of estimating their impact at a national scale. The mapping techniques used were coarse due to the paucity of reliable data, but a map at a 1:250 000 scale was produced, based primarily on the local knowledge of natural resource experts from across South Africa. The project estimated that invasive plants occupied a total of 10.1 million ha (6.82% of South Africa and Lesotho). The findings were used to estimate the impacts of invasive plants on water resources, and were very influential in expanding the Working for Water programme after 1996.

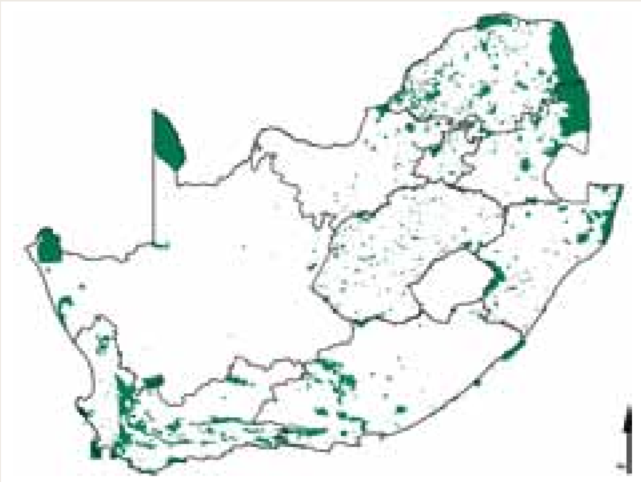
The longest-running project aimed at recording information on the national extent of alien plants is the Southern African Plant Invaders Atlas (SAPIA), which was initiated in 1994. Currently, SAPIA has over 87 000 geo-referenced records for 773 alien plant taxa that are present outside of cultivation in southern Africa, making it the most extensive source of information on the distribution of invasive plants in the region. Several other atlas databases have been developed to record the distribution of birds, frogs, freshwater fish and butterflies. These atlases all differ from SAPIA in that they are primarily aimed at recording the distribution of indigenous, rather than alien, species. However, they are also an important repository for the distribution of alien animals in the groups that they cover.

In 2008, the Department of Environmental Affairs commissioned the Agricultural Research Council to develop and implement a repeatable sampling protocol to track trends in alien plant distribution and density across the country. This project has run for almost a decade, and has mapped the distribution of 27 alien plant taxa (species in the genera *Pinus* and *Eucalyptus* and some *Acacia* were mapped collectively). The project is ongoing, but no adequate description of the sampling methodology has been published to date, nor have any peer-reviewed papers based on the findings been published. It is therefore not possible to reliably assess trends in invasion based on this method at present.

The extent of invasion by *Prosopis* species in the Northern Cape Province was mapped by the Agricultural Research Council (ARC) using remote sensing between 1974 and 2007. The surveys were repeated again between 2010 and 2014, but the most recent data could not be obtained from the ARC. The area invaded by *Prosopis* increased from 127 821 ha in 1974 to 1 473 953 ha in 2007, a mean annual increase of 7.4%. Assuming that this historic rate of spread was maintained, invasions would have increased to almost 3 million ha in 2016 (see inset).

South Africa's National Strategy for Dealing with Biological Invasions, published in 2013, recommended that a comprehensive information system incorporating alien species distribution data should be developed based on a survey of user needs. There has, however, not been any progress in the implementation of these recommendations.

BOX 5.2 INVASIVE SPECIES IN PROTECTED AREAS IN SOUTH AFRICA



Protected areas in South Africa provide examples of relatively unmodified ecosystems that are set aside for the purposes of conserving the country's unique biodiversity, and they contribute to society by providing opportunities for employment, recreation, tourism and scientific study.

Data: South Africa Protected Areas Database, Department of Environmental Affairs

In terms of the National Environmental Management: Biodiversity Act of 2004, section 77 (1) "The management authority of a protected area must at regular intervals prepare and submit to the Minister or the MEC for Environmental Affairs in the province a report on the status of any listed invasive species that occurs in that area." This requirement has not been adhered to in the past (while the requirement has been in place since 2004, the species were only listed in 2014). Only three national or provincial management authorities submitted information on request for inclusion in this status report. Their inputs are summarised here.

South African National Parks: SANParks has listed 869 alien and extra-limital species across its 39 000 km^2 estate, including 752 plants and 117 animals. Of the total species in SANParks, 263 are listed in the NEM:BA A&IS Regulations, including 12 category 1a species, 184 category 1b species, 28 category 2 species and 39 category 3 species. The number of species per park ranges from 21 (Kalahari and Richtersveld) to 415 (Kruger), although this is likely partly an artefact of greater sampling effort in some parks. Parks with over 100 invasive species recorded included Kruger (415 species), Table Mountain (295), Garden Route (283), Addo Elephant (149) and Mountain Zebra (111).

Cape Nature: The management authority for the Western Cape Province has listed 117 species across their estate of 31 protected area clusters, covering approximately 540 000 ha. The number of species per protected area cluster was less than recorded by SANParks. This likely reflects difference in survey effort rather than Cape Nature's reserves being less invaded than National Parks. The number of species per reserve cluster ranges from 5 (Robberg) to 33 (Kogelberg). Cape Nature was also able to supply information on alien plant density in protected areas. Three genera (*Pinus*, *Hakea* and *Acacia*) accounted for the bulk of invasive plant cover. About 64% of the protected area estate is invaded to some degree by alien pine trees, with the Outeniqua, Hottentots-Holland and Jonkershoek reserves being most severely affected. *Acacia* trees were also widespread, with about 40% of the protected area estate being invaded. The De Hoop and Walker Bay reserves along the coast were most affected. Over half of the protected area estate was invaded by *Hakea* shrubs, with the Outeniqua, Hottentots-Holland, Jonkershoek, Waterval and Limietberg reserves being most affected.

Ezemvelo KwaZulu-Natal Wildlife: Information on the levels of invasion in protected areas in KwaZulu-Natal was supplied by Ezemvelo KwaZulu-Natal Wildlife. The information covered 162 protected areas, including the Isimangaliso Wetland Park (which is managed by a separate authority). A total of 374 alien species were recorded in these protected areas (331 plants, 21 invertebrates, 13 freshwater fish, six birds and three mammals). The level of invasion was assessed for 95 of the 162 protected areas. Only one protected area (the Richard's Bay Coastal Game Reserve, which is mostly tidal, bounded by the high water mark) was assessed as alien-free, and 10 protected areas were assessed as being extensively invaded (including the Hluhluwe-iMfolozi, Ndumo and Ithala reserves).

BOX 5.3 TERRESTRIAL INVASIONS ON SUB-ANTARCTIC MARION AND PRINCE EDWARD ISLANDS

Photograph: M. Greve

Island ecosystems are particularly vulnerable to biological invasions. This is especially true for remote and isolated islands, which often lack the diversity of species found on continents, and whose indigenous species often lack defences against newly-introduced predators or competitors.

Besides many islands that are close to the South African coast, the country also governs the Prince Edward Islands (PEIs, comprising Marion and Prince Edward Island) in the sub-Antarctic Indian Ocean. These islands have been declared Special Nature Reserves under the Environmental Management: Protected Areas Act, No. 57 of 2003, and activities on the islands are restricted to research and conservation management.

The 2014 A&IS Regulations listed several species for control or eradication specifically on offshore islands. Several plants species have been listed as requiring control (category 1b), with some having been identified as potential targets for eradication (category 1a) on particular islands [for example *Agrostis castellana*, bent grass, on Prince Edward Island]. In addition, five mammal and one bird species have been listed as requiring control specifically on islands. These include three species of rats (genus *Rattus*), *Mus musculus* (the house mouse), *Oryctolagus cuniculus* (European rabbit) and *Alectoris chukar* (the Chukar partridge). Two mammal species *Capra hircus* (goat) and *Felis catus* (domestic cat) have also been listed as potential eradication targets (not all of these occur on the Prince Edward Islands and *Felis catus* has been successfully eradicated from Marion Island).

It has been estimated that about 5% of the Prince Edward Islands is covered by invasive plants, which have established around the coastal periphery on both Marion and Prince Edward Islands, and from where they are spreading inland. Studies on impacts have primarily focussed on the effects of vertebrate invaders, of which the house mouse, which is restricted to Marion Island, is the invasive species which probably has the greatest impact on the indigenous biota of the islands. Because of the risk of alien introductions, strict biosecurity regulations govern activities at the PEIs. These are particularly aimed at reducing the rates of introduction of new alien species. In addition, some effort is currently being made to eradicate selected range-restricted species. However, only one species that had established and spread on the PEIs, *Felis catus* (the domestic cat), has been successfully eradicated from the islands to date.

The threat of biological invasions is incorporated into all aspects of PEIs management. Given the ongoing threat of introductions, and the impacts of invaders, it is essential that these policies deal with all stages of the invasion process and that a better understanding of the risks and impacts of invasions is obtained.

6 THE EFFECTIVENESS OF CONTROL MEASURES

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Chapter summary

This chapter provides an assessment of control measures, with control effectiveness assessed in terms of inputs, outputs or outcomes, for interventions aimed at pathways, species and areas. The required monitoring data to make such assessments are largely absent, so the assessment has relied heavily on a limited number of research projects, that covered some pathways, species, and areas.

A system of risk assessment and permitting to regulate the importation of new alien species has been in place since 2014. Only one of the Republic's 72 international entry points is consistently monitored to intercept new potential environmental pests carried by air passengers and in cargo, although additional measures are in place through the Department of Agriculture, Forestry and Fisheries to limit the arrival of new agricultural pests, which likely also reduces the rate of arrival of new environmental problems. There are insufficient data to link the impact of these measures to the relevant outcome, i.e. the rate of introduction of new unregulated alien species into the Republic.

There have been nine historical attempts at eradicating species from the Republic, and three have succeeded (feral cats have been eradicated from Marion Island, and two terrestrial invertebrates from the mainland). More species are being actively targeted for eradication, and so more successes are expected over the coming decade.

Management programs have been developed for a small number of established invasive species (as provided for by the NEM:BA), but none have yet been formally implemented. However, the biological control of invasive plants has been notably successful, with 15 species under complete control, and a further 19 species under a substantial degree of control. This success has been aided by mass-rearing programs.

Ongoing conflicts over the management of invasive alien trout species have resulted in an impasse regarding the management of these species, and consequently an absence of any acceptable regulatory framework for their management. There has, however, been one successful removal of an invasive alien freshwater fish species from a natural ecosystem.

In terms of area management plans, almost none of the available plans clearly indicate the intended goals, and few cater for adequate monitoring and assessment of outcomes. Goals are typically set for the sums of money to be


Campuloclinium macrocephalum (pompom weed) – Lesley Henderson

spent, the number of jobs to be created, and the area to be treated. With this set of measures, it is all too easy for managers to meet their targets by simply creating employment and working anywhere to any standard.

Based on a small (but growing) number of case studies that have sought to assess management effectiveness, it is clear that the cover of invasive alien plants has been reduced in some localised areas, but it continues to grow in others. A number of factors contributed to at least one successful project. They included ongoing direction from a diverse project steering committee, thorough inspections of the quality of the work, a rapid response team, a focus on areas of low infestation, a very flexible management approach, regular monitoring, and generous funding. However, the effort and resources required for successful control appear to be routinely underestimated, with actual costs between 1.5 and 8.6 times higher than initial budget estimates.

Returns on investment for the biological control of invasive alien plants have provided benefit:cost ratios ranging from 8:1 to 3 726:1, depending on the species. There are no adequate assessments of the benefits and costs for mechanical and chemical measures, but if control measures are focussed on areas where progress is possible, and if they are carried out using best-practice approaches that are diligently implemented, invasive alien plant control could also deliver positive benefit:cost ratios.

Currently, however, mechanical and chemical control measures have largely failed to check plant invasions. Some of the contributing factors that were identified included the absence of effective prioritisation, goal-setting and planning; monitoring of inputs rather than of outcomes; multiple goals that lead to confusion over priorities; the fact that the actual costs of control far exceed the estimated costs; a failure to adhere to accepted best practices and standards; complex contracting and employment models; and conflicts over species that have commercial or other value, but also cause significant environmental damage.

Most (77.3%) pathways are managed, but management coverage across the country is low. Only 136 out of 556 listed invasive alien taxa (24.3%) are subjected to regular management. The management also reaches only a small proportion (~1% per year) of the populations of each managed invasive species. Besides a small proportion (6.4%) of species that have either been eradicated or brought under biological control, populations of most species continue to grow, indicating that interventions are ineffective at a broad scale. Only 0.36% of invaded land is subjected to active management. Based on a limited number of studies, 8% of this area is effectively managed, 58% is partially effectively managed, and 34% is ineffectively managed. The overall high-level indicator of management effectiveness in the country is 5.5%, with pathway management contributing most to this score. The levels of confidence in these indicators are low due to a lack of data.

EFFECTIVENESS OF RESPONSES

The returns on investment from selected biological control projects aimed at invasive alien plants are between

8:1 & 3726:1

EFFECTIVENESS OF RESPONSES

Feral cats have been eradicated from Marion Island

AND

2 terrestrial invertebrates from the mainland

6.1. INTRODUCTION

The NEM:BA A&IS Regulations (section 11) call for "a summary and assessment of [*inter alia*] the effectiveness of … control measures". In this assessment, "control measures" are understood to be any active intervention aimed at prevention, incursion response (including eradication), spread reduction (including containment), and impact reduction (see Chapter 2 for a discussion on defining effectiveness). Control initiatives in South Africa have been largely aimed at invasive alien plants to date, but there have been attempts to control other taxa. The effectiveness of control needs to be assessed for:

- Pathway-related control measures
- Species-specific control measures
- Area-specific control measures

Control effectiveness describes the relationship between a control measure and its effect on the invasion size, or other aspects such as invader density, biomass, or reproductive output (Olson & Roy, 2003; Olson, 2006; Simberloff, 2009; Palmer, Heard & Sheppard 2010). Information on control effectiveness informs decisions on the most suitable strategies to contain or eradicate an invader. Control strategies are often compared based on cost-benefit models (Van Wilgen *et al.*, 2004; Sinden & Griffith, 2007; Epanchin-Niell & Hastings, 2010), which are rendered more accurate by knowing how effective control measures are per unit of cost or effort (Olson & Roy, 2003; Olson, 2006; Epanchin-Niell & Hastings, 2010). Because the cost and effectiveness of control methods can vary non-linearly with the size of the invasion, the effects of methods should also be related to the spatial and temporal scales of application (Olson, 2006; Kettenring & Adams, 2011).

Despite the existence of national-level invasive species control programmes in several countries, comprehensive, large-scale assessments of control effectiveness are rare. Much of our knowledge of control effectiveness comes from experimental studies on various methods to control a single species (e.g. Bonesi & Palazon, 2007, Hazelton *et al.*, 2014, Lindenmayer *et al.*, 2015), or on a particular method applied to many species (e.g., biological control, Van Driesche *et al.*, 2010), but often these studies are of short duration and lack cost data (Kettenring & Adams, 2011). For example, Palmer, Heard & Sheppard (2010) reviewed the effectiveness of biological control in Australia, noting substantial investment and progress. Yet although the study assessed twelve years of control, quantitative data were only available for some species. Howell (2012) assessed 111 plant eradication programs in New Zealand, documenting some allegedly successful cases but also noting a lack of adequate quantitative data on programme costs and invasion extent. Thus, providing an adequate account of control effectiveness would be challenging anywhere in the world, and South Africa is no different.

This chapter provides an assessment of the available information on the effectiveness of control measures on invasive species in South Africa. It reviews the design and implementation of pathway-related measures, where interventions have been put in place to reduce the risk of introducing potentially harmful alien species. It then reviews the effectiveness of control measures that address individual species, with a focus on eradication programmes and the biological control of invasive plant species. Finally, area-specific control measures (where attempts have been made to reduce the combined impacts of several co-occurring invasive species in a given area) are reviewed. Data were obtained from a variety of sources (Table 6.1). The chapter concludes with an overview of aspects of the efficiency of control measures in South Africa.

TABLE 6.1 Sources of data used to assign values to indicators of control effectiveness, with levels of confidence based on the completeness and accuracy of data sets. The numbering of indicators is based on Chapter 2. Indicators are: 14. Money spent; 15. Planning coverage; 16. Pathways treated; 17. Species treated; 18. Area treated; 20. Effectiveness of species treatments; 21. Effectiveness of area treatments.

DESCRIPTION	SOURCE	SCALE	LEVEL OF CONFIDENCE BASED ON COMPLETENESS AND ACCURACY	INDICATORS INFORMED BY THESE DATA
Monitoring records from formal eradication projects	South African National Biodiversity Institute	National	High	14,17
Estimates of the effectiveness of biological control agents in discrete categories (complete, substantial, negligible or not assessed)	Regular reviews of invasive alien plant biological control (Moran, Hoffmann & Hill 2011)	National	High	17, 20
Descriptions of invasive species management programs	Published scientific literature	National	Moderate	15
Spatial database of alien plant control projects, with information on species, area treated and costs (data used in most research projects assessing control effectiveness)	Department of Environmental Affairs, Working for Water Information Management System (WIMS)	National	Low	14, 17, 18
Records of effectiveness of alien freshwater fish control projects	Cape Nature and South African Institute of Aquatic Biodiversity	River system (only one to date, see Woodford *et al.*, 2017).	High	17, 20
Monitoring of feral pig control programme	Cape Nature	Localised	Moderate	17, 20
Description of project to remove alien frog species (De Villiers *et al.*, 2016)	Published scientific literature	Localised	Moderate	17, 20
A range of studies assessing the effectiveness of alien plant control measures applied to particular areas	Published scientific literature	Studies were carried out at the scale of provinces, catchments, protected areas or privately-owned farms.	Moderate	14, 17, 18, 20, 21
A range of studies assessing the returns on investment from alien plant control projects applied to particular areas or species	Published scientific literature	Limited to the range of the target species for biological control; Other studies at provincial or catchment scales	Low	14, 20, 21
Interceptions at O.R. Tambo International Airport	Records within the Department of Environmental Affairs	A single entry point	Moderate	16

6.2. PATHWAY-RELATED CONTROL MEASURES

Pathway-based control measures focus on reducing the risk of introducing damaging species (i.e. the actual mechanism by which species arrive, rather than specific species themselves). In invasion ecology, the term "dispersal pathways" is used broadly, and refers to the combination of processes and opportunities that result in the movement of alien species from one place to another. For example, organisms can be introduced by ships through a number of pathways (as stowaways in ballast water, in cargo containers, on the hull of the ship, or in the luggage of crew or passengers).

In South Africa, intentional introductions are currently managed through a permitting system. Species require import permits that are based on a risk assessment conducted by a qualified risk assessor. These assessments are then sent by the Department of Environmental Affairs (DEA) to the Alien Species Risk Analysis Review Panel (ASRARP) for comment. ASRARP is a committee of experts set up in October 2016 to provide scientific oversight on decisions concerning biological invasions, and in particular to provide recommendations to DEA as to the quality and completeness of an invasive species risk assessment. DEA then makes a decision to approve or, should the risks be too high, reject an application for an import permit. The effectiveness of these permitting measures is covered in Chapter 7.

For air traffic, inspections by the DEA are currently only carried out at O.R. Tambo International Airport, where permit compliance is checked, illegal imports are intercepted and the luggage of tourists and cargo is searched for alien organisms that may have been unintentionally transported as stowaways. Occasional and infrequent joint operations are also carried out by DEA in conjunction with other departments at a limited number of other entry points.

For shipping, the Marine Draft Ballast Water Bill aims to reduce the risk of the unintentional introduction of alien marine species through the release of ballast water by ships. This legislation has not yet been passed.

While other control measures are in place to manage additional pathways of introduction, these focus on potential agricultural pests (e.g. phytosanitary inspections at border posts) or threats to human health (e.g. spraying the interior of aircrafts to kill insect disease vectors). In line with international obligations under the International Plant Protection Convention (IPPC) and its role as the National Plant Protection Organization (NPPO), the Department of Agriculture, Forestry and Fisheries (DAFF) regulates and monitors the importation of agricultural goods. Interceptions are often not recorded or are not entered into a database, and such databases often focus only on quarantine organisms.

Due to a lack of baseline data, increases in global travel and trade, and changes in patterns of demand, it is extremely difficult to demonstrate a direct link between control measures and changes in rates of introduction and establishment of alien species (Essl *et al.*, 2015a). Furthermore, most of the pathway-related control measures in South Africa have not been in place for long enough to properly assess their effectiveness. For example, inspections at O.R. Tambo by the Biosecurity Unit of the DEA only commenced in 2015, and currently only operate on weekdays during office hours (7:30-16:30). There were 24 735 DEA inspections between April 2015 and January 2017 (346 of commercial cargo, none at the mail centre and 24 388 at the terminals), and ten illegal imports and luggage stowaways were intercepted. Illegal imports can however enter the country almost unhindered through the remaining 71 formal ports of entry or after working hours and over weekends at O.R. Tambo airport. However, other departments like DAFF and SARS-Customs are present at other ports of entry and sometimes identify instances of non-compliance and alert DEA biosecurity. Finally, although many alien species have been accidentally introduced to South Africa (Faulkner *et al.*, 2016a; see also Chapter 3), no management is in place or has been considered for many of the pathways through which these alien species could enter the country. For example, vehicles (e.g. cars and trains) entering South Africa are not inspected for organisms transported as stowaways, and no measures are yet in place to prevent the introduction of marine species attached to the hulls of visiting ships.

6.3. SPECIES-SPECIFIC CONTROL MEASURES

6.3.1. The status of attempts at eradication

The term "eradicate" is defined as the removal of all individuals and propagules from a specified area (for the purposes of this report either the whole South Africa or any one of the offshore islands) where the likelihood of re-colonisation is negligible, i.e. a successful eradication will remove the need for future control measures. The terms "eradicate" or "eradication" are often incorrectly used in policy documents, control plans and legislation as synonyms for "control" or "manage". In this section, the effectiveness of eradication attempts, where the goal of eradication was explicitly stated, is assessed. Pluess *et al.* (2012) reviewed a global set of 136 eradication campaigns against 75 species (invasive alien invertebrates, plants and plant pathogens) and examined whether certain factors could explain success. They found that only the spatial extent of the infestation was significantly related to the eradication outcome, and that local campaigns were more successful than regional or national campaigns; a range of other factors were all unrelated to eradication success. As a result of their findings, they recommended that eradication measures should generally concentrate on incursions when infestations are still relatively small, and the variability in success is likely down to difference in the quality of the project management, including factors like monitoring and reporting.

Release of captive-bred biological control agents – Kim Weaver

It is also becoming increasingly clear that eradication measures need to be considered carefully before they are attempted, and that once they are initiated it is equally important that progress should be monitored and implementation should not be subject to the vagaries of funding cycles. In 2008, the Working for Water Programme funded the establishment of South African National Biodiversity Institute's Invasive Species Programme (SANBI ISP). SANBI ISP was designed to detect and document new invasions, and to provide the cross-institutional coordination needed to successfully implement national eradication plans (Wilson *et al.*, 2013). The focus of the unit was on species listed as category 1a under the A&IS Regulations, as well as on selected non-listed species. Candidate non-listed species were designated as 'Species Under Surveillance – Possible Eradication or Containment Targets' (SUSPECT). The SUSPECT list has no legal status, but it includes species where there is sufficient documented evidence to warrant in-depth investigation and incursion response. New additions to the SUSPECT list must be accompanied by: (1) an initial risk assessment, (2) a specimen lodged in a South African collection, (3) a short background dossier on life-form and invasive tendencies elsewhere in the world, lodged with SANBI and (4) a detailed project plan including information on current distribution in South Africa, local-scale distribution for one or more naturalised populations, an assessment of management options and an outline of proposed research. This approach has been followed since 2012, and as a result a number of SUSPECT species have been targeted for eradication (Table 6.2).

To date, 42 eradication projects have been initiated, or are under consideration, in South Africa (Table 6.2). Most of these (32) are aimed at terrestrial or freshwater plants. Of these projects, 23 are under consideration, pending the outcome of a risk analysis or the development of a detailed plan, and 10 are ongoing [eight against plants, one targeting a bird species (*Corvus splendens*, the house crow), and one targeting a mammal (*Hemitragus jemlahicus*, the Himalayan tahr) Table 6.3]. Of the completed historical projects, three were successful (one being the eradication of *Felis catus*, the domestic cat, from Marion Island, and the other two against terrestrial invertebrates). Six projects were deemed to have failed, three against plants, one against an amphibian, one against a freshwater invertebrate and one against a terrestrial invertebrate.

TABLE 6.2 The status of eradication projects in South Africa. For species listed as invasive under the NEM:BA A&IS Regulations 2016, relevant categories are shown; unlisted species are also shown. SUSPECT species are those identified as 'Species Under Surveillance – Possible Eradication or Containment Targets' (see text). The status of projects is either "Under consideration" (where a decision to proceed with eradication would depend on the outcome of a risk analysis or the development of a detailed plan); "ongoing" (where eradication attempts are under way, but where eradication has not yet been confirmed); "failed" (where the species has persisted despite eradication attempts, such that the eradication attempt was discontinued); or "successful" (where the species was eradicated).

TAXON	SPECIES AND CATEGORY	PROJECT STATUS	NOTES
Terrestrial and freshwater plants	*Acacia fimbriata* (fringed wattle) 1a	Under consideration	Removal of individuals from small populations commenced in 2012
Terrestrial and freshwater plants	*Acacia implexa* (screw pod wattle) 1a	Under consideration	Removal of individuals from small populations commenced in 2012 (Kaplan *et al.*, 2012)
Terrestrial and freshwater plants	*Acacia paradoxa* (kangaroo thorn) 1a	Ongoing	Removal of population on Table Mountain commenced in 2008 (Zenni *et al.*, 2009). Cost to date ZAR 400 000

TAXON	SPECIES AND CATEGORY	PROJECT STATUS	NOTES
Terrestrial and freshwater plants	*Acacia retinodes* (swamp wattle) (SUSPECT)	Under consideration	Removal of individuals from small populations commenced in 2012
Terrestrial and freshwater plants	*Acacia stricta* (hop wattle) 1a	Under consideration	Removal of individuals from small populations commenced in 2012 (Kaplan *et al.*, 2014)
Terrestrial and freshwater plants	*Acacia viscidula* (sticky wattle) (SUSPECT)	Under consideration	Removal of individuals from small populations commenced in 2012
Terrestrial and freshwater plants	*Alhagi maurorum* (camel thorn bush) 1b	Failed	Attempted eradication of camel thorn from irrigation schemes in 1960s
Terrestrial and freshwater plants	*Anigozanthos flavidus* (yellow kangaroo paw) (SUSPECT) Unlisted	Under consideration	Clearing has started but progress has not been assessed (Le Roux *et al.*, 2010). Landowner has expressed further interest in continuation of this work. New populations found at separate site on Agulhas Plain
Terrestrial and freshwater plants	*Anigozanthos rufus* (red kangaroo paw) (SUSPECT) Unlisted	Under consideration	Clearing has started but progress has not been assessed (Le Roux *et al.*, 2010). Should possibly deal with *Anigozanthos flavidus* and *A. rufus* as a single eradication attempt as there is hybridisation. Activities have not separated the two species or hybrids but dealt with them as a single attempt
Invertebrate	*Bactrocera invadens* (Asian fruit fly) 1a	Failed	Despite reports on the eradication of the Asian fruit fly from Limpopo Province in 2011 (Manrakhan, Venter & Hattingh 2015) the species is now widespread in the country
Terrestrial and freshwater plants	*Banksia ericifolia* (heath banksia) (SUSPECT)	Under consideration	A few small populations in the Western Cape (Geerts *et al.*, 2013b)
Terrestrial and freshwater plants	*Berberis julianae* (Chinese barberry) Unlisted	Under consideration	Small populations in Northwest, Free State, KwaZulu-Natal and Western Cape; possibly present in Lesotho (Keet, Cindi & Du Preez 2016)
Bird	*Corvus splendens* (house crow) 1a	Ongoing	The population has been reduced from 10 000 birds in 2009 to less than 400 birds by end of January 2016 in Cape Town. The eThekwini population is currently (2016) estimated at less than 5 birds, and no birds have been recorded as seen in the last 9 months
Terrestrial and freshwater plants	*Epipremnum aureum* (devil's ivy) (SUSPECT)	Under consideration	Small populations present in KwaZulu-Natal (Moodley, Procheş & Wilson 2017)
Mammal	*Felis catus* (domestic cat) 1a (on islands)	Successful	Eradication of cats from Marion Island between 1973 and 1992 (Bester *et al.*, 2002)

TAXON	SPECIES AND CATEGORY	PROJECT STATUS	NOTES
Terrestrial and freshwater plants	*Furcraea foetida* (Mauritian hemp) 1a	Under consideration	Scattered small populations in Western and Eastern Cape, and KwaZulu-Natal. Henderson and Wilson (2017) recommend reclassification as 1b
Terrestrial and freshwater plants	*Genista monspessulana* (Montpellier broom) 1a	Under consideration	Small populations present on the Cape Peninsula (Geerts *et al.*, 2013a)
Mammal	*Hemitragus jemlahicus* (Himalayan tahr) 1b	Ongoing	There was an attempted eradication of the Himalayan tahr from Table Mountain, but eradication unconfirmed
Terrestrial and freshwater plants	*Hydrilla verticillata* (hydrilla) 1a	Ongoing	Occurs in Pongolapoort Dam, on the border between KwaZulu-Natal and Swaziland. Cost to date ZAR 800 000.00 (including research on biological control) (Klein, 2011; Coetzee, Hill & Schlange 2008)
Terrestrial and freshwater plants	*Hydrocleys nymphoides* (water poppy) 1a	Under consideration	Occurs at two sites in KwaZulu-Natal (Nxumalo *et al.*, 2016)
Terrestrial and freshwater plants	*Hypericum pseudohenryi* (Henry's St. John's Wort) Unlisted	Under consideration	Several populations in KwaZulu-Natal
Terrestrial and freshwater plants	*Iris pseudacorus* (yellow flag) 1a	Under consideration	Found at several sites in Gauteng and KwaZulu-Natal (Jaca & Mkhize 2015). Cost of control to date ZAR 621 000.00.
Terrestrial and freshwater plants	*Lythrum salicaria* (purple loosestrife) 1a	Ongoing	Occurs along the Liesbeeck River in the city of Cape Town. Cost of control to date ZAR 435 000.00.
Terrestrial and freshwater plants	*Melaleuca hypericifolia* (red-flowering tea tree) 1a	Ongoing	One population on the Cape Peninsula. Clearing commenced in 2012 (Hickley *et al.*, 2017)
Terrestrial and freshwater plants	*Melaleuca parvistaminea* (rough-barked honey-myrtle) (SUSPECT)	Under consideration	Small populations in the Western Cape; feasibility of eradication under assessment (Jacobs, Richardson & Wilson 2014)
Terrestrial and freshwater plants	*Mimosa albida* (common name unknown) Unlisted	Under consideration	One small population in KwaZulu-Natal (Cheek 2015)
Terrestrial and freshwater plants	*Opuntia aurantiaca* (jointed cactus) 1b	Failed	Attempted eradication of jointed cactus in the 1930s and 1940s (Moran & Annecke, 1979)
Terrestrial and freshwater plants	*Opuntia salmiana* (bur cactus) 1a	Ongoing	Small population being managed towards eradication in the Northwest Province.

TAXON	SPECIES AND CATEGORY	PROJECT STATUS	NOTES
Invertebrate	*Otala punctata* (freckled edible snail) Unlisted	Successful	Eradication of the Mediterranean snail in the Western Cape between 1987 and 1989 at a cost of ZAR 215 000 (1988 prices) (Herbert & Sirgel 2001)
Terrestrial and freshwater plants	*Petiveria alliacea* (Guinea hen-weed) Unlisted	Under consideration	Less than 1000 plants in the city of Durban (Cheek 2013)
Invertebrate	*Polistes dominula* (European paper wasp) 1b	Under consideration	Distribution currently limited to the Western Cape Province, where control is ongoing (Benadé *et al.*, 2014)
Invertebrate	*Procambarus clarkii* (red swamp crayfish) Prohibited	Failed	Eradication was attempted in the Crocodile River, Mpumalanga in 1994, but the species has survived (Nunes *et al.*, 2017)
Terrestrial and freshwater plants	*Pueraria montana* var. *lobata* (kudzu vine) 1a	Ongoing	Earlier attempted eradication of kudzu vine in Mpumalanga in the 1960s and 1970s failed. New attempt is being implemented by SANBI (Geerts *et al.*, 2016)
Terrestrial and freshwater plants	*Sagittaria latifolia* (common arrowhead) Unlisted	Ongoing	Nine of the known ten populations have been cleared in KZN.
Terrestrial and freshwater plants	*Sagittaria platyphylla* (delta arrowhead) 1a	Under consideration	Scattered populations in four provinces
Amphibian	*Sclerophrys gutturalis* (African common toad) Unlisted	Failed	Attempt to extirpate the guttural toad on the Cape Peninsula (Vimercati *et al*, 2017; Measey *et al.*, 2017)
Terrestrial and freshwater plants	*Solanum elaeagnifolium* (silver-leaf bitter apple) 1b	Failed	Attempted eradication of satansbos in the Northwest Province between 1952 and 1972
Terrestrial and freshwater plants	*Spartina alterniflora* (smooth cord grass) 1a	Ongoing	Attempted eradication in the Groot Brak Estuary (Adams, Van Wyk & Riddin 2016; Riddin, Van Wyk & Adams 2016)
Terrestrial and freshwater plants	*Tephrocactus articulatus* (pine cone cactus) 1a	Under consideration	Populations in the Northern, Western and Eastern Cape Provinces
Terrestrial and freshwater plants	*Triplaris americana* (ant tree) 1a	Under consideration	Less than 1000 plants in the city of Durban (Lala & Ivey, 2011)
Invertebrate	*Trogoderma granarium* (khapra beetle) 1b	Successful	Eradication of khapra beetle at multiple sites, most recently near Upington in 1972
Invertebrate	*Vespula germanica* (German wasp)	Under consideration	The geographical range of the German wasp is now well documented and destructive sampling has been carried out since 2014

TABLE 6.3 Number of eradication projects attempted per high-level taxon in South Africa, with assessment of status

STATUS	TAXON					TOTAL
	TERRESTRIAL AND FRESHWATER PLANTS	MAMMALS	BIRDS	AMPHIBIANS	TERRESTRIAL AND FRESHWATER INVERTEBRATES	
Under consideration	21				2	23
Initiated and ongoing	8	1	1			10
Successfully eradicated		1			2	3
Failed	3			1	2	6
Totals	32	2	1	1	6	42

6.3.2. Biological control of invasive plants

Overview of effectiveness of biological control of alien plants. Biological control of invasive plants using introduced natural enemies has contributed significantly to sustained, cost-effective management of several invasive plant species in South Africa. Biological control programmes have been launched or are under investigation for 77 invasive plant species. Many of the most obvious successes have been against acacias, cacti (Figure 6.1) and invasive aquatic plants, although successes have certainly not been limited to these groups. Henderson & Wilson (2017), in a review based on records in the Southern African Plant Invaders Atlas, concluded that "some [invasive plant] species which have been the subjects of successful biological control programmes have shown very little expansion in their distribution" and "in general successful biological control seems to be associated with a reduction in the rate of spread". This is in stark contrast to species that have not been subjected to any biological control, where spread has accelerated in many cases.

FIGURE 6.1 *Cylindropuntia fulgida* (chain-fruit cholla) in the Northern Cape Province. The right-hand panel shows the population after the introduction of the biological control agent *Dactylopius tomentosus* (cholla biotype, cochineal cladode sucker).

Invasive plant species that are under biological control. Biological control agents have been established on 60 invasive plant species in South Africa (Table 6.4). Of these, 15 species (eight succulent cacti, four aquatic plants, two herbs and one shrub species) are under complete control; 19 species (nine tree or shrub species, eight succulent cacti, one aquatic plant and one herb) are under a substantial degree of control; a negligible degree of control has been achieved on 15 species (11 tree or shrub species, two herbs and two climbers); while the degree of control has not been determined for the remainder (three tree and shrub species, four succulent cacti, two herbs and two climbers).

TABLE 6.4 Invasive plant species on which biological control agents have been successfully established in South Africa, and the degree of biological control achieved as per the following categories: Complete: no other control measures are needed to reduce the invasive plant species to acceptable levels, at least in areas where the agents are established; Substantial: other methods are needed to reduce the invasive plant species to acceptable levels, but less effort is required (e.g. less frequent herbicide applications or less herbicide needed per unit area); Negligible: in spite of damage inflicted by the agents, control of the invasive plant species remains entirely reliant on the implementation of other control measures; and Not determined: either the release of the agents has been too recent for meaningful evaluation or the programme has not been evaluated.

INVASIVE PLANT SPECIES	LIFE FORM	REGION OF ORIGIN	DEGREE OF BIOLOGICAL CONTROL
***Acacia baileyana* (Bailey's wattle)**	Tree	Australia	Negligible
***Acacia cyclops* (rooikrans)**	Tall shrub or tree	Australia	Substantial
***Acacia dealbata* (silver wattle)**	Tree	Australia	Negligible
***Acacia decurrens* (green wattle)**	Tree	Australia	Negligible
***Acacia longifolia* (long-leaved wattle)**	Tree	Australia	Substantial
***Acacia mearnsii* (black wattle)**	Tree	Australia	Substantial
***Acacia melanoxylon* (Australian blackwood)**	Tree	Australia	Substantial
***Acacia podalyriifolia* (pearl acacia)**	Tree	Australia	Negligible
***Acacia pycnantha* (golden wattle)**	Tree	Australia	Substantial
***Acacia saligna* (Port Jackson)**	Tree	Australia	Substantial
***Ageratina adenophora* (Crofton weed)**	Perennial herb	Central America	Negligible
***Ageratina riparia* (mistflower)**	Perennial herb	Central America	Complete
***Austrocylindropuntia subulata* (long spine cactus)**	Succulent shrub	South America	Not determined
***Azolla filiculoides* (Azolla)**	Free-floating aquatic plant	South America	Complete
***Caesalpinia decapetala* (Mauritius thorn)**	Thorny evergreen shrub or climber	Asia	Negligible
***Campuloclinium macrocephalum* (pompom weed)**	Shrub	South America	Not determined
***Cardiospermum grandiflorum* (balloon vine)**	Perennial slightly woody climber	South America	Not determined
***Cereus hildmannianus* (queen of the night)**	Spiny succulent tree	South America	Complete
***Cereus jamacaru* (queen of the night)**	Spiny succulent tree	South America	Complete
***Chromolaena odorata* (triffid weed)**	Shrub	North, Central & South America	Not determined
***Cirsium vulgare* (spear thistle)**	Spiny herbaceous biennial	Europe	Negligible
***Cylindropuntia fulgida* (chain-fruit cholla)**	Compact spiny succulent shrub	North & Central America	Complete
***Cylindropuntia fulgida* var. *mamillata* (boxing-glove cactus)**	Compact spiny succulent shrub	South America	Complete
***Cylindropuntia imbricata* (imbricate cactus)**	Spiny succulent shrub	North & Central America	Substantial
***Cylindropuntia leptocaulis* (pencil cactus)**	Compact spiny succulent shrub	North & Central America	Complete
***Dolichandra unguis-cati* (cat's claw creeper)**	Woody-stemmed climber	Central & South America	Negligible
***Eichhornia crassipes* (water hyacinth)**	Free-floating aquatic herb	South America	Substantial
***Gleditsia triacanthos* (honey locust)**	Spreading tree	North America	Not determined

INVASIVE PLANT SPECIES	LIFE FORM	REGION OF ORIGIN	DEGREE OF BIOLOGICAL CONTROL
Hakea gibbosa **(rock hakea)**	Tall shrub	Australia	Negligible
Hakea sericea **(silky hakea)**	Tall shrub	Australia	Substantial
Harrisia balansae **(strangler prickly apple)**	Spiny succulent shrub	South America	Substantial
Harrisia martinii **(moon cactus)**	Spiny succulent shrub	South America	Complete
Harrisia pomanensis **(midnight lady)**	Spiny succulent shrub	South America	Substantial
Harrisia tortuosa **(spiny snake cactus)**	Spiny succulent shrub	South America	Substantial
Hylocereus undatus **(night-blooming cereus)**	Vine-like cactus	Tropical America	Not determined
Hypericum perforatum **(St John's wort)**	Perennial herb	Europe & Asia	Complete
Lantana camara **(lantana)**	Shrub	Central & South America	Negligible (Highveld) to substantial (coastal & Lowveld)
Leptospermum laevigatum **(Australian myrtle)**	Tall shrub or tree	Australia	Negligible
Leucaena leucocephala **(leucaena)**	Shrub or small tree	Tropical America	Negligible
Myriophyllum aquaticum **(parrot's feather)**	Rooted aquatic herb	South America	Complete
Opuntia aurantiaca **(jointed cactus)**	Spiny succulent shrublet	South America	Substantial
Opuntia engelmannii **(small round-leaved prickly pear)**	Succulent shrub	North & Central America	Negligible
Opuntia ficus-indica **(mission prickly pear)**	Succulent tree or shrub	Central America	Substantial
Opuntia humifusa **(large-flowered prickly pear)**	Succulent low shrublet	North America	Complete
Opuntia monacantha **(drooping prickly pear)**	Succulent shrub or tree	South America	Complete
Opuntia salmiana **(bur cactus)**	Succulent shrub	South America	Substantial
Opuntia spinulifera **(large round-leaved prickly pear)**	Succulent shrub	Central America	Not determined
Opuntia stricta **(Australian pest pear)**	Spiny succulent shrub	North America & Caribbean	Substantial
Paraserianthes lophantha **(stink bean)**	Tree	Australia	Substantial
Parthenium hysterophorus **(famine weed)**	Annual shrub	Caribbean	Not determined
Peniocereus serpentinus **(serpent cactus)**	Succulent shrub	Mexico	Not determined
Pereskia aculeata **(Barbados gooseberry)**	Spiny shrubby to clambering vine	South America & Caribbean	Not determined
Pistia stratiotes **(water lettuce)**	Free-floating aquatic herb	South America	Complete
Prosopis **species (mesquite)**	Tree	North & Central America	Negligible
Salvinia molesta **(water fern)**	Free-floating aquatic fern	South America	Complete
Sesbania punicea **(red sesbania)**	Shrub	South America	Complete
Solanum elaeagnifolium **(silverleaf bitter apple)**	Herbaceous shrublet	North, Central & South America	Substantial
Solanum mauritianum **(bugweed)**	Tree	South America	Negligible
Solanum sysimbriifolium **(wild tomato)**	Spiny low shrub	South America	Substantial
Tecoma stans **(yellow bells)**	Tree	North & Central America	Not determined

Effectiveness of mass-rearing facilities. In some cases biological control agents do not disperse quickly or it takes time for populations to build up. In order to expedite control, agents are mass-reared. Mass-rearing involves the establishment of a breeding facility, and a programme of targeted distribution of agents to field-sites. Until the mid-1990s, South African researchers conducted or oversaw most aspects of biological control, including mass-rearing, field releases and post-release monitoring. This often worked well, with a relatively high rate of establishment of agents, but for some agents (e.g. *Pareuchaetes* species on *Chromolaena odorata*, triffid weed) establishment could only be achieved by large-scale mass-rearing which was beyond the capacity of research organisations. Furthermore, with an increase in the amount of invasive plant control work following the initiation of the Working for Water (WfW) programme in 1995, the demand for agents from stakeholders increased substantially. An 'implementation' programme, embedded within WfW, was set up in the late 1990s and early 2000s (Gillespie, Klein & Hill 2004), with the aim of mass-rearing, field collection for redistribution, releases and basic monitoring of the establishment and spread of agents. Several mass-rearing centres were set up around the country, the existing insect-rearing facilities at the South African Sugarcane Research Institute (SASRI) were contracted, and implementation officers were employed. Interaction between researchers and implementers was encouraged, and facilitated by the annual 'Weed Biological Control Workshops' that have been held since the 1970s (Moran, Hoffmann & Zimmermann, 2013).

The mass-rearing programme has had mixed success, with several centres failing due to funding issues; a lack of biological control expertise at the mass-rearing centres; implementation officers being co-opted into non-biological control activities; and a lack of structured cooperation and feedback loops between researchers and implementers (e.g. on which agents to mass-rear, numbers to be released, or under what circumstances to make use of biological control). Often, an inadequate distinction was made between agents that were still at an experimental phase (i.e. their establishment or efficacy was not yet proven) and agents that had already been shown to be effective but needed further redistribution. Nevertheless, the implementation programme has substantially increased the number of biological control releases in the country, the number of plants with active biological control implementation programmes in operation, and has presumably improved the level of control for many invasive plant species. Recently, quarterly meetings between researchers and implementers, and increased field interactions have closed the perceived gap between research and implementation further.

6.3.3. Invasive species management programmes

The NEM:BA (Act 10 of 2004) requires [section 75 (4)] the Minister of Environmental Affairs to ensure the coordination and implementation of programmes for the prevention, control or eradication of invasive species. The Act also empowers [section 75 (5)] the Minister to establish an entity consisting of public servants to coordinate and implement programmes for the prevention, control or eradication of invasive species. The A&IS Regulations, published in 2014 under the NEM:BA state further (in Chapter 2) that "if an Invasive Species Management Programme has been developed in terms of section 75(4) of the Act, a person must control the listed invasive species in accordance with such programme". In many cases, the need for species-specific management programmes is clear, but neither the NEM:BA, nor the A&IS Regulations, provide guidance on which of the listed invasive species should be the subject of such a programme. The development of national-level, species-specific programmes for all listed species would be extremely onerous, and it has therefore been assumed that a start should be made with priority species. For example, Terblanche *et al.* (2016) stated that "in view of the urgent need to develop guidelines and test approaches for such strategies, it was decided to develop a strategy for the invasive alien plant *Parthenium hysterophorus*". To date, a species-specific strategy has only been developed for *P. hysterophorus* (famine weed), a rapidly-spreading annual herb that poses significant threats to rangeland productivity, biodiversity and human health. Le Maitre, Forsyth & Wilson (2015) also used *Campuloclinium macrocephalum* (pompom weed) as an example for the development of guidelines for species-specific management programmes. These guidelines recommended different management approaches for municipal areas invaded at different densities by *C. macrocephalum*, similar to the proposals made for *P. hysterophorus*. In addition, two genus-level strategies have been published (one for *Acacia*, Australian wattles, Van Wilgen *et al.*, 2011, and one for *Prosopis*, mesquite, Shackleton *et al.*, 2017a). Around 70 species of Australian *Acacia* have been introduced to South Africa, and at least 14 are now known to be invasive across South Africa. Collectively, the genus *Acacia* is the most widespread invasive taxon in the country. Numerous *Prosopis* species were introduced into South Africa from the Americas, and now constitute a hybrid swarm involving many species, and they are also the second most widespread invasive plant genus in South Africa after *Acacia*. In addition, one family-level strategy (for Cactaceae, Kaplan *et al.*, 2017) has been published. The Cactaceae family in South Africa has 35 listed invasive species, 10 of which are targeted for eradication and 12 of which are under partial or complete biological control.

None of these strategies has been formally adopted or implemented to date, and no entities have been established, as provided for in law, to co-ordinate and implement them (though the aim of the National Cactus Working Group is to facilitate the implementation of the strategy, Kaplan *et al.*, 2017), so whether or not they are going to be effective cannot yet be determined. While there are often no formal species management programmes in place, there are still a variety of control measures in place (that are mostly not monitored and are often *ad hoc*). In the following sections, the management of different taxa are discussed in turn.

6.3.4. Management of invasive plants

The most comprehensive national-scale assessment at a species level to date was published by Henderson & Wilson (2017), based on data from the Southern African Plant Invaders Atlas (SAPIA). They reported that SAPIA contained records for 773 alien plant taxa that have established populations outside of cultivation South Africa. This was an increase of 172 taxa over the last assessment in 2006 (Henderson & Wilson, 2017). Between 2000 and 2016 there was also an approximately 50% increase in the broad-scale documented range of alien plants in SAPIA. The invasive species *Campuloclinium macrocephalum* (pompom weed), *Parthenium hysterophorus* (famine weed), *Opuntia engelmannii* (small round-leaved prickly pear), *Cryptostegia grandiflora* (rubber vine), *Pennisetum setaceum* (fountain grass), *Tecoma stans* (yellow bells), *Sagittaria platyphylla* (delta arrowhead), *Gleditsia triacanthos* (honey locust) and *Trichocereus spachianus* (Torch cactus) were considered to be of particular concern, as they had increased substantially in distribution over the past decade. Henderson & Wilson (2017) reported further that approximately 126 taxa were targeted for clearing by the DEA's Natural Resource Management (NRM) programmes between 2000 and 2012. Most of this effort was directed towards eight taxa: *Solanum mauritianum* (bugweed), *Acacia mearnsii* (black wattle), *Prosopis* spp. (mesquite), *Acacia dealbata* (silver wattle), *Pinus species* (pine trees), *Cereus jamacaru* (queen of the night), *Lantana camara* (lantana) and *Eucalyptus* species (gum trees). Examination of the data suggested that whether a species was targeted by NRM for control or not made little difference, as both targeted and neglected species continued to spread at comparable rates. Henderson & Wilson (2017) concluded that this outcome was perhaps not surprising, given the lack of evidence of a general strategic approach to NRM's activities, and the absence of dedicated strategic efforts to contain specific invasive plants, or to reduce the rate at which they invade particular areas. By contrast, they found a clear signal that biological control had reduced rates of spread of several important invasive alien plant species.

A species-specific study on the integrated control of *Hakea sericea* (silky hakea) was conducted in the Western Cape Province by Esler *et al.* (2010). This study focussed on the history of measures to control the invasive Australian shrub *Hakea sericea*, which included a combination of felling and burning, augmented by biological control. Based on data from two surveys, 22 years apart, it was reported that the overall distribution of the species was reduced by 64%, from ~530 000 to ~190 000 ha between 1979 and 2001. The species either decreased in density, or was eliminated from 492 113 ha, while it increased in density, or colonised 107 192 ha. It was concluded that the initial mechanical clearing, integrated with the judicious use of prescribed burning, in the 1970s and 1980s by the then Department of Forestry was responsible for reducing the density and extent of infestations, and that biological control was largely responsible for the failure of the species to re-colonize cleared sites, or to spread to new areas following unplanned wildfires. Between 2000 and 2015, *Hakea sericea* increased its occurrence in quarter degree grid cells from 77 to 85, an increase of 10% (Henderson & Wilson, 2017). During the same period, the ecologically similar pine trees (*Pinus pinaster*, cluster pine and *P. radiata,* Monterey pine), for which no biological control is available, increased from 85 to 108, and from 70 to 95 QDGCs, or 27 and 21% respectively.

THE SITUATION

Other than for biological control, attempts to contain invasive alien plants have not prevented their ongoing spread

6.3.5. Management of invasive freshwater fish

South Africa has a long history of alien fish introductions for the enhancement of recreational and commercial fisheries. At least 58 fish species are known to be either alien in South Africa or indigenous to part of the region but introduced by humans to other parts of the country. This has resulted in at least 18 species of alien freshwater fishes having established self-sustaining populations in South Africa. At least some of these species (for example bass, trout and catfish) are important for recreational and commercial fisheries. Alien freshwater fish do, however, have important negative impacts on indigenous biota through predation, competition, habitat alteration, disease transfer and hybridisation (Richardson *et al*., 2011b), and management would be needed to reduce these impacts.

Despite the need for management, very little has been done. Managing invasive fish without harming other indigenous biota is often not possible, and there are conflicting opinions about the need for, and desirability of, control interventions. Feasible management goals could include: (1) the extirpation of alien fish from waterbodies, streams or rivers where possible and desirable; (2) the prevention of spread of species to uninvaded areas; and (3) the early detection of new incursions (with the latter requiring the ongoing monitoring of populations that have either not established or are not currently known to pose a substantial threat) (Woodford *et al.*, 2017).

Micropterus dolomieu (smallmouth bass) was extirpated from the Rondegat River in the Western Cape Province. To date, this has been the only successful complete removal of an invasive alien freshwater fish from a natural ecosystem. The Rondegat River is a tributary of the Olifants River. Smallmouth bass had invaded the lower reaches of this tributary, where they impacted negatively on indigenous fish populations. Smallmouth bass were prevented from occupying the upper reaches by a barrier waterfall, above which indigenous fish populations survived. Crucially, there was also a weir in the lower reaches that prevented re-invasion from the Olifants River if extirpation succeeded. The project employed international best practice in piscicide treatment (Impson, Van Wilgen & Weyl

2013). The target area was treated on 28 February 2012 by dispensing the piscicide rotenone, which was then de-activated immediately downstream of the weir using potassium permanganate. All fish in the treatment area died within 2 hours of treatment, whereas sentinel bass below the de-activation station survived the treatment, indicating a successful de-activation of the rotenone outside of the target area. According to standard operating procedure, a second treatment was conducted on 13 March 2013, and no further bass were collected, indicating that the prime objective had been met. During the 2013 treatment ~3000 young-of-year (< 10 cm) indigenous fishes were collected from the treatment area, including Clanwilliam yellowfish, fiery and Clanwilliam redfins and Clanwilliam rock catlets. These fish were absent from the treatment area prior to bass removal and their presence one year later suggested that a large number of indigenous fishes were previously consumed by bass, and also that indigenous fishes were likely to rapidly recolonize areas where bass were eradicated. Preliminary results of monitoring aquatic invertebrate community response to the rotenone treatment indicated that invertebrate biomass and diversity was also recovering rapidly after treatment. The total cost of the project was ~ ZAR 3.8 million (Impson, Van Wilgen & Weyl 2013).

In terms of recreational trout angling on rivers, many areas managed by the Cape Piscatorial Society (CPS) are located on provincial protected areas and in mountain catchment areas where trout have a long history of establishment. Angling activities on these rivers are currently managed by the CPS based on an agreement made in 1992 and an amended agreement in 2008. This agreement has since lapsed and a new agreement is in the process of being negotiated between CapeNature and the CPS. As the trout populations of interest to the CPS and most other angling clubs are largely self-sustaining, very few applications have been received since 2010 for the stocking of rivers. Such applications have included the Hex River, which is stocked every 2–3 years with a small number of hatchery-bred trout to maintain a viable recreational fishery in the river.

Ellender *et al.* (2014) have reported that continued stocking of trout has resulted in heavy criticism from conservationists, including references to anglers as 'eco-terrorists' and calls to review legislation to halt the spread of trout and rehabilitating invaded areas through the local eradication of trout. These views were reflected in the proposed regulations under NEM:BA, and have been fiercely contested through public and political lobbying by angling organisations. This included opposition to a project intending to remove alien fishes from four rivers (including the Rondegat River project described above) to allow for the recovery of indigenous fish populations (Marr, Impson & Tweddle 2012; Weyl *et al*., 2014); challenging 2013 and 2014 revisions of the NEM:BA A&IS Regulations as unconstitutional and challenging the status of trout as an invasive species. The trout lobby is gaining momentum, and in 2013 interested parties including legal practitioners, university academics, recreational anglers, trout hatcheries and the tourism industry, discussed the formation of a new action group to lobby against the A&IS Regulations, which they perceive as restrictive. This situation is regarded as unfortunate (Ellender *et al*., 2014) because the NEM:BA A&IS Regulations point towards a mutually beneficial strategy, conserving indigenous biodiversity in key areas while allowing for fisheries development in others.

6.3.6. Management of invasive mammals

Alien mammals that have been listed as invasive species include *Sus scrofa* (feral pig), *Hemitragus jemlahicus* (Himalayan tahr), *Capra hircus* (goat), several species of deer, *Mus musculus* (house mouse), *Rattus norvegicus* (brown rat) and *Rattus rattus* (House rat). There are also 17 African mammal species that are listed, as a result of concerns about potential hybridisation with indigenous species, or ecological impacts. *Felis catus* (domestic cat) is listed as a candidate for eradication on offshore islands, while *Canis lupis familiaris* (domestic dog), *Equus ferus caballus* (horse), and *Equus asinus* (donkey), all of which have established feral populations, are not currently listed as they are important as pets or have other utility value.

Eradication projects aimed at the Himalayan tahr on Table Mountain and the domestic cat on Marion Island are covered in section 6.3.1. Besides these two projects, there have been very few attempts to control other invasive alien mammal species. Available information is summarised below.

An attempt has been made to remove domestic cats from Robben Island. De Villiers *et al.* (2010) reported that 61 cats were shot or trapped and removed in 2005. At the end of the removal period, it was estimated that the number of cats remaining on the island was at least equal to the number that had been removed. Between 1 March and 31 August 2006 a further 95 cats were killed, taking the population down to an estimated 12–15 cats. Following the cat removal programme in 2006, there was an apparent increase in the population of *Oryctolagus cuniculus* (European rabbit) and the highest estimate of rabbits was made in November 2008. By February 2009, rabbit numbers had decreased considerably and this was attributed by De Villiers *et al.* (2010) to reduced food availability following the 2008 population explosion. Nevertheless, during 2009 rabbit numbers remained higher than they had ever been before November 2008. De Villiers *et al.* (2010) concluded that single-species eradication programmes could have devastating impacts on the island's ecology, and recommended that a thorough risk assessment be carried out and a holistic management strategy, rather than a single-species approach, be formulated.

A feral pig management programme has also been implemented in the Western Cape Province. An integrated approach was used, which employed a variety of methods including educating landowners and creating awareness, detection using cameras, trap cages and hunting. The intention was to use lessons learned from two pilot sites (Porseleinberg and Kasteelberg) in the implementation of further control projects in other affected areas. Currently the outcomes of the project are reported on a quarterly basis, and CapeNature intends to produce a guide for landowners on how to control feral pigs, which will include lessons learned from the pilot project. There have been no scientific publications on this project, but records indicate that 1 209 feral pigs have been killed to date, and that the population at Kasteelberg is coming close to extirpation.

6.3.7. Management of invasive herpetofauna

There are no examples of alien herpetofauna introduced to South Africa becoming invasive, but there are several indigenous species that have either expanded their ranges or have been translocated to new environments in South Africa ("extralimital" species). An attempt to eradicate the guttural toad is covered in section 6.3.1 above. There has also been an attempt to reduce the populations of the translocated common platanna (*Xenopus laevis*) which threatens an endemic and endangered Cape platanna *X. gilli* in the Table Mountain National Park (De Villiers *et al.*, 2016). Earlier management attempts had been terminated, but were re-instated in 2010, and formally adopted by the National Park's management in 2012. *X. laevis* control is now mandated in the annual Plan of Operations for the park's Cape of Good Hope section, and ongoing removal though seine netting is done annually. Evidence shows that management of *X. laevis* is beneficial and it aids population stability of the endemic and endangered *X. gilli*.

6.3.8. Management of invasive invertebrates

There are many introduced invertebrate species in South Africa, but there is no comprehensive list of these (though see Janion-Scheepers *et al.*, 2016, for information on alien species in some groups of soil organisms). Prinsloo & Uys (2015) provided detailed accounts of 693 insect pests of cultivated plants and pastures in South Africa; of these, 101 (14.6%) were alien species. Most of the known alien species are pests on agricultural crops, and there are many examples of successful control in the agricultural environment. The extent to which alien invertebrate species have been able to invade natural ecosystems in South Africa is however poorly understood. There are also only a few examples of control measures that have been implemented against invasive alien invertebrate species that impact on natural ecosystems rather than agricultural crop systems.

Attempts to control spread of the invasive European paper wasp (*Polistes dominula*) in the Western Cape Province are under way, and it is also being removed where it is found in the Cape Town Metropolitan areas, although this has no had measurable effect. Several contractors have been trained for nest destruction, but eradication is not considered possible, and the species is still spreading. The geographical range of the German wasp (*Vespula germanica*) is now well documented and destructive sampling has been carried out since 2014. Thus far approximately 110 nests have been destroyed between 2014 and present. Several contractors have been trained for nest destruction, and it is hoped that the species can be eradicated with three more years of constant nest destruction.

6.4. AREA-SPECIFIC CONTROL MEASURES

Control measures aimed at reducing the combined impacts of several co-occurring invasive species in a given area can be implemented in any land parcel, but in terms of the NEM:BA A&IS Regulations, management authorities of protected areas and organs of state in all spheres of government must prepare "Invasive Species Monitoring, Control and Eradication Plans" and submit those plans to the Minister of Environmental Affairs and to SANBI within one year of the publication of guidelines (the published guidelines are available at www.environment.gov.za/sites/default/files/legislations/nemba_invasivespecies_controlguideline.pdf). Given that municipalities cover the entire country, and are regarded as organs of state, all land parcels across the entire country should be covered by at least one management plan, and the level of compliance with this regulation is discussed further in Chapter 7. However, it is widely recognised that there has been a general lack of effective planning (Downey, 2010; Van Wilgen & Wannenburgh, 2016), and that this remains a key weakness in the management of biological invasions in South Africa. In the absence of plans, and their associated management goals and monitoring programmes, any assessment of the effectiveness of control measures that specifically target particular areas has to be based on a small (but growing) number of case studies that have assessed management effectiveness at the scale of individual protected areas, catchments, or farms. This section provides an overview of available case studies in this regard.

6.4.1. Assessment of effectiveness at a national scale

In 2004, Marais, Van Wilgen & Stevens (2004) reported that good progress had been made with clearing certain species (at a cost of ~ ZAR2.3 billion between 1996 and 2004, unadjusted for inflation), but also that at current rates of clearing, many other species would not be brought under control within the next half century. They stressed that their estimates were preliminary, given the incomplete data on the project management system, and should be treated as such. In 2012, Van Wilgen *et al.* (2012) reported that control operations were in many cases only applied to a relatively small portion of the estimated invaded area (2–5% depending on the species), despite substantial spending (ZAR 3.2 billion in 2012 values). Despite these efforts, invasions appeared to have increased, and remain a serious threat in many biomes (Henderson & Wilson, 2017).

6.4.2. Assessments of control effectiveness at finer scales where information is available

The effectiveness of control measures in a particular area (for example a protected area, a catchment area, a farm, or a stretch of river) would need to be assessed against the intended goals of the measure. In addition, the assessment should be based on regular monitoring of outcomes. Almost all area-based control measures are aimed at alien plant species, and most have the goal of reaching a "maintenance level", although this goal is seldom explicitly stated (Van Wilgen *et al*., 2016a; Fill *et al*., 2017). The concept of a maintenance level recognises that, for many invasions, eradication is infeasible, but that they can be reduced to a level where the negative impacts are negligible and control costs are relatively low in perpetuity. This was defined by Goodall & Naude (1998) as "the systematic reduction of the major invasive alien plant species in defined tracts of land to a level where they no longer present a problem". In South Africa, as in many other parts of the world, the intended goals of control measures are predominantly not explicit. In the vast majority of South Africa's government-funded alien plant control projects, the indicators used to monitor progress and set targets include the amounts of money to be spent, the number of people to be employed, and the areas to be treated. These are input or output indicators, rather than outcomes in terms of changes in the levels of plant invasions. In the absence of a monitoring programme that is focussed on outcomes, it is difficult to assess effectiveness objectively. However, several studies have been conducted, particularly over the past decade, in which the effectiveness of management has been assessed, and these are presented and summarised here in chronological order. These studies provide a limited basis from which to derive broad conclusions about the effectiveness of control measures.

Alien plant control in the Cape of Good Hope Nature Reserve, Western Cape Province, 1941-1987 (Macdonald, Clark & Taylor 1989). The Cape of Good Hope Nature Reserve is a fynbos shrubland area now incorporated into the Table Mountain National Park. It was historically heavily invaded by alien trees and shrubs, and control operations started in 1943. These proved to be almost totally ineffective for at least the first 35 years; no systematic control strategy was implemented, follow-up and control was inadequate to prevent re-establishment of felled thickets and the supervision of control teams was deficient. Linkage of control operations to firewood production was a significant factor in this failure. In 1974 a 10-year control strategy was drawn up and later began to be effectively implemented. Surveys of 40 plots in the centre of the reserve in 1966, 1976–1980 and 1986 showed increasing densities of species other than the easily controlled *P. pinaster* up to 1976–1980. Since then almost all individual alien plants taller than 1.8 m in height were eliminated and indications from smaller height classes are that seed banks were depleted. This study provided an early indication of the value of a strategic approach to alien plant control.

Management of Prosopis *species (mesquite) in the Northern Cape Province* (Van den Berg, 2010; Wise, Van Wilgen &Le Maitre, 2012; Van Wilgen et al., 2012). Trees in the genus *Prosopis* (mesquite) were introduced to provide a source of fodder for livestock in the arid areas of South Africa. They later became invasive, spreading over large areas and causing many negative impacts. Historical estimates for the rate of spread of *Prosopis* trees in South Africa ranged from 3.5 to 18% per year, which implied that the invaded area could double every 5 to 8 years. In the Northern Cape, the estimated total invaded area increased by almost a million hectares between 2002 and 2007, which is equivalent to 27.5% per year, and this occurred at a time during which ZAR 390 million (2012 values) was spent on control. Overall, it was concluded that estimated control costs would exceed the financial capabilities of Public Works programmes, and that more effective control methods, such as biological control, would be needed to prevent substantial

INPUTS TO CONTROL

The amount spent by the DEA per year on control operations is at least **R1.5 BILLION** economic losses. A more recent update (R.T. Shackleton unpublished data) found that the public works clearing projects had treated 203 000 ha of the area invaded by *Prosopis* between 2000 and 2015 (clearing consisted of an initial clearing and three follow-up clearings, on average, to remove seedlings). The cost of these measures amounted to ZAR 1.8 billion (R 4.2 billion expressed in 2016-value ZAR, or over ZAR 2000/ha treated) over the same period. The project started in 1995, but cost estimates prior to the year 2000 are not available. These figures also excluded the cost of researching and introducing the three biological control agents, as well as private landowner control costs which averages around ZAR 21 000 per farm per year (Shackleton, Le Maitre & Richardson 2015). Between 2000 and 2016, *Prosopis glandulosa*, and *Prosopis* hybrids increased their range from 40 to 112, and 390 to 481 quarter-degree grid cells, increases of 50 and 180% respectively (Henderson & Wilson, 2017), suggesting that substantial control measures were doing little to stop the spread of this damaging species.

Cost-effectiveness of alien plant clearing in the Krom and Kouga River catchments, *Eastern Cape Province* (McConnachie *et al.*, 2012). This assessment was carried out in the Krom (1 556 km^2) and Kouga (2 426 km^2) catchments in the Eastern Cape Province. It concluded that the cost to clear invaded land was 2.4 times higher than the highest equivalent estimate made elsewhere in South Africa. At rates of clearing at the time of the study, it would have taken between 54 and 695 years to clear the catchments, in the Krom and Kouga, respectively, assuming no further spread. By taking ongoing spread into account, it was apparent that current control measures would be inadequate, and invasions would most likely continue to spread in the catchments. The study also found significant inefficiencies in the form of inaccurate records, where 25% of the areas recorded as having been cleared had in fact not been cleared.

Historical costs and future scenarios for alien plant control in protected areas in the Cape Floristic Region (Van Wilgen *et al.*, 2016). This study sought to document the extent and costs of substantial control efforts in the Cape Floristic Region (CFR) over the past two decades, and to estimate the resources that would be needed to reduce the problem to a "maintenance level" at which it could be sustainably contained in perpetuity. Historical costs for control in CFR protected areas between 1996 and 2015 amounted to ZAR 564 million (2015 values). Predicting future control effectiveness required a number of assumptions to be made about the future funding levels, rates of spread, and the effort that would be required to bring alien plants down to a maintenance level. The study concluded that, for scenarios in which control measures continued against all invasive plant species, the estimated required funding to achieve the goal of reducing invasions to a manageable level was up to 4.6 times greater than the amount spent over the past 20 years. Under many plausible future scenarios (for example 8% spread and current or reduced funding) the invaded area would continue to grow, despite significant ongoing spending.

Effectiveness of alien plant clearing in the Berg River catchment in the Western Cape Province (Fill *et al*., 2017). This study assessed alien plant (mainly *Pinus* and *Acacia*) control activities in the Berg River catchment in the Western Cape Province. Control operations took place over 13 years, at a cost of ZAR 50 million (net present value in 2015 ZAR), and succeeded in greatly reducing the cover of alien plants, but not to a maintenance level. At the time of assessment, over 1000 ha still supported dense or medium invasions (> 25% cover), and the area occupied by scattered *Pinus* plants had increased by over 3000 ha to > 5 700 ha (Figure 6.2). While the project is ongoing, it was concluded that the entire area would revert to a more densely-invaded state in the event of a reduction of funding, given that a significant population of invasive plants of all species remained present in fairly large numbers. The study pointed to several factors that had contributed to inefficiencies, including the lack of a plan, a failure to integrate prescribed burning and mechanical clearing, a failure to co-ordinate high-altitude clearing with other operations, and the use of (relatively inefficient) hand tools instead of power tools.

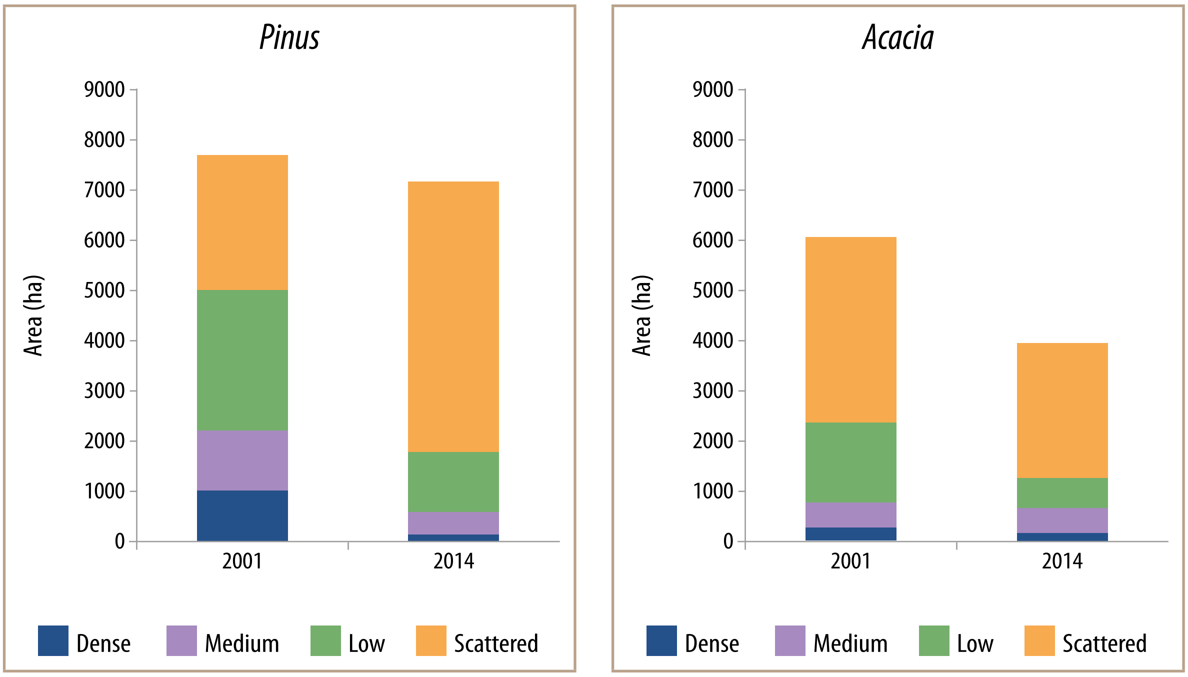

FIGURE 6.2 Area occupied by alien *Pinus* and *Acacia* trees at different levels of cover in the upper Berg River catchment at the initiation of a control project in 2001, and after 13 years of treatments in 2014. Cover levels are dense (> 50% cover), medium (26–50% cover), low (6–25% cover) and scattered (0.5–5.0% cover). Figure redrawn from Fill *et al*. (2017).

Alien plant control projects in the Hawequas Mountain complex in the Western Cape Province (McConnachie *et al*., 2016). This study took place in the Hawequas Mountain Fynbos complex, an area covering 1 451 km^2 in the south-western part of the Western Cape Province. The area had been subjected to alien plant control operations over several years, including the removal of abandoned pine plantations. Control reduced cover – it was estimated that the proportion of the area covered by invasive trees would have been almost 50% higher had there been no control. However, the costs were three to five times higher than the predictions made when the programme was initiated. It was concluded that control might have prevented a larger area from being invaded, if it had focussed all of its effort on untransformed land and not on abandoned plantations.

Efficiency of invasive alien plant management in the Garden Route National Park (GRNP), Western and Eastern Cape Province (Kraaij *et al*., 2017). The GRNP is situated along the southern Cape coast of South Africa between the Indian Ocean in the south and the watershed of the Outeniqua and Tsitsikamma Mountains in the north, extending over 152 500 ha of which ~78 000 ha comprises fire-prone fynbos shrublands and ~41 500 ha comprises Afrotemperate forest. The fynbos areas were substantially invaded by trees and shrubs in the genera *Acacia*, *Hakea* and *Pinus*. Invasive alien plant control operations had been active in the park since 1995. The study set out to assess the efficiency of alien plant management practices in the field. Parts of the GRNP have a long history of alien plant control operations, but comprehensive strategic planning, prioritisation and improved monitoring had only recently been initiated. The study sought to investigate the alignment of implementation with management plans, and the effectiveness of alien plant clearing practices in the field. The study found that, although detailed management plans were developed, implementation was poorly aligned with plans. The quality of many treatments was found to be inadequate, with work done to standard in only 23% of the assessed area. Problems encountered included a complete absence of treatment application despite payment of contractors (33% of assessed area); partial treatment of areas (38%), species (11%) or age classes (8%), leaving others untreated; use of inappropriate treatment methods (9%); and failure to adhere to treatment standards (7%). Accordingly, successive follow-up treatments largely did not reduce the cover of invasive plants. Field surveys and clearing records suggested that inaccurate (or lack of) infield estimation of cover prior to contract generation resulted in an erroneous estimation of effort required, and expenditure disparate with required norms. This study points to substantial inefficiencies in the application of control methods, and identified the need for rigorous, compulsory, infield assessment of invasive plant cover prior to contract allocation and assessment of the quality of treatments applied prior to payment of contractors.

Managing invasive plants on Vergelegen Wine Estates in the Western Cape Province (Van Rensburg, Richardson & Van Wilgen 2017). This study took place on the privately-owned Vergelegen Estate (5 332 ha) in the Hottentots Holland Mountain Range Basin near the town of Somerset West in the Western Cape. The area had become substantially invaded by trees and shrubs in the genera *Acacia*, *Hakea* and *Pinus*. Invasive plant control operations commenced in 2004, and the study assessed their cost and effectiveness over more than a decade. The assessment showed that the cover of dense invasive plants declined by 70% over the 10 years since management operations began (Table 6.3), but that operations cost 3.6 times more than was originally estimated (ZAR 43.6 vs 12.19 million respectively). The challenges associated with managing invasive plants on private land were very similar to those faced on state-owned land, with the efficiency of management being constrained by multiple interacting environmental and socio-economic factors. However, some success in managing the invasions was achieved by adhering to best practice approaches, including careful planning with clear achievable goals in mind, a commitment to stable long-term funding, and regular monitoring.

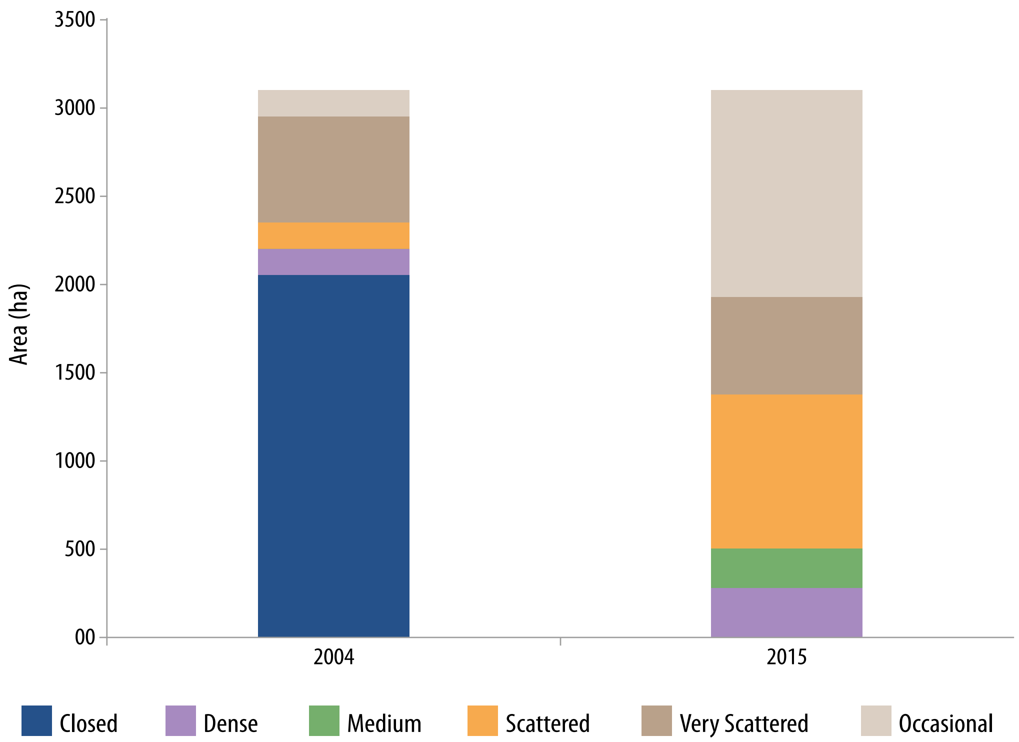

FIGURE 6.3 Area occupied by invasive plants in six cover classes at Vergelegen Wine Estates in 2004 and 2015. The classes are occasional (< 1% cover); very scattered (1–5% cover); scattered (5–25% cover); medium (25–50% cover); dense (50–75% cover); and closed (> 75% cover). Figure redrawn from Van Rensburg, Richardson & Van Wilgen (2017).

Alien plant control and ecosystem recovery along the Rondegat River in the Western Cape Province "(Fill, Kritzinger-Klopper & Van Wilgen 2017). The study took place along the Rondegat River, which flows in a north-westerly direction for 28 km from its source in the Cederberg Wilderness Area to its confluence with the Olifants River at the Clanwilliam Dam. The river was invaded by dense stands of alien trees, mainly black wattle (*Acacia mearnsii*), blackwood (*Acacia melanoxylon*) and gum trees (*Eucalyptus grandis*). A project to clear these invasive species was initiated in 2013. The study aimed to review the land-use practices both on the project site and on adjacent areas, and examine how they could affect the project's success over the long term. The assessment revealed recovery of indigenous riparian shrubs after clearing of dense stands of *Acacia mearnsii*, but also that grasses became dominant on cleared sites and in pastures. This study concluded that secondary invasions, especially by grasses, can have strong effects on ecosystem dynamics and that achieving the goals of restoration may therefore require additional active management.

Invasive plant control in the Kruger National Park (KNP), Mpumalanga and Limpopo Provinces (Van Wilgen *et al.*, 2017). The KNP is one of few protected areas in South Africa that has had a long history of controlling invasive species, particularly plants. Attempts to control alien plants in the KNP began in the mid-1950s, and expanded substantially in the late 1990s. The study sought to document the goals of alien plant management and the plans for achieving them; to identify the species targeted for control and the historical costs of their management; and to document and assess the effectiveness of the management interventions. This assessment reported that over ZAR 300 million had been spent on control interventions between 1997 and 2016. There was evidence of good progress with the control of several species, notably *Opuntia stricta* (Australian pest pear), *Sesbania punicea* (red sesbania), *Lantana camara* (lantana) and several invasive aquatic plant species, mainly because of effective biological control. On the other hand, over one third (38%) of the funding was spent on species that have subsequently been recognised as being of lower priority, most of which were alien annuals. The allocation of funds to non-priority species was sometimes driven by the need to meet additional objectives (such as employment creation), or by perceptions about relative impact in the absence of documented evidence. Management goals were also limited to inputs (funds disbursed, employment created) or outputs (area treated) rather than ecological outcomes, and progress was consequently not adequately monitored. The study recommended that funds should be re-directed to those species that clearly pose greater threats, and for which other solutions (such as biological control) are not an option.

Control of invasive Chromolaena odorata *(triffid weed) in the Hluhluwe-iMfolozi Park, KwaZulu-Natal Province* (Dew *et al.*, 2017; Te Beest *et al.*, 2017). This study took place in the 90 000 ha Hluhluwe-iMfolozi Park (HiP) in KwaZulu-Natal, South Africa. Infestations of *Chromolaena odorata* were first noticed in 1978, and increased to cover almost half of the HiP (40 000 ha) in 2003. After a substantial investment in control (ZAR 103 million in funding and 2000 person-years of effort), invasions were reduced to acceptably low levels by 2011 (Figure 6.4). A number of clear factors contributed to this success. They included ongoing direction from a diverse project steering committee (including managers, researchers, the private sector and community representatives), a rapid response team, a focus on areas of low infestation, a very flexible management approach, regular monitoring and generous funding. In addition, Te Beest *et al.* (2017) reported that "the team was only paid following completion of a contract and after a thorough inspection of the quality of the work by the Project Manager". These features of the HiP project are often in marked contrast to those associated with most other studies outlined above, and in all likelihood account for the differences in success. This work was, however, essentially a species management programme applied to a specific area, and the control of other invasive taxa was not documented.

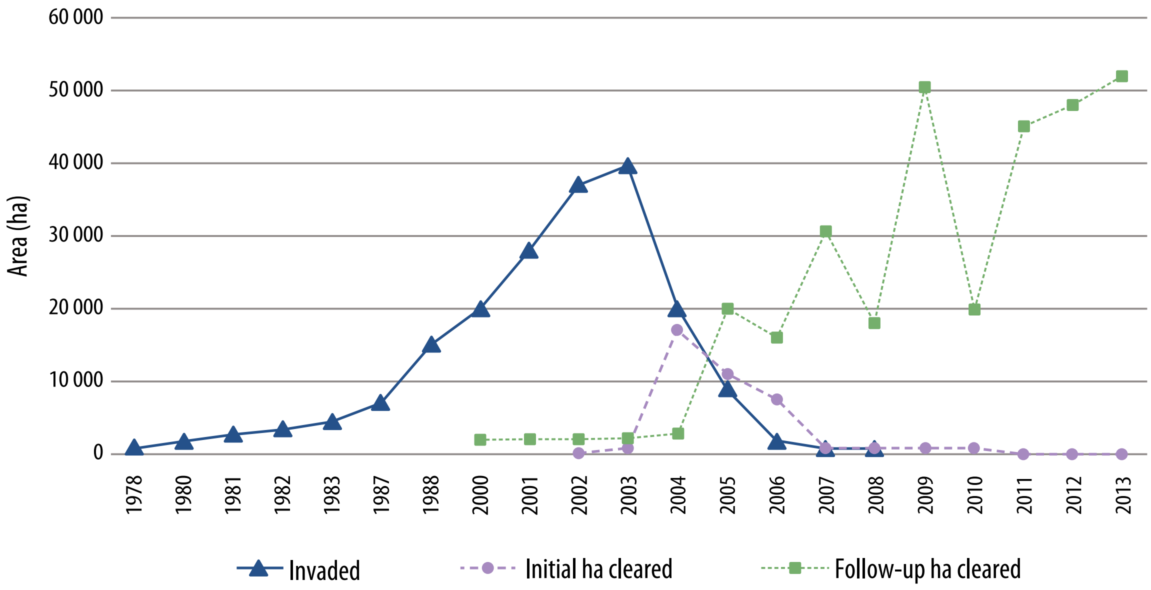

FIGURE 6.4 Area invaded by *Chromolaena odorata* in Hluhluwe-iMfolozi Park, and areas cleared and followed up between 2000 and 2013. Figure redrawn from Te Beest et al. (2017).

Control of invasive Chromolaena odorata *(triffid weed) in the Paradise Valley and Roosfontein Nature Reserves, KwaZulu-Natal Province* (Adam, Ngetara & Ramdhani 2017). This remote sensing study took place in the Paradise Valley and Roosfontein Nature Reserves in KwaZulu-Natal, each approximately 300 ha. It was estimated that control operations reduced the extent of invasions from 154 to 3 ha between 2010 and 2015. No further information was given, so the methods employed in control, and the cost of the operations is not known. Again this work was essentially a species management programme applied to a specific area, and the control of other invasive taxa was not documented.

6.4.3. Returns on investment from control measures

The economic costs of plant invasions, and the economic benefits of control, have also been the subject of a small number of studies in South Africa. The level of understanding of impacts and their economic costs is low, but estimates indicate that the cost of some impacts (lost water, grazing and biodiversity) is currently about ZAR 6.5 billion per annum, but could become much higher as invasions grow (De Lange & Van Wilgen, 2010). In the case of biological control of invasive plants, all studies have estimated very high returns on investment. By comparing the costs of biological control research and implementation to the benefits of restored ecosystem services, or avoided ecosystem degradation, and avoided ongoing control costs, biological control was shown to be extremely beneficial in economic terms, with estimated benefit:cost ratios ranging from 8:1 up to 3726:1 (Van Wilgen & De Lange, 2011).

In order to estimate a return on investment from past mechanical and chemical alien plant control measures at a national scale, it would be necessary to know both the historic cost of control, and the value of impacts avoided due to control. De Lange & Van Wilgen (2010) provided a crude estimate of the area that remained free of invasions due to all historic control efforts in South Africa, but because there were large assumptions in making this estimate, the level of certainty regarding the estimate is very low. The estimated value of potential ecosystem services (water, grazing and biodiversity) amounted to ZAR 152 billion annually (2008 ZAR values, De Lange &

Van Wilgen, 2010). Although an estimated ZAR 6.5 billion was lost every year due to invading alien plants, this would have been an estimated additional ZAR 41.7 billion per year had no control been carried out (as invasions would have been far more widespread). This indicates a saving of ZAR 35.2 billion every year due to the effects of historic control efforts, but little confidence can be placed in this estimate due to large and untested assumptions used in making the estimate. It does however suggest that, potentially, returns on investment into invasive species control projects could be very large.

At a finer scale, some studies have estimated returns on investment from catchment-scale alien plant control projects. Hosking & Du Preez (2004) conducted cost-benefit analyses at six sites (Tsitsikamma, Kouga, Port Elizabeth Driftsands, Albany, Kat River and Pott River), and concluded that "catchment management on all the sites carried out by the Working for Water Programme is inefficient", with benefit:cost ratios ranging between 0.03 and 0.75, which indicates a negative return on investment (though the benefits of job creation were not included). Van Wilgen *et al.* (1997) modelled the spread and effects of alien plants on streamflow in the 8 000 ha Berg River catchment (Western Cape), and concluded that such management would be "effective and efficient". They estimated that water could be delivered at a cost of 57 and 59 c/kl respectively, with and without the management of alien plants, indicating that such management would be cost-effective. The estimate was based on projected clearing costs of around ZAR 180 000 per year for initial clearing over ten years, and about ZAR 25 000 per year for maintenance thereafter (1997 values). Fill *et al.* (2017) subsequently reviewed the actual costs and effectiveness of control operations over the past 20 years in the catchment of the Berg River. Their study found that the cost of control had amounted to almost ZAR 50 million by 2015 (2015 values, 7.2 times greater than the net present value of costs estimated in 1997), and that although the cover of alien plants was greatly reduced, over 1 000 ha still supported dense or medium invasions (> 25% cover), and the area occupied by scattered *Pinus* plants had increased by over 3 000 ha to > 5 700 ha. It appears therefore that the projected efficiencies were not realised, both because the control costs were underestimated, and because control methods were not effectively applied (Fill *et al.*, 2017).

Finally, there have been several recent studies on the potential returns on investment from invasive plant control operations (Vundla *et a*l., 2016; Mudavanhu, Blignaut & Nkambule 2016; Morokong *et al*., 2016; Nkambule *et al*., 2017). These studies were conducted by ASSET Research, an African-initiated and led research and development platform (http://www.assetresearch.org.za/). The studies took place in the northern KwaZulu-Natal, Mpumalanga, Western Cape and Eastern Cape Provinces, where the economic viability of a range of management scenarios was modelled into the future. The scenarios included a range of rates at which invasive plants could spread in the future, as well as scenarios with and without the inclusion of value-added products derived from the processing of biomass from invasive plants, and with or without co-funding from the private sector. The results typically suggested that the inclusion of value-added products, and of co-funding, delivered higher, and positive, returns on investment, and that a "do nothing" scenario would deliver negative net present values. These studies suggest that the operations could be financially viable in future, if the underlying assumptions behind the models are valid. These assumptions included:

1. That clearing will continue into the future, and will be carried out effectively and professionally;
2. That co-financing will be available;
3. That there will be due compensation for the services rendered and the value-added products produced;
4. That the estimates of invaded area (derived from mapping exercises) are accurate; and,
5. That the resources required to complete the projects have been accurately estimated.

It is unlikely, however, that most or even all of the above assumptions hold. There is a low level of confidence in the mapping of plant invasions (see Box 5.1); the costs of control effort required are routinely under-estimated by 3–7 times (see above); alien plant control work is often characterised by low levels of efficiency; and the inclusion of value-added products could lead to unintended consequences (Box 6.3). There is consequently a low level of confidence in these predictions.

6.4.4. Negative impacts of control

The use of control measures are not without potential negative non-target impacts. These effects have not been assessed in this report, but should be a key component of future reports (Chapter 8).

6.5. SYNTHESIS AND INDICATOR VALUES

6.5.1. Overall effectiveness of control measures

This assessment of the effectiveness of control measures has highlighted a number of points. It would clearly be beneficial to gain control of invasive species because of the substantial economic costs that would accompany widespread, rampant invasions (Box 6.1). In recent years, the overriding source of funding for control measures was from the Working for Water programme within the Department of Environmental Affairs (Box 6.2). This public works programme has spent ZAR 12 billion (unadjusted for inflation) on invasive plant control projects between 1995 and 2012. However, this amount has only been enough for control teams to reach somewhere between 2% and 5% of the estimated extent of the most important invasive species, and consequently invasions continue to spread (Van Wilgen *et al*., 2012; Henderson & Wilson, 2017). Nonetheless, the fact that the Working for Water (WfW) programme exists, and is well-funded, is remarkable, especially for a developing country. There are significant opportunities for improvements to WfW (Box 6.2), some of these are summarised in the points below.

This assessment has highlighted that the biological control of invasive plants has been notably successful. The South African government, through the WfW programme, has continued to fund biological control research and implementation, with very encouraging results. Of the 60 invasive plant species or taxa targeted for biological control thus far in South Africa, 15 species are now under complete control, with a further 19 species under a substantial degree of control (Zachariades *et al.*, 2017). By combining biological and mechanical and chemical control, it has been possible to effectively reduce the populations of some of the most damaging invasive species, as appears to have been the case for *Hakea* and *Acacia* species in the Western Cape (Esler *et al.*, 2010; Moran & Hoffmann, 2012), and for *Lantana* and *Opuntia* species in the Kruger National Park (Van Wilgen *et al.*, 2017). The economic benefits of these interventions have been substantial, with estimated cost to benefit ratios indicating that, for every one ZAR invested into biological control, economic losses due to invasive alien plant invasions of between ZAR 8 and over ZAR 3 000 have been avoided.

A few eradication projects have been successful, and more are likely to follow in the near future. The number of species targeted for eradication is increasing, with several other assessments of eradication feasibility underway.

Several studies have also shown that control interventions have succeeded in reducing the extent of invasions in some areas. An early example of this was provided by Macdonald, Clark & Taylor (1989), who demonstrated that a properly planned and executed approach was able to substantially reduce populations of invasive alien trees and shrubs in the Table Mountain National Park. Concerted efforts to remove invasive pine trees (and other species) from fynbos ecosystems have resulted in marked declines in the density of these species in the Berg River Catchment (funded by WfW; Fill *et al.* 2017), and on the Vergelegen Estate (privately funded; (Van Rensburg, Richardson & Van Wilgen 2017). McConnachie *et al.* (2016) were similarly able to demonstrate that the invaded area in the Hawequas Mountains would have been almost 50% higher if there had been no control intervention. In savanna ecosystems, ongoing control has reduced the degree of invasion by a number of species (including *Opuntia stricta*, Australian pest pear, and *Lantana camara*, lantana, in the Kruger National Park (Van Wilgen *et al.*, 2017) and *Chromolaena odorata*, triffid weed, in the Hluhluwe-iMfolozi Park (Dew *et al.* 2017; Te Beest *et al.* 2017). Thus, at a local scale, some control measures have demonstrably been effective.

However, despite the expenditure of at least ZAR 12 billion (over 20 years, unadjusted for inflation), and the localised successes outlined above, plant invasions have nonetheless generally continued to grow, some substantially (see Henderson & Wilson, 2017; and the discussion in Chapter 4).

One of biggest problems impacting on the effectiveness of alien plant control measures in South Africa is the lack of adequate goal-setting and planning, accompanied by the monitoring of inputs rather than outcomes. A lack of clear strategic planning and goal-setting arguably leads to too many projects that are ineffective, rather than having fewer but more effective projects in agreed priority areas. Successive reviews of the Working for Water programme (in 1997, 2003, 2012 and 2014) have explicitly raised the concern of a lack of strategic planning (see Van Wilgen & Wannenburgh, 2016, for a review). Most alien plant control projects in South Africa have been given goals for the amounts to be spent, the number of people to be employed, and the areas to be treated. Monitoring of progress has a focus on these goals, and there are typically no goals that describe desired outcomes in terms of reducing plant invasions to manageable levels, what those manageable levels would be, and how long it would take to achieve them. In the absence of monitoring programmes that are focussed on these ecological outcomes, it is not possible to objectively assess management effectiveness. The absence of adequate planning and monitoring could be attributed to the requirement to minimise the costs per person-day (and thus maximise the number of people employed), which is a key target on which continued funding depends. This reduces the programme's ability to adequately invest in planning and monitoring, which would be relatively expensive and would increase the overall costs per person-day.

The existence of dual goals (ecological restoration and the creation of employment) is a double-edged sword. On the one hand, it is absolutely essential for the retention of the political support that ensures funding, but on the other it restricts the ability to focus funds where they are most needed for ecosystem restoration purposes. The achievement of employment and spending targets are relatively easy to understand, as is the target to treat a particular area. The target of an area to treat is not useful, however, as it provides no guidance on the purpose of treatment (for example to prevent erosion of, or to restore, vital ecological services), nor does it require the quality or effectiveness of the treatment to be recorded. The formulation of meaningful targets for ecosystem restoration, and a formal requirement to meet them, could alleviate this problem, but given the current set of measures it is all too easy for managers to meet their targets by simply creating employment and working anywhere to any standard.

Several studies have shown that the actual costs of alien plant control operations (be they publically or privately funded) are much larger than the estimated costs. Actual costs should be 100% of the estimated costs, but in a range of studies they were found to be 150–860% (McConnachie *et al.*, 2012); 300–500% (McConnachie *et al.*, 2016); 360% (Van Rensburg, Richardson & Van Wilgen 2017); and 720% (Van Wilgen *et al.*, 1997; Fill *et al.*, 2017, with the project still ongoing). These findings point to the complexity of effectively managing invasive plants, and the effort needed to address the issue, as well as to inefficiencies in the implementation of management.

Effective control of invasive species would require adherence to best practice methods where these are available. This has not always been the case, and has led to inefficiencies. For example, Macdonald, Clark & Taylor (1989) noted that the practice of linking alien plant clearing projects to the supply of firewood led to substantial inefficiencies. Fill *et al.* (2017) found that alien plant clearing operations in the Berg River catchment, Western Cape, failed to make adequate use of power tools, did not make any use of prescribed burning, and ran un-coordinated, separate projects to control plants in accessible and inaccessible areas, resulting in inefficiencies. The frequent failure to integrate biological control with mechanical and chemical control in many cases was outlined by Zachariades *et al.* (2017), with, in one case, millions of rands spent mechanically clearing *Cereus jamacaru*, a cactus species that is under complete biological control (Van Wilgen *et al.* 2012a). McConnachie *et al.* (2016) also noted that control success in the Hawequas Mountains would have prevented a larger area from being invaded if it had focussed all of its clearing effort on scattered plants in untransformed land, rather than on dense invasions and abandoned plantations. Some of these issues could be addressed by aligning plans with best practice, but others would require improved training of workers to higher levels of competency. For example, both the use of power tools and the setting of prescribed burns can be risky, and are currently avoided due to concerns for the safety of inadequately-trained workers and others.

The employment model currently used by public works programs can lead to substantial inefficiencies. The practice of issuing short-term contracts for clearing and follow-up (instituted as a developmental opportunity for disadvantaged contractors) requires cumbersome procedures to approve and implement, and results in delays to work schedules and late payments to intended beneficiaries, substantially diluting the intended social benefits (Ashton, 2012; Coetzer & Louw, 2012; Hough & Prozesky, 2012). It would arguably be better to employ fewer, better-trained, better-equipped personnel on a more permanent basis. The current model also does not allow for capacity to be built within the conservation authorities who are ultimately mandated to manage protected areas, and a scenario in which this funding is phased out, or channelled elsewhere, would leave the conservation agencies without embedded capacity and experience to manage invasions. However, other employment models are used. For example, Working on Fire, another in the suite of public works programs, requires beneficiaries that meet fitness standards, provides training to ensure adherence to work standards, and employs people on an annual contract basis, where they receive a regular, dependable wage.

Overall, there is a general concern among many stakeholders regarding the efficiency of government-sponsored alien plant control projects, but this is difficult to substantiate due to the scarcity of documented evidence. The findings of McConnachie *et al.* (2012), and Kraaij *et al.* (2017) that point to inefficiencies in the application of treatments, including non-treatment of areas, provides some evidence. Shackleton *et al.* (2016), in a survey of perceptions of managers, landowners, officials and academics, found that most landowners (> 80%) regarded the on-the-ground management as "poor", but few WfW managers (< 20%) regarded this as an issue. Shackleton *et al.* (2016) interpreted this as reflecting a view among managers that, as long as they created employment, they would have met their targets, regardless of environmental outcomes.

Conflicts over certain important invasive species can retard or prevent the implementation of effective control measures. For example, proposals to introduce biological control for invasive Australian *Acacia* species in the 1970s met with stiff resistance from the wattle industry because of their commercial value (Stubbings, 1977). This has since been overcome through the deployment of non-lethal, seed-feeding insects, but the problem remains for other groups of plants. The planned biological control of invasive *Pinus* species in South Africa, by introducing a cone-feeding weevil, led to concern over the weevil feeding on shoots and allowing fungal infection, with possible risk to commercial production (Lennox *et al.*, 2009). The biological control programme has therefore been discontinued, despite a substantial investment. Some of these issues may be impossible to solve, as illustrated by the case of proposed regulation of trout, described above.

Finally, negative non-target impacts of the control measures were not assessed in this report, but are vital if the true cost and benefit of control measures are to be understood.

Overall, therefore, the picture that emerges is that despite considerable investments, and some localised or technique-specific successes, control measures have by-and-large failed to reverse the spread of invasive species. It nonetheless remains true that there are significant opportunities to improve the effectiveness of control. Some authors have proposed an approach of "conservation triage" (Bottrill *et al.*, 2008), in which control measures focus on priority areas and species, and in which a trade-off between conserving biodiversity and reducing the extent of invasions is accepted.

6.5.2. Allocation of values to indicators of pathway management effectiveness

Inputs for the management of the pathways of introduction can be gauged from information on the money spent to prevent both intentional and unintentional introductions, as well as information on the pathways for which management plans have been developed. Information on the money spent is currently not available. A number of government departments are involved in managing pathways [e.g. Department of Environmental Affairs (DEA), Department of Agriculture, Forestry and Fisheries (DAFF), Department of Transport (DoT)], and obtaining a more meaningful estimate of the money spent would require data from all of the departments involved. Planning coverage can be determined based on the number of pathways that are currently managed and those for which plans have been developed but for which management is not yet in place. Of the 44 pathways of introduction (CBD subcategories, see Chapter 3), 20 involve the intentional import of organisms, while ten involve the accidental introduction of organisms as contaminants of imported commodities. There is currently legislation [e.g. National Environment Management: Biodiversity Act (Act No. 10 of 2004), Agricultural Pests Act (Act No. 36 of 1983), Animal Diseases Act (Act No. 35 of 1984)] and international agreements (e.g. IPPC) in place that aim to prevent the introduction of potentially harmful species through these pathways. There are 11 pathways involved in the accidental introduction of alien species as stowaways on transport vectors. Under international agreements and regulations (IPPC and International Health Regulations) wood packaging should be treated to prevent the spread of timber pests, and aircrafts should be sprayed to kill insect disease vectors (e.g. mosquitos). Cargo and passengers entering South Africa are also searched for alien organisms, and legislation to prevent the introduction of species through the release of ballast water by ships has been drafted. Therefore, five of the 11 stowaway pathways currently have management plans in place. As such we believe that 35 of the 44 pathways of introduction (79.5%) have plans in place for management, but as this assessment is solely based on the knowledge of experts, our confidence is low.

Outputs are gauged in terms of the number of pathways requiring management that are managed to some degree. We determined that all 44 pathways should require management. Although organisms may not have been introduced through some pathways, changes to socio-economic trends could lead to changes in the rate of introduction through the pathways. Currently, all pathways with management plans in place are managed to some degree, except ship/boat ballast water for which the legislation has not yet been passed. Therefore, 35 pathways of introduction (77.3%) are managed; 31.8% of the pathways have partial management, as interventions for pathways that involve the unintentional introduction of alien taxa are not in place at all ports of entry. As permits are required to import alien taxa, all pathways that involve the intentional introduction of alien taxa have complete management (45.4% of pathways). However, as this assessment is solely based on the knowledge of experts, our confidence is low.

Outcomes are gauged on recent changes to the rate of introduction, which are determined by comparing the rate of introduction in the last full decade (2000–2009) to that of the previous decade (1990–1999) (see Chapter 3 for details). One pathway of introduction ('landscape flora/fauna improvement in the wild) has permanent management (2.3%), as this pathway is no longer present and thus does not require ongoing management. Eight pathways (18.2%) are effectively managed as there have been no recent introductions or as the rate of introduction has declined. However, 17 pathways (38.6%) have no management (10 pathways) or management is ineffective (7 pathways), as there has been either a minimal change or an increase in the rate of introduction. The management effectiveness of 18 pathways (40.9%) is not known as there are either no introductions recorded, or the data appears to be inadequate. As this assessment is based on incomplete data and expert opinion our confidence is low.

The input indicator values for *money spent* are given in Table 6.5 across all activities (pathways, species, and areas). The other indicator values for control effectiveness for pathway management are given in Table 6.6.

TABLE 6.5 Values for the input indicator Money spent across all activities (pathways, species, and areas).

INDICATOR	VALUE			LEVEL OF CONFIDENCE	NOTES
14. Money spent (input)	**14.1.** Annual government expenditure ZAR 1 805 million/yr	**14.2.** Annual government expenditure on pathways, species and areas Pathways: No data Species: ZAR 55 million/yr Areas: ZAR 1 750 million/yr	**14.3.** Annual government and private sector expenditure on pathways, species and areas No data	**14.1.** Low **14.2.** Low **14.2.** N/A	The estimate of total expenditure does not contain the amount spent on control measures that focus on the pathways of introduction. 14. *Money spent* on species and areas are solely based on DEA funding for biological control and on public works funding by the DEA. Therefore, these are all underestimates.

TABLE 6.6 Values for indicators for control effectiveness of pathways

INDICATOR	VALUE			LEVEL OF CONFIDENCE	NOTES
15. Planning coverage (input)	**15.1.** Pathways that have management plans in place 79.5% of pathways have plans	**15.2.** Pathways that have management plans in place, with assessment of quality of management plans No data	**15.3.** As for 15.2, with priority rankings No data	**15.1.** Low **15.2.** N/A **15.3.** N/A	
16. Pathways treated (output)	**16.1.** Degree to which pathways are managed 77.3% of pathways are managed Not known: 0% None: 22.7% Partial: 31.8% Substantial: 0% Complete: 45.5%	**16.2.** Degree to which vectors within pathways are managed No data	**16.3.** As for 16.2, with assessment of quality of interventions No data	**16.1.** Low **16.2.** N/A **16.3.** N/A	Legislation to manage introductions through the release of ballast water has been drafted but has not been finalised
19. Effectiveness of pathways treatments (outcome)	**19.1.** Proportion of pathways in control effectiveness categories AND an assessment of any negative impacts of control Counter-productive: 0% Not known: 40.9% None/ineffective: 38.6% Partially effective: 0% Effective: 18.2% Permanent: 2.3% An assessment of the negative impacts of control has not been made	**19.2.** Pathways categorised by measurable outcomes AND a formal environmental and social assessment of non-target effects of the interventions No data	**19.3.** Returns on investment for pathway interventions AND non-target impacts as costs No data	**19.1.** Low **19.2.** N/A **19.3.** N/A	Of the pathways classified as having effective management some have not facilitated the introduction of a new taxon for many years (before the implementation of control measures), therefore, socio-economic trends (e.g. fur farming) could be playing a more important role

6.5.3. Allocation of values to indicators of species management effectiveness

Inputs for the management of particular species are either in the form of biological control (which uses host-specific biological control agents that target particular species), or eradication projects that target particular species. In terms of *money spent*, the Department of Environmental Affairs' Natural Resource Management Programmes currently provides ZAR 55 million/yr in support of biological control projects (Table 6.5). There are other sources of funding (for example from the budgets of the Agricultural Research Council's Plant Protection Research Institute, and from participating universities), but information about these is not readily available. In addition, records of funding for species-specific eradication projects are not readily available, so the estimate of ZAR 55 million/yr is almost certainly an underestimate.

In terms of control expenditure per species, available data at a national scale are restricted to a single study that covers expenses up to 2008 (Van Wilgen *et al.*, 2012b). An extract from this study reads as follows: "The largest portion of funding (561.9 million rands) was spent on the control of *Acacia mearnsii*. If this is added to the costs associated with the closely-related wattle species *Acacia dealbata* (cost of 79.3 million rands), the costs of control of these two species accounted for 19.4% of the costs of all alien plant control. A total of 435.5 million rands was spent on the next most-targeted taxon (*Prosopis* species), while 237.0 and 183.5 million rands were spent on *Eucalyptus* and *Pinus* species respectively. The remaining taxa in the top 10 (and costs of control in millions of rands) were *Lantana camara* (180.6), *Chromolaena odorata* (171.8), *Solanum mauritianum* (121.5), *Hakea* species (69.0) and *A. cyclops* (58.0)". Other relatively recent studies have quantified the costs per species for limited areas. For example, Van Wilgen *et al.* (2016) reported that historical control costs in the protected areas of the Cape Floristic Region amounted to ZAR 564 million (2012 rands), most of which (90%) was expended on the genera *Acacia*, *Pinus* and *Hakea* in that order. In the Kruger National Park, Van Wilgen *et al.* (2017) reported that ZAR 350 million had been spent on invasive alien plant control up to 2015. The following species received most funding: *Lantana camara* (lantana, ZAR 66.6 million), *Ricinus communis* (castor oil plant, ZAR 36.7 million), *Xanthium spinosum* (spiny cocklebur, ZAR 27 million), *Argemone mexicana* (yellow-flowered Mexican poppy, ZAR 18.3 million) and *Chromolaena odorata* (triffid weed, ZAR 11.8). The largest amount spent on a single taxon to date is the estimated ZAR 1.8 billion for *Prosopis* species (mesquite) in the Northern Cape Province up to 2016 (R.T. Shackleton unpublished data), although this is probably exceeded by the total amount spent on *Acacia mearnsii* (black wattle). There is, however, no comprehensive recent assessment of expenditure per species at a national scale.

Planning coverage can be gauged in terms of the five available invasive species management programmes (see section 6.3.3 above). In addition to the two species covered: *Parthenium hysterophorus* (famine weed), and *Campuloclinium macrocephalum* (pompom weed), plans are available for the genera *Acacia* (14 species listed in the A&IS Regulations) and *Prosopis* (2 species listed) and for the family Cactaceae (35 species listed). These 53 species are 9.5% of the 556 invasive taxa listed in the NEM:BA A&IS Regulations. Based on the fact that four out of five of these plans have been peer-reviewed and published, 80% can be regarded as adequate (Section 6.6.3).

Outputs are expressed as the number of species requiring management that are actually managed to some degree. Of the 556 taxa listed in the NEM:BA A&IS Regulations, 136 (24.3%) are managed to some degree (i.e. funds have been expended on their control), most (126 species) are plants. Management operations only reach a very small proportion (~1% every year) of the total area invaded by each species, however. In terms of categories of management, only invasive plants targeted for biological control are known to be under substantial or complete control (Table 6.4). For most other regulated taxa there are few examples of species under active management, and most species are not managed at all, or the degree of management is not known. The level of confidence in these estimates is low, given the low confidence in the records of extent of management (Table 6.7).

TABLE 6.7 Number of regulated alien species within higher-level taxa in different categories of management effort and effectiveness. Species which have been eradicated are not included.

TAXON	EXTENT TO WHICH NATIONAL POPULATION IS MANAGED (number of species in categories of management effort and effectiveness)				TOTAL NUMBER OF SPECIES
	NOT KNOWN OR NOT MANAGED	PARTIAL	SUBSTANTIAL	COMPLETE	
Amphibians	6	1	0	0	7
Birds	23	1	0	0	24
Fish	13	2	0	0	15
Invertebrates	29	3	0	0	32
Mammals	38	3	0	0	41
Marine species	21	0	0	0	21
Microbial species	7	0	0	0	7
Reptiles	30	0	0	0	30
Terrestrial and freshwater plants	253	92	19	15	379
Total	420	102	19	15	556
Proportion (%)	75.6	18.3	3.4	2.7	100

Outcomes are gauged in terms of the level of control achieved for each species. Of the 556 listed taxa, 36 (6.4%) have either been eradicated or brought under complete or substantial biological control (Table 6.4). For most other species, however, ranges continue to expand. Returns on investment into species-specific control interventions have been excellent for biological control (where benefit:cost ratios between 8:1 to 3000:1 have been achieved), but this applies only to a small percentage of all species.

The input indicator values for money spent are given in Table 6.5 across all activities (pathways, species and areas). The other indicator values for control effectiveness for species management are given in Table 6.8.

TABLE 6.8 Indicators for control effectiveness for species

INDICATOR	VALUE BASIC		ADVANCED	LEVEL OF CONFIDENCE	NOTES
15. Planning coverage (input)	**15.1.** Species that have management plans in place 9.5% of species have plans	**15.2.** Species that have management plans in place, with assessment of quality of management plans 80% of species plans adequate; 20% partially adequate	**15.3.** As for 15.2., with priority rankings No data	**15.1.** High **15.2.** Medium **15.3.** N/A	Plans developed for ~53 species (2 species, 2 genera and one family) out of 556 listed taxa. Four out of five taxon-specific plans covering 53 species published in the peer-reviewed literature
17. Species treated (output)	**17.1.** Proportion of regulated species subjected to management 24.3% of species are treated	**17.2.** Proportion of regulated species in categories of management coverage. Complete: 2.7% Substantial: 3.4% Partial: 18.3% None: 0% Not known: 75.6%	**17.3.** As for 17.2., with assessment of quality of individual interventions No data	**17.1.** Low **17.2.** Low **17.3.** N/A	136 out of out of 556 listed taxa have some management. Most (126) are plants.
20. Effectiveness of species treatments (outcome)	**20.1.** Proportion of species in control effectiveness categories AND an assessment of any negative impacts of control Counter-productive: 0% Not known: 20.4% None/ineffective: 73% Partially effective: 4.9% Effective: 0.9% Permanent: 0.8% An assessment of the negative impacts of control has not been made, except for biocontrol agents, where no significant impacts have been noted	**20.2.** Species categorised by measurable outcomes AND a formal environmental and social assessment of non-target effects of the interventions No data	**20.3.** Returns on investment for species interventions AND non-target impacts as costs Benefit:cost ratios between 8:1 to 3000:1 for biological control These do not include any costs of non-target impacts, though none are known.	**18.1.** Low **18.2.** N/A **18.3.** Low	Ranges of most species expanding at present, except where under biological control All unlisted species (1 507 species, or 73% of all alien species) assumed to be unmanaged. The effectiveness of management for the remainder is unknown. Benefit:cost ratios for species under biocontrol only (i.e. for 6.4% of listed species)

6.5.4. Allocation of values to indicators of area management effectiveness

Inputs for the management of particular areas are mainly in the form of invasive plant control operations in catchments, protected areas or on other land. In terms of *money spent*, the Department of Environmental Affairs' Natural Resource Management Programmes currently provides ZAR 1 750 million/yr in support of such projects (Table 6.5). There are other sources of funding (for example from provincial conservation agencies, municipalities and private landowners), but these are not readily available, so the estimate of ZAR 1 750 million/yr is almost certainly an underestimate. Expenditure on alien species control in particular areas is available for a limited number of areas (Table 6.9).

TABLE 6.9 Estimates of expenditure on alien species management in individual areas. Costs marked with an asterisk (*) are totals unadjusted for inflation and not net present values.

AREA	COST OF MANAGEMENT (NET PRESENT VALUE IN MILLIONS OF ZAR)	BASE YEAR FOR NET PRESENT VALUE	SOURCE
Protected areas in the Cape Floristic Region	564	2014	Van Wilgen *et al.* (2016)
Kruger National Park	350	2015	Van Wilgen *et al.* (2017)
Hluhluwe iMfolozi Park	103	2016	Te Beest *et al.* (2017)
Vergelegen Estate (private land)	43.6	2016	(Van Rensburg, Richardson & Van Wilgen 2017)
Berg River catchment	50	2012	Fill *et al.* (2017)
Krom River catchment	9.89*	2002–2008*	McConnachie *et al.* (2012)
Kouga catchment	9.38*	2002–2008*	McConnachie *et al.* (2012)

Planning coverage is difficult to gauge at a national level. However, evidence suggests that planning is generally poor, as there is a lack of clear goals, and almost no allowance for monitoring and evaluation (Van Wilgen & Wannenburgh, 2016; Fill *et al.*, 2017; Van Wilgen *et al.*, 2017). Planning coverage can be gauged by the area covered by invasive species monitoring, control and eradication plans submitted in terms of the NEM:BA A&IS Regulations (see section 7.4.4); these plans only cover 4% of the country, and vary in terms of their adequacy (Table 7.13; see also Appendix 4).

Outputs are measured in terms of the proportion of land requiring management that is actually managed. In South Africa, there is approximately 973 643 km^2 of untransformed natural vegetation. The only available estimate of the proportion of this land that is invaded to some degree, and thus requires management, is 8% (i.e. 77 900 km^2, Versfeld, Le Maitre & Chapman 1998). The records of the public works alien plant control projects indicate that 282 km^2 have been treated over 20 years, which is approximately 0.36% of the land requiring management. This is an underestimate given the lack of information on other control operations, but the figure is likely to be very low even if other control operations were to be included.

EFFECTIVENESS OF RESPONSES

The number of invasive alien plant species now under complete or substantial biological control is

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Outcomes are gauged in terms of the *Effectiveness of area treatments*. Given the absence of formal monitoring programmes, the level of effectiveness can only be gauged based on available research studies that have attempted to do this (see section 6.4.2). Of the 12 studies reviewed here (section 6.4.2), 8% were gauged to be effective, 58% partially effective and 34% ineffective. The level of confidence in this estimate is therefore low.

The input indicator values for money spent are given in Table 6.5 across all activities (pathways, species and areas). The other indicator values for control effectiveness for area management are given in Table 6.10.

TABLE 6.10 Indicators for control effectiveness of areas

INDICATOR	VALUE BASIC ·····		····· ADVANCED	LEVEL OF CONFIDENCE	NOTES
15. Planning coverage (input)	**15.1.** Areas that have management plans in place. 4% of areas have plans	**15.2.** Areas that have management plans in place, with assessment of quality of management plans 2% of plans are adequate 42% are partially adequate 56% are inadequate	**15.3.** As for 15.2, with priority rankings No data	**15.1.** Medium **15.2.** Medium **15.3.** N/A	Based only on plans submitted in terms of the alien and invasive species regulations, but the absence of adequate plans is a well-documented phenomenon.
18. Area treated (output)	**18.1.** Proportion of area that needs to be managed and is being managed. 0.36%		**18.2.** As for 18.1, with interventions assessed for adequacy. No data	**18.1.** Low **18.2.** N/A	18.1. is based on the area of untransformed land in South Africa (973 643 km^2), assuming that 8% (Versfeld, Le Maitre & Chapman, 1998) (i.e. 77 900 km^2) is invaded and needs to be managed. The area that has been treated (282 km^2) includes all land parcels that have been worked on by public works alien plant control teams over 20 years.
21. Effectiveness of area treatments (outcome)	**21.1.** Proportion of areas in control effectiveness categories AND an assessment of any negative impacts of control Not known: 99.6% Counter-productive: 0% None/Ineffective: 0.1% Partially effective: 0.2% Effective: 0.1% Permanent: 0% An assessment of the negative impacts of control has not been made.	**21.2.** Quantitative measure of control on Relative invasive abundance or Invasive species richness AND a formal environmental and social assessment of non-target effects of the interventions No data	**21.3.** Return on investment expressed as a ratio of the amount spent on control to the value of avoided cost of impact. AND non-target impacts as costs Benefit:cost ratios between 0.03 and 0.75 Non-target impacts not assessed	**21.1.** Low **21.2.** N/A **21.3.** Low	For 21.1., it was assumed that 77 900 km^2 is invaded and needs to be managed, and that 282 km^2 is known to be being managed (see above). Proportion in effectiveness categories based on 12 available studies (section 6.4.2) where the outcomes of management were documented (8% were effective, 58% were partially effective, and 34% were ineffective). Benefit:cost ratios are from a single study involving six projects (Hosking & Du Preez, 2004)

THE SITUATION

The returns on investment from selected biological control projects aimed at invasive alien plants are between

8:1 & 3726:1

6.6.5. Estimation of high-level indicators for overall management effectiveness

High-level indicators are provided in Table 6.11 (see Table 6.12 for the calculation). The high-level indicator for the *Rate of introduction of new unregulated species* was estimated based on the average for the decade 2000–2009 (see Figure 3.8). The *Number of species that have major impacts* was the sum of species considered by experts to have either major or severe impacts (Table 4.7). However, as explained earlier, there have been almost no formal assessments of species impacts, and thus the indicator should not be used as a basis for estimating trends in future. A formal re-assessment of all alien species using the EICAT and SEICAT methods every three years is required.

Obtaining an accurate estimate of the *Area experiencing major impacts* would be dependent on: (1) a formal assessment of the impact of individual species, and (2) a reliable estimate of the distribution of those species. Currently, both components do not exist. The estimate of 1.4% is simply illustrative. It assumes that the area estimated to be densely covered by alien plants will experience major impacts, and is based on a mapping exercise that is both crude and 20 years out of date (Le Maitre, Versfeld & Chapman 2000).

The indicator for overall *Level of success in managing invasions* (Table 6.11) is calculated as the mean of estimates of level of success for pathways, species and areas. Each was obtained by multiplying the proportion that are treated (from indicators 16.1, 17.1 and 18.1 for pathways, species and areas respectively) by the weighted outcome indicators (indicators 19.1, 20.1 and 21.1) as described for high-level indicator D in Appendix 1. See Table 6.12 for the values at each step of the calculation.

TABLE 6.11 High-level indicators of the status of biological invasions and their management in South Africa in 2017.

HIGH-LEVEL INDICATOR	VALUE	LEVEL OF CONFIDENCE	NOTES
A. Rate of introduction of new unregulated species	7 species per year	Low	Based on the average for the decade 2000–2009 (see Figure 3.8)
B. Number of species with major impacts	107 species	Not applicable	Based entirely on expert opinion, and so does not represent an appropriate base-line. For future reports, formal assessments of impact will need to be conducted (see Table 4.7)
C. Percent of area experiencing major impacts	1.4%	Low	Based on the only available estimate of dense ("condensed") cover of invasive alien plants in South Africa (1.7 million ha, (Le Maitre, Versfeld & Chapman, 2000))
D. Level of success in managing invasions	5.5%	Low	Average of pathway success (15.8%), species success (0.65%) and area success (0.0005%)

TABLE 6.12 Values used to calculate the high-level indicator D. Level of success in managing invasions. The proportion managed is based on the output indicators: 16. Pathways treated, 17. Species treated and 18. Areas treated. The proportion with partially effective/effective or permanent management is based on the outcome indicators: 19. Effectiveness of pathway treatments, 20. Effectiveness of species treatments and 21. Effectiveness of area treatments. The management effectiveness score is calculated by determining the sum of the weighted proportion with partially effective management (multiplied by 0.2) and the weighted proportion with effective management (multiplied by 1). The level of success is the product of the proportion managed and the management effectiveness score.

	PROPORTION MANAGED	PROPORTION WITH PARTIALLY EFFECTIVE MANAGEMENT	PROPORTION WITH EFFECTIVE OR PERMANENT MANAGEMENT	MANAGEMENT EFFECTIVENESS SCORE	LEVEL OF SUCCESS (PROPORTION)
Pathways	0.773	0	0.205	0.205	0.158465
Species	0.243	0.049	0.017	0.027	0.0065124
Areas	0.004	0.002	0.001	0.001	0.00000504

BOX 6.1 THE POTENTIAL ECONOMIC BENEFITS OF EFFECTIVE CONTROL MEASURES

Estimates of the monetary value of impacts generated by invasive species in South Africa indicate substantial negative effects in economic terms. For example, one study estimated that, at levels of infestation in 2010, invasive alien plants caused economic losses amounting to over ZAR 6 500 million every year, mostly for losses of water runoff, but also for loss of livestock production from invaded rangelands, and income from biodiversity-related goods and services.

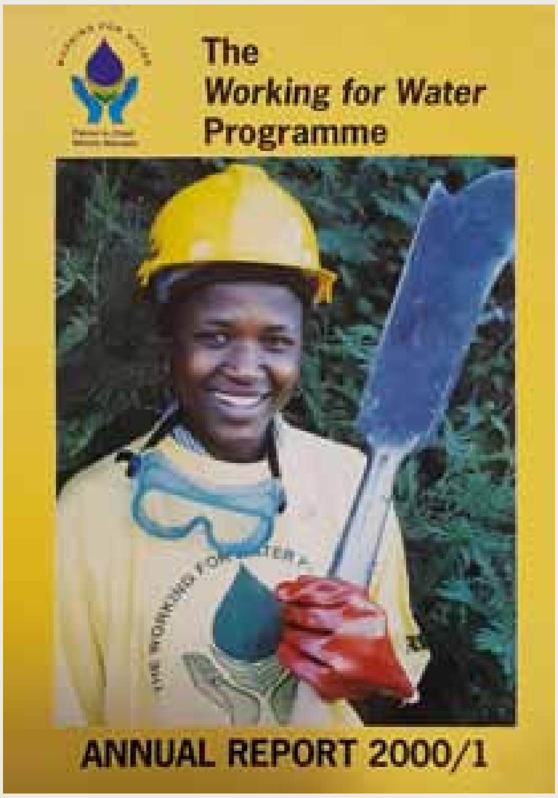
Three points should be noted with regard to these estimates:

- Because of the lack of accurate data, it was necessary to make a number of assumptions when making these estimates. The estimates are therefore crude, but are large enough to indicate that the real economic impacts could be substantial.
- The estimates only include water runoff, production of livestock from rangelands, and limited biodiversity goods and services. There are many other impacts associated with invasive species that were not included because of a lack of data. These estimates are therefore conservative, and will almost certainly be greater.
- The impacts will grow as invasive species continue to spread, and as additional species become invasive.

Given the large and growing impacts of invasive species, attempts to contain or reduce these impacts would be economically justifiable if the control measures were effective and efficient. The best available evidence for this comes from the field of biological control. By comparing the costs of biological control research and implementation to the benefits of restored ecosystem services, or avoided costs, and avoided ongoing control costs, biological control has been shown to be extremely beneficial in economic terms: estimated benefit: cost ratios ranged from 8:1 up to 3 726:1. This essentially means that for every one rand invested into control, losses of between ZAR 8–3 700 were prevented.

Key references:
Le Maitre *et al.* (2011); Van Wilgen & De Lange (2011a).

BOX 6.2 THE WORKING FOR WATER PROGRAMME: ACHIEVEMENTS AND CHALLENGES



The Working for Water Programme (WfW) is South Africa's largest funder of invasive species control measures. Established within the Department of Water Affairs in 1995 with an initial annual budget of ZAR 25 million, its original purpose was to implement invasive plant control operations to reduce their impacts on water resources, and to create much-needed employment amongst the rural poor.

It has subsequently been moved to the Department of Environmental Affairs, where it remains the largest of a suite of programmes in the Department's Natural Resource Management Programmes. Currently, it has an annual budget of ZAR 1.5 billion, and employs 39 500 people in 358 clearing projects across the country.

WfW has achieved a great deal. The fact that a programme of this size exists at all, especially in a developing country, is a remarkable achievement, and it bears testimony to the hard work of those responsible for its establishment and growth. The programme has secured ZAR 10 billion (unadjusted for inflation) for invasive species management over the past 20 years, and has provided conservation agencies, water and irrigation boards, municipalities and private landowners with funding for the management of invasive alien plants, that they would otherwise not have had.

However, the programme faces significant challenges. Despite the generous budget, it is patently inadequate to achieve effective control everywhere, and it is forced to make choices about where, and on which species, to spend money. The vital political support that is needed to sustain this programme arises from its demonstrated ability to create employment, but this can be a double-edged sword as the employment goal is often given higher priority than the goal of achieving ecological restoration (and all of the benefits that go with ecological restoration). The need to maximise employment also reduces the programme's ability to invest adequately in planning and monitoring, which would be expensive and would increase the overall costs per person-day. Minimising the costs per person-day (and thus maximising the number of people employed) is a key target on which continued funding depends. Consequently, the programme's achievements are arguably far less than they could have been under different operating rules.

Key reference:
Van Wilgen & Wannenburgh (2016).

BOX 6.3 THE POTENTIAL CONTRIBUTION OF BIOMASS UTILISATION TO THE EFFECTIVE CONTROL OF INVASIVE SPECIES.

Example of a prototype low-cost housing unit that utilises chip-board manufactured from invasive alien plant biomass.

Given that the clearing of invasive species (especially woody species) can generate a large amount of potentially useful biomass, it seems logical that the opportunity should be taken to make use of this biomass. Currently, South Africa's National Strategy on Biological Invasions calls for clear recommendations to be made on this approach based on "an assessment of the feasibility, viability and effectiveness of projects aimed at producing energy [and other products] from plant biomass". Such an assessment has not yet been carried out. South Africa has nevertheless already established several factories that manufacture furniture from alien plant wood, and is seriously investigating the potential to mass-produce low-cost housing from alien plant biomass.

Despite the apparent substantial potential for biomass utilisation to contribute to invasive plant control efforts, it would be prudent to investigate this thoroughly before making any decision to implement utilisation on a large scale. A number of points need to be explicitly considered:

- Developing the infrastructure to process biomass could create a large dependency on a resource that is targeted for reduction to very low levels. This would be problematic as it could create a substantial conflict in future.
- Utilisation does not necessarily contribute to effective control. Utilisation targets usable biomass, and does not address smaller trees, regeneration or re-sprouting, or seed banks. Site disturbance and transport could also actually exacerbate rather than reduce the problem.
- Utilisation may only be economically feasible in certain areas, but not in remote or inaccessible sites, or in cases where there are scattered populations that should receive priority as targets for clearing.
- Utilisation projects can, and often have, generated unintended consequences, including using infrastructure to process non-target or indigenous species, or encourage spreading of the target invasive species by people who want to benefit from utilisation projects where the species does not yet occur.

Three studies of the potential effectiveness of utilisation have been carried out in South Africa to date. Mugido *et al.* (2014) investigated the feasibility of using harvested invasive plant biomass in the Port Elizabeth area. The study showed that the project proved to be "financially viable", but only when the energy entrepreneur obtained biomass generated by government-funded clearing projects at no cost, and then only under specific conditions. The potential use of *Acacia cyclops* from the De Hoop Nature Reserve (Western Cape) to generate electricity was investigated by Mudavanhu, Blignaut & Nkambule 2016. They concluded that this would be favourable when compared to electricity generation using diesel generators. Finally, Vundla *et al.* (2016) estimated the contribution of value-added products to the viability of woody plant control projects in the Kouga, Krom and Baviaans catchments (Eastern Cape). They concluded that value addition would increase the returns on investment from these projects. All of these studies are predictions, based on assumptions, including that control operations will be effective and efficient, and will be completed within budget. More studies are needed to establish whether this is the case.

Key references:

Mugido *et al*. (2014); Vundla *et al*. (2016); Mudavanhu, Blignaut & Nkambule (2016) .

7

EFFECTIVENESS OF REGULATIONS

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Chapter summary

This chapter reports on the current regulatory framework in South Africa for dealing with biological invasions, and specifically the effectiveness of the Alien and Invasive Species Regulations (A&IS Regulations) under the National Environmental Management: Biodiversity Act (NEM:BA). Effectiveness is discussed here in terms of managing pathways of introduction and dispersal, individual species and specific areas, as well as on other aspects that are required to be reported on under the A&IS Regulations (e.g. state-funded research).

South Africa is one of the few countries that has comprehensive regulations in place to manage biological invasions, and many parts of the regulations are innovative. The regulations deal with most aspects of biological invasions (pathways, species, and areas) and most mechanisms to implement, update, review, and appeal the regulations are clear, and as such were rated as "substantial". However, although there are some sections of the legislation that are relevant to the management of some specific pathways (e.g. the intentional import of alien species for the pet trade), the NEM:BA A&IS Regulations do not specifically regulate pathways. In addition, there are several factors, such as the lack of a national strategy to manage biological invasions, as well as organisational and human capacity constraints, that limit the implementation of the regulations. The evidence base for listing species was not presented in a standard, transparent manner prior to the promulgation of the regulations, although some species have subsequently been assessed. While these assessments are consistent with the regulations, they do not meet international best practice for risk analyses. A risk analysis framework has been developed but is still to be implemented.

Applications were made for the import of 6 unlisted species and on the basis of risk assessments for these species, 21 import permits were issued for five species. A total of 647 permits were issued for restricted activities involving 50 listed alien taxa, including permits for multiple species that are listed in various categories. Permits were for restricted activities related to the trade (44%), conveyance (26%), possession (21%), and import (8%) of alien species, as well as for research (2%) on these species. For listed invasive alien plants, notices have been served to the owners of 85 properties across South Africa (59 to private landowners and 26 to plant traders), with an overall compliance of 95%. For listed invasive alien animals, notices have been served to the owners of 119 properties (78 to pet shops, 19 to game farms, 12 to private holdings and 10 to sanctuaries or zoological gardens) with an overall compliance of 82%).

Limonium sinuatum (statice) – Sofia Turner

Species management programmes (as catered for in the A&IS Regulations) have only been developed for *Parthenium hysterophorus* (parthenium) and *Campuloclinium macrocephalum* (pompom weed), as well as for the genera *Acacia* (Australian wattles) and *Prosopis* (mesquite) and the family Cactaceae. None have yet been formally implemented, so their potential effectiveness cannot yet be assessed.

Landowners are required to notify government of the listed invasive species on their land, but only 59 notifications were received, constituting less than 0.001% of the total number of land parcels in the country.

Although required, it is not possible to assess whether, or to what degree, the sellers of immovable property have notified the purchaser of that property of the presence of listed invasive species on that property, as there is no legal requirement for any person other than the purchaser to be notified.

Only 29 area management plans (termed "Invasive Species Monitoring, Control and Eradication Plans" in the regulations), covering about 4% of the land-surface of the country, were submitted to the Department of Environmental Affairs (DEA) and the South African National Biodiversity Institute (SANBI). Only one of these plans was of adequate quality when assessed against the guidelines for the preparation of such plans. Therefore, a lack of adequate planning remains an obstacle to the control of biological invasions in specific areas.

Organisations that conduct state-funded research on invasive species must lodge research proposals and findings with SANBI. As of March 2017, no such proposals or findings had been lodged with SANBI, despite a substantial amount of research being funded by the state.

A person who fails to comply with the provisions of the A&IS Regulations would be liable, on conviction, to a fine or imprisonment, or both. To date, no cases have been brought to trial.

The regulations have been in place for less than three years, and it is probably premature to expect that their effectiveness could be assessed at this early stage. However, a number of important points emerge, including: high levels of non-compliance with some regulations; a shortage of capacity within the DEA to ensure compliance (although the magnitude of the shortage has not been assessed); the apparent absence of a strategic approach to implement the regulations in a capacity-constrained environment; and contestation of the desirability of regulations for particular species. Finally, where there has been activity and data are available for this report, the data only focussed on outputs (e.g. number of permits issued). Linking these data to outcomes in terms of the state of biological invasions in South Africa will require the development of agreed methodologies.

7.1 INTRODUCTION

In 2014 the government published the Alien and Invasive Species Regulations (A&IS Regulations) in terms of the National Environmental Management: Biodiversity Act (NEM:BA, Act 10 of 2004). These regulations specify the way in which alien species are to be managed. In addition, the regulations prescribe the process to be followed if a new alien species is to be imported into the country, and they also list species that are prohibited from importation. The intent of the regulations is to reduce the risk of importing alien species that could become invasive and harmful, reduce the number of alien species becoming invasive, limit the extent of invasions, and reduce the impacts caused by these invasions. This is to be achieved, in particular, by assigning responsibilities for the control of listed invasive species, and where appropriate to prescribe the conditions under which species that are both invasive and beneficial can be owned, cultivated, transported and traded, as well as assign the responsibility to owners to prevent the spread of such species. The regulations also require that research proposals, and research findings should be submitted to the South African National Biodiversity Institute (SANBI). This includes any "research and biological control relating to any aspect of the invasiveness or potential invasiveness of an alien species or a listed invasive species or the prevention, eradication or control of such invasive or potentially invasive species" that is wholly or partly funded by the state, or conducted in terms of a permit to carry out research on a listed invasive species. The regulations further require SANBI to report, within three years of the promulgation of the regulations and every three years thereafter, on the effectiveness of the regulations, based *inter alia* on notifications from land owners, permits issued, cancelled or refused, and management plans submitted (see Table 7.1 for details). This chapter considers the effectiveness of the NEM:BA A&IS Regulations in terms of managing pathways of introduction and within-country dispersal, individual species and specific areas, and assessing alien species-related research. There are also several additional Acts in South Africa that are relevant to the management of biological invasions. The most important of these (Box 7.1) are under the jurisdiction of the Department of Agriculture, Forestry and Fisheries (DAFF), and are not covered in this report.

TABLE 7.1. Aspects of the National Environmental Management: Biodiversity Act (NEM:BA) and the Alien and Invasive Species (A&IS) Regulations relevant to the management of species, areas and research.

CATEGORY	ASPECT THAT REQUIRES REGULATION	RELEVANT SECTION OF THE A&IS REGULATIONS (AND OF NEM:BA AS SPECIFIED)
Regulations relevant to managing individual invasive *species*	Permits issued for the import of new species that previously were not in South Africa	Section 17
	Permits issued for taxa in Category 2 and other categories that are already in the country; permits refused or cancelled	Section 9.1 (a); Section 12(1); Section 21 (2) (b)
	Invasive Species Management Programmes	Section 9(1) I
	Emergency interventions and enforcement actions involving listed invasive species issued by the Minister.	Section 11 (2) (b) (iv)
	Prosecution of offenders	Section 35
Regulations relevant to managing specific *areas*	Notifications received from owners of land regarding the listed invasive species occurring on their land	Section 11(2)(b)(i) of the regulations, with reference to Section 73(2)(a) of the NEM:BA Act
	Notifications and directives issued to landowners	Section 13(1)(a); Section 31
	Level of compliance with property transfer notifications	Section 29 (3)
	Invasive Species Monitoring, Control and Eradication Plans (i.e. area management plans) received from organs of state and management authorities of protected areas	Section 8 (2) (b); Section 9(1)(b)
	Invasive species status reports for protected areas, submitted since 2004	Section 77 (1) and (2) of NEM:BA
	Prosecution of offenders	Section 35
Regulations relevant to *research* on biological invasions	Research proposals, and biological control proposals, submitted	Section 10 (1)
	Research reports or publications submitted	Section 10(4)

BOX 7.1 ADDITIONAL LEGISLATION IN SOUTH AFRICA THAT IS RELEVANT TO THE REGULATION AND MANAGEMENT OF BIOLOGICAL INVASIONS THOUGH NOT SPECIFICALLY DEALT WITH IN THIS REPORT

There are several Acts in South Africa, in addition to the National Environmental Management: Biodiversity Act, that are relevant to the management of biological invasions. This box lists examples of these acts, along with the relevant reporting requirements.

ACT	ADMINISTERED BY	REPORTING REQUIREMENTS
Agricultural Pests Act, 1983 (Act No. 36 of 1983)	Department of Agriculture, Forestry and Fisheries	• Compulsory notifications of certain pests from land users • Control measures prescribed for different taxa, or in respect of different areas, different circumstances, or in other respects as the Minister may think fit • Permits that have been issued for controlled goods showing the reason for the permit • Offenses and successful prosecutions
Animal Diseases Act, 1984 (Act No. 35 of 1984)	Department of Agriculture, Forestry and Fisheries	• Permits for imported controlled animals or other items • Control measures for controlled animals or other items • Reports of controlled animal disease • Offenses and successful prosecutions
Animal Health Act, 2002 (Act No. 7 of 2002)	Department of Agriculture, Forestry and Fisheries	• Reports of controlled animal disease • Permits and health certificates for animals, parasites, contaminated or infectious items that have been imported into the country • Offenses and successful prosecutions
National Environmental Management: Protected Areas Act (Act 57 of 2003)	The Department of Environmental Affairs	• Register of alien species in protected areas • Performance monitoring indicators • Offenses and successful prosecutions
Conservation of Agricultural Resources Act (Act 43 of 1983)	Department of Agriculture, Forestry and Fisheries	• Declared weed and invader list • Weed control schemes and progress reports • Weeds on any seed, grain, hay or other agricultural product • Weeds on any animal which is driven on a public road, conveyed in a vehicle or offered for sale at a livestock auction • Orders issued for weed destruction, removal or return of the above-mentioned weeds. • Control plans for invaders and weeds • Directives for complying with control measures

7.2. THE STATE OF THE CURRENT REGULATORY FRAMEWORK

The status of the current regulatory framework was assessed using the indicator *Quality of regulatory framework* (see Appendix 1 for more details). The indicator is an input indicator that helps to address three questions: 1) what regulatory framework is in place to manage biological invasions; 2) what is its level of completeness (does it cover all aspects of pathways, species, and areas); and 3) what mechanisms are in place to enable its implementation, update, review, and appeal? At a basic level the indicator is meant to provide a country-level assessment of the degree to which authorities are able to regulate the utilisation, movement, and trade of alien species and citizens are able to take steps to control problematic invasive species. At a more advanced level, the indicator can be used to assess the quality of the regulatory framework at lower administrative entities (e.g. provinces), and also to assess the level of inter-agency co-operation. The quality of the regulations is evaluated as either: *none*, *partial*, *substantial* or *complete* based on their completeness and the presence of enabling mechanisms for implementation, update, review, and appeal. In this report the NEM:BA A&IS regulations (2014) were assessed as "*substantial*" because they deal with most aspects of biological invasions and most mechanisms for implementation, update, review, and appeal are clear. However, pathway specific actions are partly addressed and there are several factors such as the lack of a national strategy to manage biological invasions, organisational and human capacity constraints that may limit the implementation of the regulations (Table 7.2).

TABLE 7.2 A breakdown of coverage of the National Environmental Management: Biodiversity Act's Alien and Invasive Species Regulations (2014) across all aspects of biological invasions. This is with reference to indicator 13. Quality of regulatory framework.

ASPECT OF REGULATIONS	ASPECT OF BIOLOGICAL INVASIONS		
	PATHWAYS (incl. subcategories)	SPECIES (incl. all taxa)	AREAS (incl. different spatial scales and ownership)
Is there a mandate for management interventions?	Partial	Substantial	Substantial
Is there provision for enforcement of non-compliance?	Partial	Substantial	Substantial
Is there a requirement for regular assessment of performance, and review?	Partial	Substantial	Substantial

7.2.1. What is required to improve the effectiveness of the regulations?

Need for pathway-specific management measures. The NEM:BA A&IS Regulations do not specifically regulate pathways but several sections or aspects of the regulations are relevant to the management of some pathways. For example, the regulations require permits for the import of new species. However, these measures are actually species-specific measures and not pathway management actions. There is therefore a need for the regulations to have pathway specific-management measures, for example the proposed Ballast Water Act that is specifically meant to prevent the transfer of alien and invasive species into South African waters through the release of ballast water by ships.

Which alien species should be regulated? Currently, the NEM:BA A&IS regulations list 556 taxa as invasive. However, not all of these species are necessarily harmful to the extent that would justify the expenditure of time and effort on their management, given that capacity to manage and to regulate is limited. Regulations should therefore arguably focus on priority species. The question could be asked whether some of the species that are currently regulated could be removed from the list, and what the procedure for this should be. Invasive species have been included in the NEM:BA A&IS Regulations because they are found outside of captivity or cultivation, and are therefore presumed to be harmful. However, it is clear that not all invasive species are equally harmful, and several may be relatively harmless.

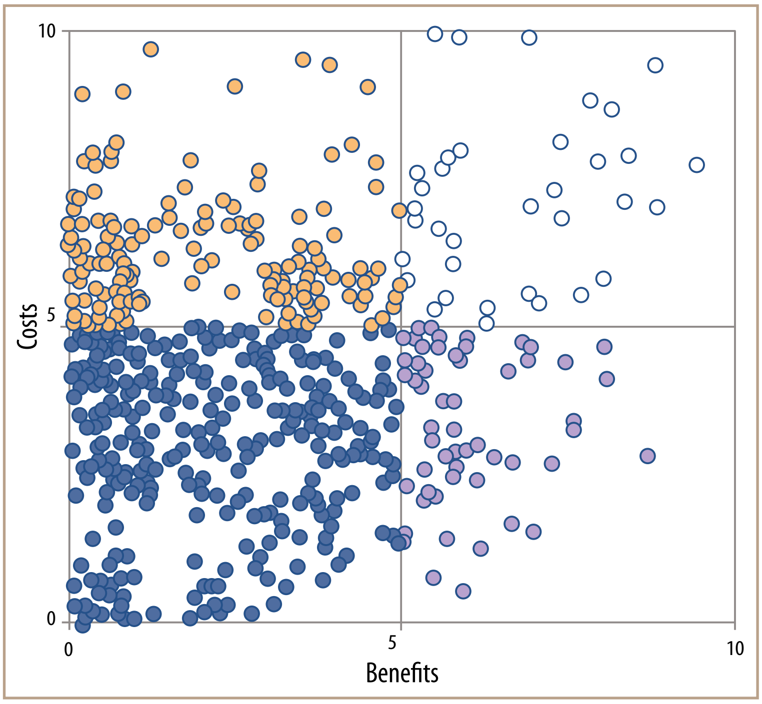

FIGURE 7.1 Categorisation of all alien species that are listed under the NEM:BA A&IS Regulations, based on the degree of their negative impacts (costs) and their benefits scaled from 0 (low) to 10 (high). Inconsequential species are those whose costs and benefits are low (lower left cell in diagram). Redrawn from Zengeya *et al*. (2017).

A recent assessment by Zengeya *et al.* (2017) suggested that of the 556 listed invasive alien taxa, more than half (304 species) can be categorised broadly as "inconsequential", meaning that they are currently associated with relatively low costs and low benefits (Figure 7.1). The inclusion of these species on the list of regulated species means that their control is compulsory, and that management plans need to be drawn up and implemented by organs of state. Removing some of these species from the list of regulated species would free up scarce capacity, and allow both managers and regulators to focus on more harmful species that should arguably receive priority. Their retention on the list of regulated species arguably ties up scarce capacity in activities that do not deliver the returns on investment that would come from a focus on more harmful species. This aspect deserves more attention, and the species classified as "inconsequential" should receive priority as candidates for risk analysis. Those found to pose a low risk should be removed from regulated lists. Following biological control, several species (including cacti and Australian acacias) no longer pose a major threat, and a process for considering their delisting should be instigated. Several plant taxa are listed that are not environmental problems [as the lists were brought over from the Conservation of Agricultural Resources Act (CARA)]. Examples of species that could be considered for delisting from the NEM:BA A&IS Regulations are given in Henderson & Wilson (2017); Kaplan *et al.* (2017); and Zachariades *et al.* (2017).

The evidence as to why particular species are listed is not available in a consistent, publically accessible and standardised form (see section 7.3.5).

Listing errors. There are some errors with the list of regulated species. These errors include: 1) species that are listed as invasive in the country but there are no records of them in the country, for example, two amphibian taxa [the genus *Pelophylax* (marsh frogs) and *Triturus carnifex* (Italian crested newt)] (Measey *et al.*, 2017) and several marine species [*Tetrapygus niger* (blach sea-urchin), *Fenneropenaeus indicus* (Indian prawn), *Ostrea edulis* (European flat oyster*), Penaeus monodon* (giant tiger prawn)] (Tammy Robinson, personal communication, 2017); 2) several species that are listed as prohibited are already present in the country, for example *Procambarus clarkii* (red swamp crayfish) (Nunes *et al.*, 2017); and 3) taxonomic issues where whole genera or families are listed instead of species, for example *Pelodiscus* (Chinese softshell terrapins), *Trachemys* (sliders), *Dendrobatidae* (poison arrow frogs) and *Lantana* (all seed-producing species or seed-producing hybrids that are nonindigenous to South Africa).

There is a need for a national strategy to manage biological invasions. This assessment has not found any evidence of the strategic use of the regulations to achieve particular goals or priorities. South Africa's National Strategy for Dealing with Biological Invasions, finalised in 2013, outlined several recommendations for the cost-effective management of biological invasions in the country. There has, however, not been any progress in the implementation of these recommendations. For example, there is a need to identify and prioritise management interventions that could be more easily achieved with the limited human and financial resources available. A prioritised approach, followed by focussed interventions, would seem to be more likely to deliver positive outcomes, and should be considered.

Organisational capacity. The mandate to manage several aspects of biological invasions is currently fragmented across several government departments and not conflated in a single piece of legislation. The NEM:BA A&IS Regulations are administered by The Department of Environmental Affairs (DEA) but there are other Acts administered by other departments that are also relevant to the management of biological invasions (see Box 7.1). It is not clear the degree to which the approach among the various departments is co-ordinated to avoid duplication of effort and increase efficiency.

Human capacity. National initiatives to manage biological invasions require expertise in numerous disciplines such as natural and social sciences, legal and law enforcement. The capacity of officials in the DEA to ensure compliance with the regulations is limited. There are millions of land parcels in South Africa, large numbers of people who cultivate, own and trade in listed invasive species, hundreds of regulated species, and large volumes of trade, and numbers of people, passing through South Africa's 72 legal points of exit and entry. There are specific requirements that need to be met, for example the need to develop and implement invasive species management programmes for a suite of priority species and area management plans for priority areas. There does not appear to have been an assessment of the work needed to ensure compliance with the regulations, or the capacity that would be needed to do that effectively, so the magnitude of the capacity shortfall cannot be accurately gauged at present, although it is certainly an issue.

Accessibility of data and information. The regulations specify that the national status report on biological invasions must contain a summary and assessment of the status of listed invasive species and the effectiveness of these regulations and control measures based on several reporting requirements (Table 7.2). However, this information exists in several different databases that are often dispersed and not easily accessible. In addition, these databases were created for different purposes and vary in completeness and information content. Such information needs to be accurately collected, subjected to adequate quality control, and safely curated. This can be achieved by developing systems to integrate and archive information from these various sources so that information can be easily accessed and appropriately used.

Information regarding the implementation and effectiveness of the regulations was obtained from a variety of sources (Table 7.3).

TABLE 7.3 Sources of data that were used to assess the degree to which the National Environmental Management: Biodiversity Act's Alien and Invasive Species Regulations (2014) were being complied with, with levels of confidence based on the completeness and accuracy of data sets.

SOURCE	DESCRIPTION OF REPORTING REQUIREMENT	LEVEL OF CONFIDENCE BASED ON COMPLETENESS AND ACCURACY
Department of Environmental Affairs	Permits issued for both alien and listed invasive species	High
Scientific literature	Invasive species management programmes	High
South African National Biodiversity Institute; Department of Environmental Affairs	Risk assessments	Moderate
Department of Environmental Affairs	Notifications from landowners	High
Department of Environmental Affairs	Notifications and directives to landowners, and levels of compliance	High
Department of Environmental Affairs	Invasive Species Monitoring, Control and Eradication Plans (i.e. area management plans) received from organs of state and management authorities of protected areas	High

7.3. EFFECTIVENESS OF REGULATIONS RELEVANT TO MANAGING ALIEN SPECIES

7.3.1. Permits issued for the import of new species

Applications were made for the import of 6 unlisted species (four freshwater fish species, one marine invertebrate species, and one reptile species, Table 7.4). On the basis of risk assessments of these species, 21 import permits were issued for five species (four freshwater fish and one marine invertebrate).

TABLE 7.4 Alien species for which permission was sought for an import permit into South Africa on the basis of a risk assessment.

TAXON	SPECIES	NUMBER OF PERMITS GRANTED	NUMBER OF PERMITS REFUSED	NUMBER OF OUTSTANDING PERMIT APPLICATIONS
MARINE INVERTEBRATES	*Carcinus aestuarii* (Mediterranean green crab)[1]	4	0	0
FRESHWATER FISH	*Pangasianodon hypophthalmus* (iridescent shark catfish)	1	0	0
	Oncorhynchus kisutch (coho salmon)	8	0	0
	Oncorhynchus tshawytscha (Chinook salmon)	4	0	0
	Lates calcarifer (barramundi)	4	0	0
REPTILES	*Protobothrops mangshanensis* (Mangshan pit viper)	0	0	1

[1] Permits granted to import gill tissue for genetic analysis and not for live specimens

There are currently no guidelines for completing an invasive species risk assessment. The A&IS Regulations specify data that need to be included but not how such information should be interpreted in terms of the risk of any introduction. A proposed framework has been developed, but is yet to be approved and implemented by DEA (as of end of March 2017). An independent Alien Species Risk Analysis Review Panel (ASRARP) has, however, been constituted by SANBI to provide scientific oversight of the issuing of import permits. ASRARP is routinely consulted before import permits are granted.

7.3.2. Permits issued for listed invasive species

Under the NEM:BA A&IS Regulations, invasive species placed in Category 2 can be owned, cultivated, harvested and traded only if a permit is granted to carry out these otherwise restricted activities. Such a permit must also stipulate the responsibilities placed on the permit-holders to prevent the spread of the permitted species. The intention is to regulate ownership, cultivation and trade of invasive species that also have commercial value, and to prescribe responsibilities to permit holders to prevent spread. Under certain circumstances, permits may also be issued for category 1(b) species, for example to scientific institutions and zoological gardens to either conduct research, or to house specimens for display in captivity.

A total of 647 permits were issued for restricted activities involving 50 alien taxa, including permits for multiple species that are listed as genera or families from various categories. Most of the permits were issued for species listed as Category 2 (480), followed by "context-specific" species that are listed in different categories (154), depending on where in the country they occur [e.g. *Rattus rattus* (house rat) is listed as 1b for off-shore islands but is not listed for the mainland, and species listed in category 1b (13) (Table 7.5)]. The highest number of permits was issued for mammals (317 permits for 15 species), followed by freshwater fishes (117 permits for seven species) and birds (85 permits for three species) (Figure 7.2). The other taxa that received fewer permits were reptiles (58 permits for 10 species), terrestrial and freshwater plants (45 permits for 12 species), freshwater invertebrates (13 permits for two species) and marine invertebrates (12 permits for one species). There were no permits issued for microbes, marine plants, terrestrial invertebrates or amphibians.

TABLE 7.5 Number of permits issued or refused for species listed in category 2 and other categories of the A&IS Regulatory Lists (2016). 'Context specific' refers to species that are listed in several categories depending on the area in which they occur (regulation by area).

TAXON	NEM:BA CATEGORY	SPECIES	RISK ASSESSMENT COMPLETED?	NUMBER OF PERMITS GRANTED	NUMBER OF PERMITS REFUSED
TERRESTRIAL AND FRESHWATER PLANTS (45 permits applied for)	1b	*Cryptostegia grandiflora* (rubber vine)	No	1	0
	2	*Acacia dealbata* (silver wattle)	Yes	3	0
		Acacia mearnsii and hybrids (black wattle)	Yes	6	0
		Acacia melanoxylon and hybrids, varieties and selections (blackwood)	No	5	0
		Agave sisalana (sisal)	Yes	1	0
		Nasturtium officinale (watercress)	Yes	4	0
		Pinus patula and hybrids (patula pine)	Yes	3	0
	Context specific	*Casuarina cunninghamiana* (beefwood)	Yes	10	0
		Eucalyptus camaldulensis and hybrids (river red gum)	Yes	3	0
		Murraya paniculata (listed as *Murraya exotica* on the permit) (orange jessamine)	Yes	1	0
		Pinus pinaster and hybrids (cluster pine)	Yes	4	0
		Pinus radiata and hybrids (Monterey pine)	Yes	4	0
FRESHWATER INVERTEBRATES (15 permits applied for)	2	*Cherax cainii* (smooth marron)	No	5	0
		Cherax tenuimanus (hairy marron)	No	8	2

TAXON	NEM:BA CATEGORY	SPECIES	RISK ASSESSMENT COMPLETED?	NUMBER OF PERMITS GRANTED	NUMBER OF PERMITS REFUSED
MARINE INVERTEBRATES (12 permits applied for)	1b	*Carcinus maenas* (green crab)	Yes	12	0
FRESHWATER FISHES (121 permits applied for)	Context specific	*Ctenopharyngodon idella* (grass carp)	No	27	0
		Ctenopharyngodon idella (triploid grass carp)	Yes	22	0
		Cyprinus carpio (common carp)	Yes	3	0
		Gambusia affinis (mosquito fish)	Yes	1	0
		Micropterus dolomieu (smallmouth bass)	Yes	1	0
		Micropterus salmoides (largemouth bass)	Yes	2	0
		Oreochromis niloticus (Nile tilapia)	Yes	61	4
REPTILES (59 permits applied for)	2	*Basiliscus plumifrons* (plumed basilisk)	No	1	0
		Bitis gabonica rhinoceros (Gaboon viper)	Yes	4	0
		Centrochelys sulcata (spur-thighed tortoise)	Yes	5	0
		Chelydra serpentina (common snapping turtle)	Yes	2	0
		Gekko gecko (tokay gecko)	Yes	1	0
		Macrochelys temminckii (alligator snapping turtle)	Yes	2	0
		Morelia spilotes (carpet/diamond python)	No	14	0
		Python bivittatus (Burmese python)	Yes	16	0
		Trachemys species (slider turtles)	No	1	0
	Context specific	*Iguana iguana* (green iguana)	Yes	12	1
BIRDS (85 permits applied for)	2	*Acridotheres fuscus* (jungle mynah)	Yes	2	0
		Psittacula krameri (rose-ringed parakeet)	Yes	81	0
	Context specific	*Alectoris chukar* (chukar partridge)	Yes	2	0
MAMMALS (318 permits applied for)	2	*Addax nasomaculatus* (addax)	Yes	1	0
		Aepyceros melampus petersi (black-faced impala)	Yes	1	0
		Ammotragus lervia (barbary sheep)	Yes	14	0
		Antilope cervicapra (Indian blackbuck)	Yes	3	0
		Axis axis (Chital)	Yes	7	0
		Axis porcinus (hog deer)	Yes	7	0
		Cervus elaphus (red deer)	Yes	3	0
		Dama dama (fallow deer)	Yes	71	0
		Hydrochaeris hydrochaeris (capybara)	Yes	1	0
		Kobus ellipsiprymnus defassa (defassa waterbuck)	Yes	1	0
		Kobus leche kafuensis (Kafue lechwe)	Yes	19	0
		Kobus leche leche (red lechwe)	Yes	165	1
		Oryx dammah (oryx)	Yes	22	0
		Ovis aries musimon (mouflon)	No	1	0
	Context specific	*Erythrocebus patas* (pata`s monkey)	Yes	1	0

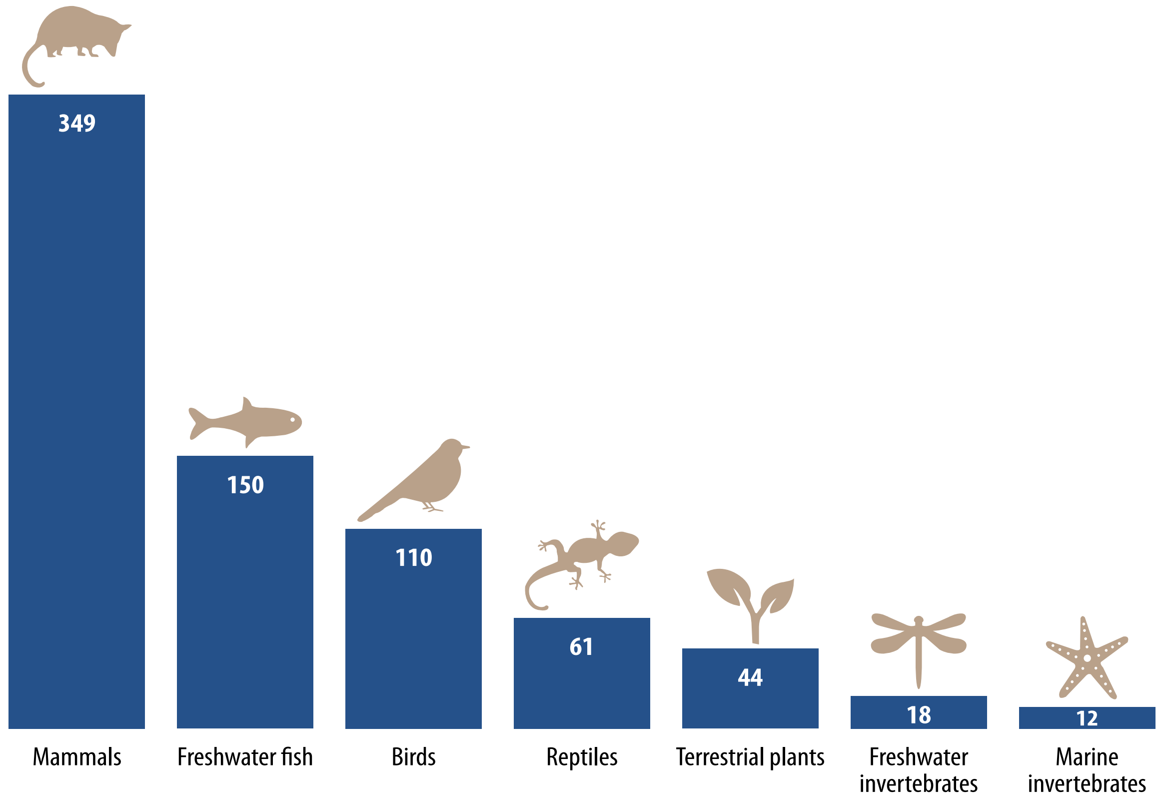

FIGURE 7.2 The number of permits issued for restricted activities with listed invasive species in different taxa.

The species that had the highest number of permits issued for use of the species within South Africa were *Kobus leche leche* (red lechwe) (196), *Psittacula krameri* (rose-ringed parakeet) (108), *Oreochromis niloticus* (Nile tilapia) (94) and *Dama dama* (fallow deer) (72). A total of eight permits were refused, four for *O. niloticus*, two for *Cherax tenuimanus* (hairy marron), and one each for *Iguana iguana* (green iguana) and *K. l. leche*. The reasons why the permits were refused are that the national and provincial authorities took an in-principle decision not to allow the introduction of alien species to areas where they do not occur and in areas of biodiversity concern, and in some cases provinces did not to allow restricted activities with alien species regarded as high risk within their provinces. Copies of risk assessments for all species that were permitted have been lodged with the DEA, except for five species: *Ovis aries musimon* (mouflon), *Morelia spilotes* (carpet python), *Basiliscus plumifrons* (plumed basilisk), *Cherax cainii* (smooth marron), *C. tenuimanus* (hairy marron) and the genus *Trachemys* (slider turtles).

Permits allow the holders to engage in activities involving the alien species that would otherwise be restricted and several activities may be listed on one permit. The type of permit could be categorised into five broad categories (Figure 7.3). The category with the highest proportion of permits (44%) issued was "trade" and permits is this category allowed the applicant to undertake several activities such as the possession, breeding, cultivation and trading with the listed invasive species (Table 7.6). The second highest proportion of permits (26%) was in the category "conveying" which allowed the permit holder to transport or move alien and invasive species from one locality to another. "Possession" had the third highest proportion of permits (21%), and this allowed the applicant to exercise physical control over and keep the permitted species. The other two categories "import" (8%) and "research" (2%) had the lowest proportions of issued permits. The "import" category is for the import of species not yet in the country or for other listed species that are present in the country. Research permits were issued to research institutions to conduct research on several aspects of listed alien and invasives species.

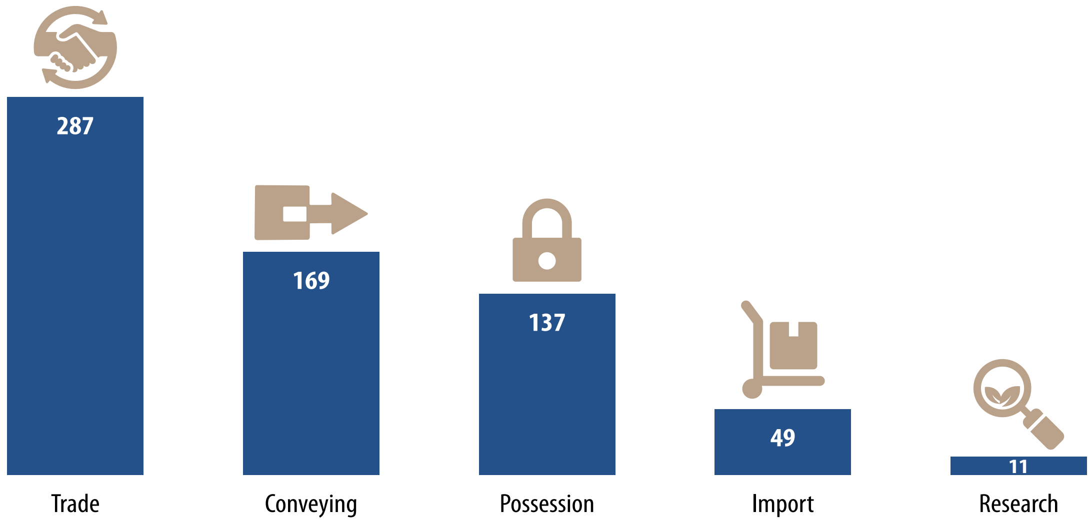

FIGURE 7.3 The number of permits issued for different categories of intended use. "Trade" refers to the selling or buying of any listed invasive species; "Conveying" refers to moving or otherwise translocating any specimen of a listed invasive species; "Possession" refers to exercising physical control over any specimen of a listed invasive species; "Import" refers to new introductions into the country of any listed alien species; and "Research" refers to the use of the species for research purposes.

TABLE 7.6 Number of permits issued, and refused, between January 2016 and March 2017 or a range of restricted activities associated with five categories of intended use of invasive species. "Conveying" refers to moving or otherwise translocating any specimen of a listed invasive species, "import" refers to new introductions into the country of listed alien species, "possession" refers to exercising physical control over any specimen of a listed invasive species, "research" refers to research studies on various aspects, and "trade" refers to selling or buying of any listed invasive species.

CATEGORY	RESTRICTED ACTIVITY PERMITTED	NUMBER OF PERMITS ISSUED	NUMBER OF PERMITS REFUSED
CONVEYING	Convey	156	0
	Convey and release	13	0
IMPORT	Import and research	5	0
	Import, possession, breeding, selling, release, transfer across catchments	0	2
	Import	44	0
POSSESSION	Possession and release	3	0
	Possession, breeding and display purposes	1	0
	Possession and breeding/growing	63	1
	Possession	69	0
	Possession, convey and dispose	1	0
	Possession, breeding and conveying	0	1
	Possession and convey	0	1
RESEARCH	Convey and research	5	0
	Possession and research	4	0
	Possession, breeding/growing and research	2	0
TRADE	Possession, breeding and selling	3	0
	Possession, breeding, selling and discharging into waterways	2	0
	Possession, breeding, selling and conveying	1	4
	Possession, breeding, selling and research	1	0
	Possession and selling	16	0
	Possession and buying	1	0
	Possession, breeding and selling	246	0
	Buying and conveying	10	0
	Possession, growing and selling	7	0

7.3.3. Invasive species management programmes

The NEM:BA requires [section 75 (4)] the Minister to ensure the coordination and implementation of programmes for the prevention, control or eradication of invasive species. The Act also empowers [section 75 (5)] the Minister to establish an entity consisting of public servants to coordinate and implement programmes for the prevention, control or eradication of invasive species. The A&IS Regulations, published in 2014 under the NEM:BA state further (in Chapter 2 of the regulations) that "if an Invasive Species Management Programme has been developed in terms of section 75(4) of the Act, a person must control the listed invasive species in accordance with such programme". In many cases, the need for species-specific management programmes is clear, but neither the Act, nor the regulations, provide any guidance on which of the listed invasive species should be the subject of such a programme.

The development of national-level, species-specific programmes for all listed alien species would be extremely onerous, and it has therefore been assumed that a start should be made with priority species. For example, Terblanche *et al.* (2016) stated that "in view of the urgent need to develop guidelines and test approaches for such strategies, it was decided to develop a strategy for the invasive plant *Parthenium hysterophorus* (famine weed)". To date, two species-specific strategies have been developed, one for *P. hysterophorus*, a rapidly-spreading annual herb that poses significant threats to rangeland productivity, biodiversity and human health (Terblanche *et al.*, 2016), and another for *Campuloclinium macrocephalum* (pompom weed) (Le Maitre, Forsyth & Wilson 2015). These strategies both recommended different management approaches for municipal areas depending on the stage of invasion (absent, rare, spreading or dominant). In addition, two genus-level strategies have been published (one for Acacia, Van Wilgen *et al*., 2011, and one for Prosopis, Shackleton et al., 2017a). Around 70 species of Australian *Acacia* have been introduced to South Africa, and at least 14 are now known to be invasive across South Africa. Collectively, the genus *Acacia* is the most widespread invasive taxon in the country. Numerous *Prosopis* species were introduced into South Africa from the Americas, and now constitute a hybrid swarm involving many species. *Prosopis* is the second most widespread invasive alien plant genus in South Africa after *Acacia*. In addition, one family-level strategy (for Cactaceae, Kaplan *et al.*, 2017) has been published. The Cactaceae has 35 listed alien species in South Africa, 10 of which are targeted for eradication and 16 of which are under substantial or complete biological control (Zachariades *et al.*, 2017). None of these strategies has been formally adopted or implemented to date, and (although there is a National Cactus Working Group) no entities have been formally mandated to co-ordinate and implement them, so whether or not they are going to be effective cannot yet be determined.

7.3.4. Emergency interventions and enforcement actions involving listed invasive species

Although the regulations make allowance for the Minister to issue emergency interventions and enforcement actions involving listed invasive species, no such interventions have been issued by the Minister to date.

7.3.5. Risk assessments of listed species, or candidates for listing

The listing of 556 alien taxa in a number of categories in the NEM:BA A&IS Regulations was based on expert opinion, and not on formal risk assessments. The DEA, through SANBI, has embarked on a retrospective exercise aimed at completing risk analyses for all listed alien species, as well as for species that are candidates for listing in the future. Such a process is necessary for two reasons – first, to ensure that all listed alien species do pose significant risks, and that expending time and effort on them would be justified (Section 7.2.1.2); and secondly, to assemble the necessary evidence of risk for use in cases where the listing may be challenged (as has happened in the case of trout species, Woodford *et al.*, 2017). Initially, SANBI was tasked with conducting risk assessments for all species in category 1(a) (i.e. potential candidates for eradication), but the Institute has subsequently started work on risk analyses for all listed species. The species that have been assessed to date were those proposed by the DEA, focussing on species where there was some controversy (category 2 in particular).

Risk assessments have been retrospectively completed for 150 species (Table 7.7). Most risk assessments were for plant species (75), followed by birds (27), mammals (20), reptiles (11), freshwater fish (10), freshwater invertebrates (5), amphibians (1) and marine fish (1). Of the plant species assessed, 31 were in category 1(a) (i.e. candidates for eradication), or were included in a list of 'Species Under Surveillance – Possible Eradication or Containment Targets' (SUSPECT, 42 species). None of these assessments have been independently checked for quality, and they did not follow a set protocol.

TABLE 7.7 Alien species that have been subjected to a risk assessment as part of a retrospective exercise aimed at completing risk assessments for all listed alien species, as well as for species that are candidates for listing in the future. Note that while the risk assessments conducted here fulfil the requirements of the A&IS Regulations, they do not necessarily constitute a risk assessment in terms of assessing the likelihood and consequence of invasions. The risk analysis framework that has been developed for South Africa incorporates this explicitly and is due to be implemented in future. "SUSPECT" refers to Species Under Surveillance – Possible Eradication or Containment Targets. "Context-specific" refers to species that are listed in different categories depending on their location.

TAXON	SPECIES	REGULATORY CATEGORY
AMPHIBIANS	*Dendrobates auratus* (poison arrow frog)	2
BIRDS	*Acanthis flammea* (common redpoll)	Unlisted
	Acridotheres cristatellus (crested myna)	2
	Acridotheres fuscus (jungle myna)	2
	Alectoris chukar (chukar partridge)	Context-specific
	Alectoris rufa (red-legged partridge)	Prohibited
	Carduelis carduelis (European goldfinch)	2
	Chloris chloris (European greenfinch)	Unlisted
	Colinus cristatus (crested quail)	Prohibited
	Colinus virginianus (northern bobwhite)	2
	Coloeus monedula (Eurasian jackdaw)	Unlisted
	Corvus brachyrhynchos (American crow)	Prohibited
	Corvus frugilegus (rook)	Prohibited
	Francolinus pondicerianus (grey francolin)	Prohibited
	Fringilla coelebs (chaffinch)	2
	Haemorhous mexicanus (house finch)	Unlisted
	Passer hispaniolensis (Spanish sparrow)	Prohibited
	Passer montanus (Eurasian tree sparrow)	Prohibited
	Pavo cristatus (common peafowl)	Unlisted
	Perdix perdix (grey partridge)	Prohibited
	Psittacula cyanocephal (plum-headed parakeet)	Unlisted
	Psittacula krameri (rose-ringed parakeet)	2
	Pycnonotus cafer (red-vented bulbul)	2
	Sicalis flaveola (saffron finch)	2
	Turdus merula (common blackbird)	Prohibited
	Turdus philomelos (song thrush)	Prohibited
	Uraeginthus bengalus (red-cheeked cordon-bleu)	Unlisted
	Zenaida asiatica (whitewinged dove)	Prohibited

TAXON	SPECIES	REGULATORY CATEGORY
FRESHWATER FISH	*Clarias gariepinus* (African sharptooth catfish)	Unlisted
	Ctenopharyngodon idella (grass carp)	Context-specific
	Gambusia affinis (mosquito fish)	Context-specific
	Lepomis macrochirus (bluegill sunfish)	Context-specific
	Micropterus punctulatus (spotted bass)	Context-specific
	Micropterus salmoides (largemouth bass)	Context-specific
	Oncorhynchus mykiss (rainbow trout)	Unlisted
	Oreochromis niloticus (Nile tilapia)	Context-specific
	Pangasianodon hypophthalmus (striped catfish)	Unlisted
	Salmo trutta (brown trout)	Unlisted
FRESHWATER INVERTEBRATES	*Cherax cainii* (smooth marron)	2
	Cherax destructor (yabby)	1a
	Cherax quadricarinatus (redclaw crayfish)	1b
	Cherax tenuimanus (hairy marron)	2
	Neocardina davidi (red/cherry shrimp)	Unlisted
MAMMALS	*Addax nasomaculatus* (addax)	2
	Ammotragus lervia (barbary sheep)	2
	Antilope cervicapra (Indian blackbuck)	2
	Axis axis (Chital)	2
	Boselaphus tragocamelus (nilgai)	2
	Cervus elaphus (red deer)	2
	Cervus nippon (sika deer)	2
	Diceros bicornis michaeli (black rhinoceros (Kenya))	2
	Elaphurus davidianus (Père David's deer)	2
	Erythrocebus patas (patas monkey)	Context-specific
	Hippotragus equinus (western roan)	2
	Hydrochaeris hydrochaeris (capybara)	2
	Kobus ellipsiprymnus defassa (Defassa waterbuck)	2
	Kobus leche kafuensis (Kafue lechwe)	2
	Kobus vardonii (puku)	2
	Macaca fascicularis (crab-eating macaque)	2
	Myocastor coypus (coypu)	2
	Ovis ammon (mouflon)	2
	Taurotragus derbianus (Lord Derby eland)	2
	Tragelaphus spekii (sitatunga)	2
MARINE FISH	*Hippocampus whitei* (white's seahorse)	Unlisted (illegal import)

TAXON	SPECIES	REGULATORY CATEGORY
PLANTS	*Acacia implexa* (screw-pod wattle)	1a
	Acacia paradoxa (kangaroo thorn)	1a
	Acacia stricta (hop wattle)	1a
	Acacia fimbriata (fringed wattle)	1a
	Acacia pendula (myall)	Unlisted (Suspect list)
	Agave americana L. var. *americana* (American agave)	Unlisted (Suspect list)
	Albizia julibrissin (silk tree)	Unlisted (Suspect list)
	Anigozanthos flavidus (yellow kangaroo paw)	Unlisted (Suspect list)
	Asphodelus fistulosus (onion weed)	Unlisted (Suspect list)
	Banksia (banksia)	Unlisted (Suspect list)
	Berberis juliana (wintergreen barberry)	Unlisted (Suspect list)
	Billardiera heterophylla (bluebell creeper)	1a
	Bromus (brome grasses)	Unlisted (Suspect list)
	Cabomba caroliniana (Cabomba)	1a
	Calluna vulgaris (common heather)	Prohibited
	Canna × generalis (garden canna)	Unlisted (Suspect list)
	Carex buchananii (New Zealand sedge)	Unlisted (Suspect list)
	Carex comans (New Zealand sedge)	Unlisted (Suspect list)
	Carex flagellifera (New Zealand sedge)	Unlisted (Suspect list)
	Carex longebrachiata (Australian sedge)	Unlisted (Suspect list)
	Carex testacea (New Zealand sedge)	Unlisted (Suspect list)
	Chondrilla juncea (skeleton weed)	1a
	Crotalaria agatiflora (canary bird bush)	1b
	Cryptostegia grandiflora (rubber vine)	1b
	Cryptostegia madagascariensis (Madagascar rubber vine)	1b
	Cyathea cooperi (Australian tree fern)	Unlisted (Suspect list)
	Cytisus scoparius (Scotch broom)	1a
	Diplocyclos palmatus (lollipop climber)	1a
	Equisetum hyemale (rough horsetail)	1a
	Euphorbia esula (leafy spurge)	1a
	Fallopia sachalinensis (giant knotweed)	1a
	Furcraea foetida (Mauritius-hemp)	1a
	Genista monspessulana (Montpellier broom)	1a
	Hakea drupacea (sweet hakea)	1b
	Hakea salicifolia (willow hakea)	Context-specific
	Harrisia balansae (strangler prickly apple)	1a
	Helianthus tuberosus (Jerusalem artichoke)	Unlisted (Suspect list)
	Hydrilla verticillata (hydrilla)	1a
	Hydrocleys nymphoides (water poppy)	1a
	Iris missouriensis (western blue flag)	Unlisted (Suspect list)
	Iris pseudacorus (yellow flag)	1a
	Kunzea ericoides (white tea-tree)	1a
	Leucaena leucocephala (white leadtree)	2

TAXON	SPECIES	REGULATORY CATEGORY
	Ludwigia peruviana (water primrose)	1a
	Lythrum salicaria (purple loosestrife)	1a
	Melaleuca hypericifolia (hillock bush)	1a
	Melaleuca parvistaminea (rough-barked honey myrtle)	Unlisted (Suspect list)
	Melaleuca quinquenervia (broad-leaved paperbark)	Context-specific
	Metrosideros excelsa (New Zealand Christmas tree)	Context-specific
	Nymphoides peltata (gringed water lily)	1a
	Oenothera biennis (evening star)	Unlisted (Suspect list)
	Oenothera glazioviana (large-flowered evening primrose)	Unlisted (Suspect list)
	Oenothera indecora (small-flower evening primrose)	Unlisted (Suspect list)
	Oenothera jamesii (trumpet evening primrose)	Unlisted (Suspect list)
	Oenothera laciniata (cutleaf evening primrose)	Unlisted (Suspect list)
	Oenothera rosea (rose evening primrose)	Unlisted (Suspect list)
	Oenothera stricta (evening primrose)	Unlisted (Suspect list)
	Oenothera tetraptera (white evening primrose)	Unlisted (Suspect list)
	Orchids	Unlisted
	Paspalum quadrifarium (tussock paspalum)	1a
	Paulownia tomentosa (empress tree)	1a
	Petiveria alliacea (guinea henweed)	Unlisted (Suspect list)
	Phytolacca octandra (red inkplant)	1b
	Populus deltoides (eastern cottonwood)	Unlisted (Suspect list)
	Populus nigra (Lombardy poplar)	Unlisted (Suspect list)
	Pterocarya fraxinifolia (wingnut)	Unlisted (Suspect list)
	Pueraria montana var. *lobata* (kudzu vine)	1a
	Rosa canina (dog rose)	Unlisted (Suspect list)
	Rivina humilis (bloodberry)	1b
	Sagittaria latifolia (broad-leaved arrowhead)	Unlisted (Suspect list)
	Salix babylonica (Babylon willow)	Unlisted (Suspect list)
	Spartina alterniflora (smooth cord grass)	1a
	Syncarpia glomulifera (turpentine)	Unlisted (Suspect list)
	Tephrocactus articulatus (paper spine cactus)	1a
REPTILES	*Anolis carolinensis* (green anole)	Context-specific
	Basiliscus plumifrons (plumed basilisk)	Context-specific
	Bitis nasicornis (rhinoceros viper)	Context-specific
	Bitis gabonica rhinoceros (western Gaboon adder)	Context-specific
	Boa constrictor (common boa)	Context-specific
	Crotalus atrox (western-diamond backed rattlesnake)	Unlisted
	Furcifer pardalis (panther chameleon)	2
	Macrochelys temminckii (alligator snapping turtle)	2
	Morelia spilota (carpet/diamond pythons)	2
	Trioceros jacksonii (Jackson's three horned chameleon)	Context-specific
	Trioceros melleri (Meller's chameleon)	Context-specific

7.4. REGULATIONS RELEVANT TO MANAGING SPECIFIC AREAS

7.4.1. Notifications from landowners regarding alien species on their land

Section 73(2)(a) of NEM:BA requires that "a person who is the owner of land on which a listed invasive species occurs must notify any relevant competent authority, in writing, of the listed invasive occurring on that land". The A&IS Regulations require that an assessment of the effectiveness of these regulations should be based on, inter alia, "notifications received from owners of land regarding listed invasive species occurring on their land".

Notifications received regarding alien species: There are nearly 6 million land parcels in South Africa of which 19% are state-owned, with the remainder in private ownership (Table 7.8). A total of 59 notifications were received and these constitute less than 0.001% of the total number of land parcels in the country. More than half of these (33) were from KwaZulu-Natal, and no submissions were received from four of the provinces (Limpopo, Mpumalanga, Northern Cape and Northwest). It appears that the vast majority of landowners are either ignorant of this requirement, or have chosen to ignore it.

TABLE 7.8 The number of land parcels in state and private ownership in South Africa, and the number of landowners that complied with the regulatory requirement to send notifications of alien and invasive species occurring on their property. Data are from www.ruraldevelopment.gov.za/phocadownload/Cadastral-Survey-management/Booklet/land%20audit%20booklet.pdf and www.politicsweb.co.za/documents/state-owns-19-of-land-parcels-in-sa--surveyor-gene

PROVINCE	STATE LAND	PRIVATE LAND	TOTAL NUMBER OF LAND PARCELS	NUMBER OF NOTIFICATIONS RECEIVED FROM OWNERS OF LAND PARCELS
Eastern Cape	113 195	547 856	661 051	9
Free State	163 012	439 407	602 419	2
Gauteng	249 057	1 400 348	1 649 405	3
KwaZulu-Natal	148 956	734168	883124	33
Limpopo	53 203	206 416	259 619	0
Mpumalanga	115 109	329 826	444 935	0
Northern Cape	56 263	176 346	232 609	0
North West	139 186	334 856	474 042	0
Western Cape	117 527	648 218	765 745	12

7.4.2. Notifications and directives issued to landowners

The NEM:BA empowers competent authorities to issue notices and directives to landowners, to ensure their compliance with the requirements of the Act and its regulations. There are three types of notifications – pre-compliance notices, compliance notices and warning letters. The National Environmental Management Act (NEMA) [section 31L (1)] and its regulations under the Act [Regulation 8] define and prescribe the procedure for issuing compliance notices (Box 7.2). Regulation 8 prescribes that before issuing a compliance notice, the intended recipient should be notified of the intention to issue such a notice in the form of a pre-compliance notice. A competent authority may also issue a warning letter, pre-directive and directive, usually to compel a person to take steps to minimise harm caused by listed invasive species on their property. However, the NEMA or NEM:BA Acts and their associated regulations do not define a "warning letter" and "pre-directive", nor do they prescribe their format.

These notifications and directives may be issued to a person who has: (i) failed to notify any relevant competent authority of the listed invasive species that occur on their property or to take steps to prevent or minimise harm to biodiversity; (ii) failed to comply with conditions specified on a permit, or who has failed to take all the required steps to prevent or minimise harm to biodiversity; and (iii) carried out a restricted activity with a listed alien species without a valid permit.

BOX 7.2 DEFINITIONS OF NOTICES, DIRECTIVES AND SEVERAL ASPECTS OF COMPLIANCE AS DEFINED BY THE NEMA AND NEM:BA ACTS, AND THEIR REGULATIONS.

There are several types of notifications and directives that can be issued to landowners to ensure their compliance with the requirements of the NEM:BA Act and its regulations. This box lists examples of the notifications and directives, which a competent authority can issue and under what circumstances.

Pre-compliance notice

Regulation 8 of the National Environmental Management (NEMA) Act 107 of 1998 prescribes that before issuing a compliance notice, the environmental management inspectorates (EMI) must give the person to whom the inspector intends to issue the compliance notice, an advance warning of the intention to issue the compliance notice. This is done by issuing a pre-compliance notice. The Regulations, therefore, provide for a reasonable opportunity to make representations to the EMI regarding why a compliance notice should not be issued. If an EMI has reason to believe, however, that the issuing of a pre-compliance notice will cause a delay that will result in significant and irreversible harm to the environment, the inspector may issue a compliance notice without meeting this requirement. If an EMI, for example, wants to issue a compliance notice to ensure compliance with section 28(1) of NEMA in a situation where harm to the environment is significant and imminent, he or she may issue a compliance notice directly. In such an instance, the EMI must explain the reasons for not issuing a pre-compliance notice in the eventual compliance notice.

Compliance notice

The overall aim of a compliance notice is to bring non-compliant actors into compliance with environmental legislation or with the conditions of permits, authorisations or other regulatory instruments. Non-compliance with a compliance notice, however, is an offence in terms of the NEMA. In this regard, section 31L(1) of NEMA states that an EMI may issue a compliance notice if there are reasonable grounds for believing that a person has not complied with a provision of the law for which that inspector has been designated or with a term or condition of a permit, authorisation or other instrument issued in terms of such law.

Directive

NEMA makes provisions to establish a duty of care and empower competent authorities (EMI) to direct transgressors to take a number of steps to remedy harm to the environment. A directive serves to direct, guide, and usually impels a person or company to take the necessary steps to remedy any harm to biodiversity caused by the action of that person or company.

Compliance

The action or fact of complying with instructions. This means that the person to whom the compliance notice was issued should comply with the instructions in the compliance notice e.g. applied for a permit.

Non-compliance

The failure to act in accordance with instructions. The means that the person to whom the compliance notice was issued did not comply with or adhere to the instructions in the compliance notice. And further action is required.

Criminal Investigation

An investigation into a crime, usually seeking to identify the offender and build a legal case against him or her. This action will be taken once there is non-compliance and can lead to the prosecution and sentencing of such a person.

Representations

Formal statements made to the Department of Environmental Affairs, especially to communicate an opinion or register reasons why a compliance notice should not be issued.

Notifications regarding invasive plant species. Notices have been served to the owners of 85 properties across South Africa; 59 of these notices went to private landowners, and 26 to plant traders. The notices involved up to 37 species on a single property and the two most common species were *Solanum mauritianum* (bugweed) (24 out 85 properties) and *Acacia mearnsii* (black wattle) (22 out 85 properties) (Table 7.9). Traders tended to receive notices regarding a single species; only a few of the species involved were found at more than one business premise. These were *Rubus fruticosus* (European blackberry) (8 out of 26 nurseries), *Pyracantha coccinea* (red firethorn) (4 out of 26), *Murraya paniculata* (orange jasmine) (5 out of 26), *Cinnamomum camphora* (camphor tree) (4 out 26), and *Murraya exotica* (orange jasmine) (3 out of 26) (Table 7.9). The notifications and directives were issued in six of the nine provinces (Figure 7.4); most were in the Western Cape and Mpumalanga, with none being issued in the North West, Northern Cape and Free State.

TABLE 7.9 The number of properties (either privately-owned land or business premises) that were served with notices and directives in connection with alien plant species in South Africa.

TAXON	SPECIES, COMMON NAMES IN BRACKETS	PRIVATE LANDOWNERS	PLANT TRADERS
PLANTS	*Acacia cyclops* (rooikrans)	7	0
	Acacia longifolia (long-leaved wattle)	3	0
	Acacia mearnsii and hybrids (black wattle)	22	1
	Acacia melanoxylon and hybrids, varieties and selections (Australian blackwood)	1	0
	Acacia saligna (Port Jackson)	9	0
	Acer buergerianum (Chinese maple)	0	1
	Agave americana subsp. *americana* var. *expansa* (spreading century plant)	1	0
	Ageratum housetonianum (Mexican ageratum)	1	0
	Arundo donax (giant reed)	3	0
	Callistemon viminalis (weeping bottlebrush)	1	0
	Campuloclinium macrocephalum (pompom weed)	1	0
	Casuarina cunninghamiana (beefwood)	2	0
	Chromolaena odorata (triffid weed)	1	1
	Cinnamomum camphora (camphor tree)	2	5
	Duranta erecta (forget-me-not-tree)	0	1
	Equisetum hyemale (rough horsetail)	0	1
	Eucalyptus camaldulensis and hybrids (red river gum)	2	0
	Eucalyptus cladocalyx and hybrids (sugar gum)	6	0
	Eucalyptus conferruminata (spider gum)	1	0
	Eucalyptus grandis and hybrids (saligna gum)	9	0
	Eucalyptus saligna (Sydney blue gum)	4	0
	Eucalyptus (gums)	3	0

TAXON	SPECIES, COMMON NAMES IN BRACKETS	PRIVATE LANDOWNERS	PLANT TRADERS
PLANTS Continued	*Jacaranda mimosifolia* (jacaranda)	0	1
	Lantana – all seed-producing species or seed-producing hybrids that are nonindigenous to South Africa (lantana)	17	1
	Litsea glutinosa (Indian laurel)	1	0
	Melia azedarach (syringa)	6	1
	Murraya paniculata (listed as *Murraya exotica* on the permit) (orange jasmine)	0	8
	Opuntia ficus-indica (sweet prickly pear)	1	1
	Pennisetum purpureum (elephant grass)	0	1
	Pinus (pines)	2	0
	Pinus elliottii and hybrids (slash pine)	1	1
	Pinus pinaster and hybrids (cluster pine)	8	1
	Pinus radiata and hybrids (Monterey pine)	2	0
	Pontederia cordata (pickerel weed)	0	1
	Populus alba (white poplar)	5	0
	Populus × *canescens* (grey poplar)	3	0
	Prosopis velutina (velvet mesquite)	2	0
	Pyracantha angustifolia (yellow firethorn)	0	1
	Pyracantha coccinea (red firethorn)	0	4
	Pyracantha koidzumii (formosa firethorn)	0	1
	Ricinus communis (castor-oil plant)	2	0
	Robinia pseudoacacia (black locust)	1	0
	Rubus cuneifolius and hybrid (American bramble)	1	0
	Rubus fruticosus (European blackberry)	0	8
	Sesbania punicea (red sesbania)	1	0
	Solanum mauritianum (bugweed)	24	0
	Tecoma stans (yellow bells)	2	0

Compliance with alien plant species notifications. The overall compliance was high (95%), and this was achieved through clearing plants from properties, applying for permits, withdrawing listed species from trade, submitting invasive species management plans or making representations as to the need for a compliance notice; there were only 4 cases that were non-compliant (Table 7.10). In three of these cases, the landowners were either issued with a pre-compliance notice or pre-directive, but they did not submit any representations as to why a compliance notice or directive should not have been issued. In one case, the landowner did not comply with a directive to submit an invasive species management plan and to clear listed invasive plant species from their property, and the DEA intends to open a criminal case.

TABLE 7.10 The level of compliance by landowners issued with notifications for restricted activities with listed alien and invasive plant species in South Africa.

TAXON	TYPE OF NOTIFICATION AND DIRECTIVE	COMPLIANCE	NON-COMPLIANCE	CRIMINAL INVESTIGATION	PROSECUTIONS
PLANTS	Pre-compliance notice	24	1	0	0
	Compliance notice	0	0	0	0
	Pre-directive	53	2	0	0
	Directive	0	1	0	0

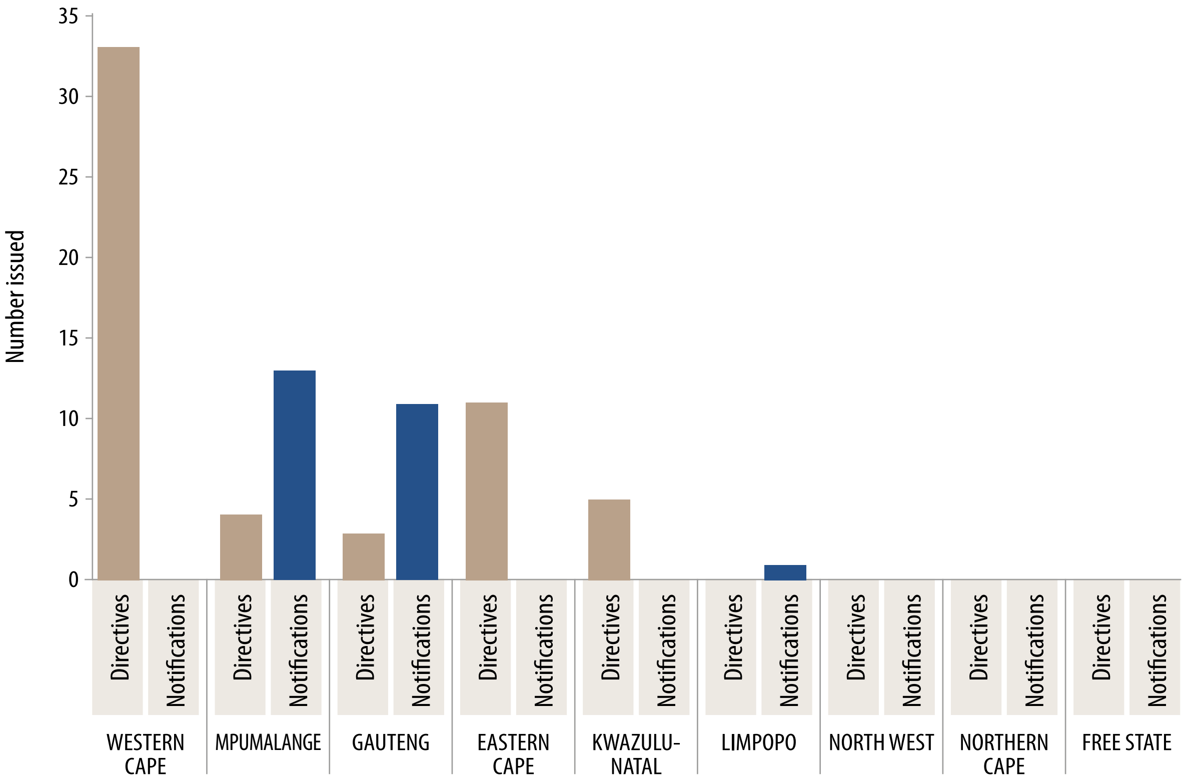

FIGURE 7.4 The number of notifications (pre-compliance notices, compliance notices and warning letters) and directives (pre-directive and directive) that were issued for activities with listed alien and invasive plant species in each province in South Africa, 2014–2016.

Notifications regarding invasive animal species. Notices have been served to the owners of 119 properties across South Africa; 78 of these properties (66%) were pet shops, 19 were game farms (16%), 12 were other private landowners (10%) and 10 were sanctuaries or zoological gardens (8%). The highest number (60%) of species was owned by pet shops and these included reptiles (14 species), birds (2 species), one fish and one terrestrial invertebrate species (Table 7.11). The species that were common were *Psittacula krameri* (rose-ringed parakeet) (55 out 78 properties), *Boa constrictor* (common boa) (26), *Iguana iguana* (green iguana) (17) and *Python molurus* (Indian rock python) (17). Sanctuaries and zoological gardens held specimens of reptiles (5 species), mammals (5 species) and birds (3 species) (Table 7.11). Species found on game farms included mammals (9 species) and one reptile (*Basiliscus plumifrons*, plumed basilisk). The notifications covered all the nine provinces of the country (Figure 7.5). The highest number of notifications was recorded in KwaZulu-Natal (16%), Limpopo (15%) and Mpumalanga (15%) while the least was in Free State (7%) and Western Cape (7%). No directives were issued for any restricted activity with alien and invasive species in any of the provinces in the country.

TABLE 7.11 The number and type of properties served with notices and directives for restricted activities with listed alien and invasive animal species in South Africa.

TAXON	SPECIES	GAME FARMS	PRIVATE HOLDINGS	SANCTUARY OR ZOOLOGICAL GARDENS	TRADERS
TERRESTRIAL INVERTEBRATES	*Achatina fulica* (giant African snail)	0	0	0	1
FISHES	*Oreochromis niloticus* (Nile tilapia)	0	1	0	0
	Plecostumus (loricariid catfishes)	0	0	0	2
REPTILES	*Basiliscus plumifrons* (plumed basilisk)	1	0	0	1
	Basiliscus vittatus (basilisk)	0	0	0	4
	Bitis nasicomis (rhinoceros viper)	0	0	0	1
	Boa constrictor (common boa)	0	2	2	26
	Crotalus (rattlesnakes)	0	1	1	7
	Furcifer pardalis (panther chameleon)	0	0	0	2
	Iguana iguana (green iguana)	0	0	3	17
	Morelia amethistina (amethystine python)	0	0	0	2
	Morelia spilota (carpet/diamond python)	0	2	2	7
	Pantherophis guttatus guttatus (cornsnake)	0	0	0	2
	Python bivittatus (Burmese python)	0	0	0	2
	Python molurus (Indian python)	0	2	3	17
	Trachemys scripta elegans (red eyed elegans)	0	0	0	2
	Trachemys (sliders turtles)	0	0	0	1
BIRDS	*Alectoris chukar* (chukar partridge)	0	0	1	0
	Anas platyrhynchos (mallards)	0	2	2	3
	Psittacula krameri (rose-ringed parakeet)	0	7	6	55
MAMMALS	*Aepyceros melampus petersi* (black-faced impala)	3	0	0	0
	Ammotragus lervia (babary sheep)	8	0	1	0
	Antilope cervicapra (Indian blackbuck)	1	0	0	0
	Axis axis (Chital)	1	0	0	0
	Axis porcinus (hog deer)	2	0	0	0
	Cervus elaphus (red deer)	0	1	3	0j
	Dama dama (fallow deer)	11	0	1	0
	Kobus leche kafuensis (Kafue lechwe)	2	0	0	0
	Kobus leche leche (red lechwe)	14	0	1	0
	Oryx dammah (scimitar-horned oryx)	6	0	1	0

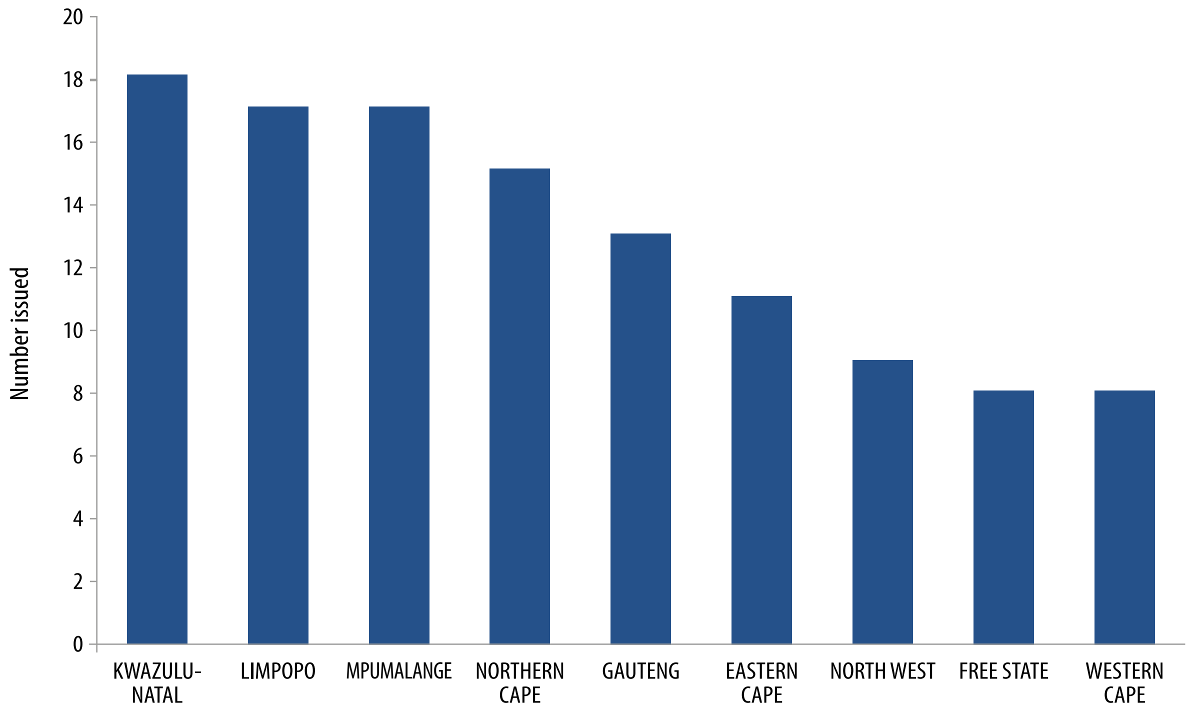

FIGURE 7.5 The number of notifications (pre-compliance notice, compliances notice and warning letters) issued for activities with listed alien and invasive animal species in each province in South Africa, 2014–2016. There were no directives (pre-directive and directive) issued.

Compliance with alien animal species notifications. The notifications and directives issued for restricted activities with alien and invasive animal species consisted mainly of pre-notices (66%) with a few warning letters (20%) and compliance notices (14%) (Table 7.12). The overall compliance for all the notifications was 82%, and compliance was achieved through applying for permits, the removal of some species from the list of regulated species, and removal of the species from properties. There was only one case of a pending criminal investigation that was instituted after the landowner was issued with a compliance notice but she still continued to trade listed alien species without a permit.

TABLE 7.12 The level of compliance by landowners issued with notifications for restricted activities with listed alien and invasive animal species in South Africa.

TYPE OF NOTIFICATION AND DIRECTIVE	COMPLIANCE	NON-COMPLIANCE	CRIMINAL INVESTIGATION	PROSECUTIONS
Pre-compliance notice	69	10	0	0
Compliance notice	14	2	1	0
Warning letter	15	8	0	0

7.4.3. Level of compliance with property transfer notifications

The regulations require that the sellers of any immovable property must, prior to the conclusion of the relevant sale agreement, notify the purchaser of that property, in writing, of the presence of listed invasive species on that property. However, it is not possible to assess whether, or to what degree, this requirement has been adhered to. There is no requirement in the regulations for any person other than the purchaser to be notified, and the DEA has no information in this regard.

7.4.4. Invasive Species Monitoring, Control and Eradication Plans (i.e. area management plans)

Management authorities of protected areas, and all other organs of state in all spheres of government are required to prepare area management plans (termed "Invasive Species Monitoring, Control and Eradication Plans" in the regulations), and to submit those plans to the Minister and to SANBI. In order to facilitate the preparation of these plans, guidelines were developed and published by the DEA one year after the publication of the A&IS Regulations (www.environment.gov.za/sites/default/files/legislations/nemba_invasivespecies_controlguideline.pdf). Plans then had to be submitted within two years of the publication of the guidelines. A total of 29 control plans were submitted during the period between September 2016 and March 2017, 12 of which were separate plans submitted by the City of Cape Town (Table 7.13). Five of the plans were for private land, even though private landowners are not obliged to submit such plans unless requested by the DEA and three of these were requested. The submitted control plans cover only about 4% of the country and most of the plans were for the Western Cape (Figure 7.6).

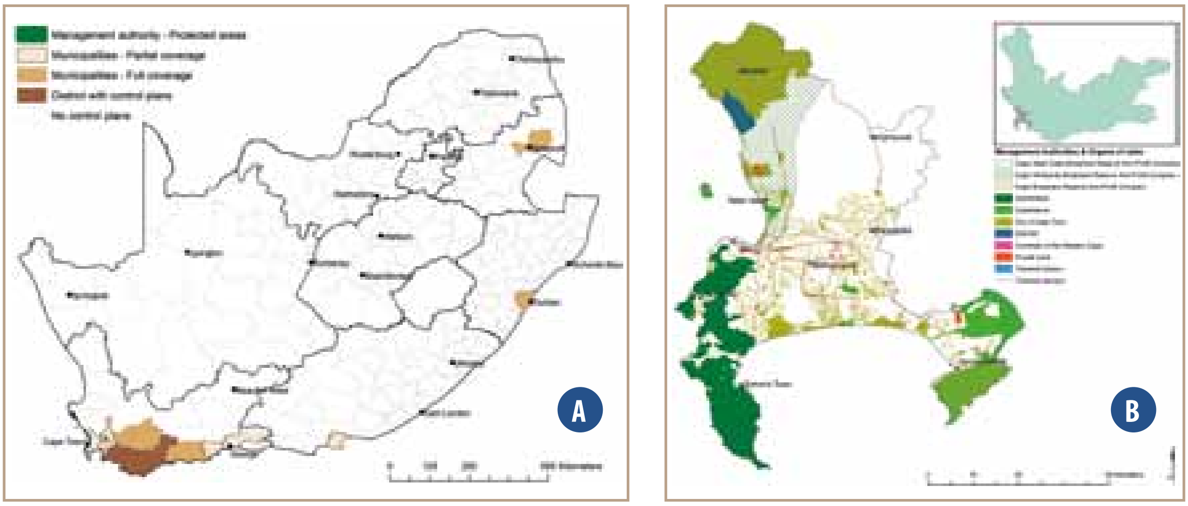

FIGURE 7.6 (a) Coverage of area management plans in South Africa. (b) Boundary of the Cape Town municipality, showing the range of protected areas managed within the municipal boundary by various organs of state, and for which area management plans are required. These include a National Park, provincial nature reserves, municipal nature reserves, other municipal land, transport networks, airports and harbours, university and school grounds, electricity supply premises and biosphere reserves, indicating the complexities in assessing which land is under management and the organ of state that must submit the area management plan.

The guidelines for control plans set out the requirements for adequate planning, and plans were required to include the following:

- A detailed list and description of any listed invasive species occurring on the relevant land.
- A description of the part of land that is infested with such listed invasive species.
- An assessment of the extent of such infestation.
- A review of the efficacy of previous control and eradication measures.
- A description of the measures to monitor, control and eradicate the listed invasive species.
- Measurable indicators of progress and success, and indications of when the control plan is to be completed.

The degree to which each of these requirements was met was assessed for each of the submitted plans, using the proposed indicator *Planning coverage* (see Appendix 1). Each plan was placed into one of three categorises, as follows:

- Adequate: all of the criteria from the guidelines were addressed and are of adequate standard;
- Partially adequate: most of the required criteria (> 50%) were addressed, and are of adequate standard; and,
- Inadequate: most of the required criteria (≤ 50%) were not addressed from the control plan.

Using these criteria, only one plan was of adequate quality, 12 were partially adequate and 16 inadequate (Table 7.13). The reason for both the relatively small number of plans, and the inadequacy of many plans, could be a lack of capacity or expertise within many organs of state. Several organs of state have officially requested an extension on the deadline for submission of plans. In some of the stakeholder meetings held during the preparation of this report, it became evident that there might be more plans that were prepared by several government entities, but these were not submitted to DEA in terms of the NEM:BA regulations and therefore were not available for assessment.

TABLE 7.13 Area management plans submitted to the Department of Environmental Affairs in terms of the 2014 A&IS Regulations (termed "Invasive species monitoring, control and eradication plans" in the regulations) up until March 2017.

SUBMITTING AGENCY	LOCATION	AREA (hectares unless stated otherwise)	AREA CATEGORY	ADEQUACY OF PLAN
South African National Roads Agency (SANRAL)	All national roads	21 945 km of road network	Organ of state	Inadequate
Breede Valley Municipality	Breede Valley Municipality	299 500	Municipality	Inadequate
Langeberg Municipality	Langeberg Municipality	451 800	Municipality	Inadequate
Eskom	Koeberg Nature Reserve	2667.48	Organ of state	Inadequate
N3 Toll Concession	N3 Toll Road	1 600 km of road	Organ of state	Inadequate
Overberg District Municipality	Overberg District Municipality	1 224 100	Municipality	Inadequate
Hessequa Municipality	Hessequa Municipality	No data	Municipality	Partially adequate
Airports Company South Africa	King Shaka International Airport	2 060	Organ of state	Inadequate
Drakenstein Municipality	Paarl Mountain Nature Reserve	2 038	Protected area	Partially adequate
City of Cape Town	Blaauwberg Nature Reserve	1 452	Protected area	Partially adequate
	Cape Town Parks	372	Protected areas	Inadequate
	Dassenberg Coastal Catchment Programme	30 000	Protected area	Partially adequate
	False Bay Nature Reserve	1 957	Protected area	Partially adequate
	City of Cape Town residential units	1 136	Housing land parcels	Inadequate
	Hout Bay Llandudno suburbs	141	Residential areas	Inadequate
	Kenilworth Racecourse Conservation Area	45	Protected area	Adequate
	Macassar Dune Nature Reserve	910	Protected area	Partially adequate
	Table Bay Nature Reserve	956	Protected area	Partially adequate
	Wemmershoek Dam catchment area	2 486	Municipality	Partially adequate

SUBMITTING AGENCY	LOCATION	AREA (hectares unless stated otherwise)	AREA CATEGORY	ADEQUACY OF PLAN
Fancourt South Africa	Fancourt Hotel and Estate, George	No data	Private land	Partially adequate
Arabella Country Estate	House of Arabella hotel and residential plots and Golf course	113	Private land	Partially adequate
The Alien SWAT Team (Pty) Ltd and Charlotte Jefferey	Erf 4211, 9 Mount Street, Grahamstown	1	Private land	Partially adequate
Stellenbosch University	Stellenbosch University Campus	447	Organ of state	Partial adequate
Kana Environmental Consultants	Portion 1 of farm Schuinspad No. 375.	No data	Private land	Inadequate
Cape Environmental Assessment Practitioners	Portion 1 of Farm 210 Saffraan Rivier, Oudtshoorn	52	Private land	Inadequate
Transnet	Transnet freight railways	861.51 km of rail lines	Organ of state	Inadequate
Bitou/Eden Municipality	Bitou/Eden Municipality	99 200	Municipality	Inadequate
COEGA Industrial development zone and port	Port Elizabeth	11 362	Organ of state	Inadequate
eThekwini Municipality	eThekwini Municipality	75 000	Municipality	Inadequate

7.4.5. Status reports for protected areas

The management authorities of protected areas have been required [since 2004 in terms of Section 77 (1) of NEM:BA] to prepare a report on the status of any listed invasive species that occur in protected areas under their jurisdiction at "regular intervals", and to submit these to the Minister or the MEC for Environmental Affairs in their respective province. Such reports must include a detailed list and description of all listed invasive species that occur in the protected area; provide a detailed description of the parts of the area that are infested with listed invasive species; an assessment of the extent of such infestation; and a report on the efficacy of previous control and eradication measures.

It appears that no such reports have been prepared. Given that the reports were to be prepared for *listed* species, and the fact that species were only listed in 2014, it is perhaps not surprising that reports have not been prepared. Nonetheless, there do appear to be capacity constraints that may affect the ability of the relevant management authorities to prepare such reports (Box 5.2).

7.5. RESEARCH PROPOSAL AND REPORTS

The A&IS Regulations require organisations that conduct state-funded research on an invasive species, or potentially invasive species, to lodge the proposals for such research with SANBI. This requirement also applies to research by any person to whom a permit has been issued to carry out restricted activities for the purposes of research involving an alien or listed invasive species. The regulations also require that copies of any findings of research must, upon completion, be lodged with the Institute and with the Minister. The intention of these regulations is presumably to build a database of state-funded research projects and research findings, to guide policy formulation and management.

As of October 2017, no such proposals or findings had been lodged with the Institute, despite a substantial amount of research being funded by the state. For example, the Natural Resource Management (NRM) programs of the Department of Environmental Affairs have allocated around ZAR90 million to research on invasive species over three years (presentations made to the DEA NRM's Research Advisory Panel); the DST-NRF Centre for Invasion Biology has an annual budget of ZAR25 million; and science councils such as the Council for Scientific and Industrial Research and the Agricultural Research Council, funding agencies such as the Water Research Commission and the National Research Foundation, universities and municipalities all invest state funds into relevant research. It appears, therefore, that researchers and research organisations are either ignorant of this requirement, or have chosen to ignore it.

7.6. PROSECUTIONS UNDER THE REGULATIONS

A person may be found guilty of an offence if that person contravenes or fails to comply with certain provisions of the A&IS Regulations. Such a person would be liable, on conviction, to a fine not exceeding five million rand, and in the case of a second or subsequent conviction, to a fine not exceeding ZAR10 million; or imprisonment for a period not exceeding 10 years; or to both a fine and imprisonment. To date, no cases have been brought to trial and there have therefore not been any successful, or unsuccessful, prosecutions under the A&IS Regulations.

7.7. SYNTHESIS AND INDICATOR VALUES

The A&IS Regulations were published in 2014 and have been in effect for less than three years. It is therefore somewhat early to assess their effectiveness, and at this stage most of the reporting requirements outlined above describe inputs rather than outputs or outcomes. Nonetheless, a number of points emerge.

There appear to be very high levels of non-compliance with many of the regulations at this stage. Non-compliance can be seen in the very low number of submissions of area management plans, and of notifications from land owners of listed alien species on their land; a complete absence of research proposals and outputs submitted; and very low numbers of requests received for permits for widespread category 2 species. The reasons for non-compliance could include widespread ignorance of the regulations, a lack of capacity to comply with the regulatory requirements (reflected, for example, in requests from organs of state for extensions to submission deadlines for plans), or a decision to ignore the requirements.

There is also a need for monitoring the long-term trends in compliance and effectiveness. Most of the reporting requirements presented here are simply inputs, and monitoring outcomes, and ways of linking those outcomes to regulatory inputs remains a challenge.

This assessment has not found any evidence of the strategic use of the regulations to achieve particular goals in priority areas. For example, areas could be identified where the reduction of alien plant invasions could be more easily achieved because the invasions are at an early stage, and where the consequences of not acting rapidly would mean that the problem would grow to unmanageable proportions. The approach at present seems to either be random, or to deal with easy targets such as traders (nurseries and pet shops), rather than identifying and prioritising relevant landowners for the issuing of notifications on the basis of the impact they might have on invasions.

The implementation of the regulations has been particularly challenging in cases where the regulated species have commercial or other value, and dealing with these issues has absorbed a great deal of capacity (though the amount of capacity has not been formally computed as of yet). The most prominent example has been the attempt to regulate both *Oncorhynchus mykiss* (rainbow trout) and *Salmo trutta* (brown trout) (Woodford *et al.*, 2017). This has been fiercely contested through public and political lobbying by angling organisations. This included opposition to a project intending to remove alien fishes from four rivers to allow for the recovery of indigenous fish populations (Marr, Impson & Tweddle 2012; Weyl *et al.*, 2014); challenging 2013 and 2014 revisions of the NEM:BA regulations as unconstitutional, and challenging the status of trout as an invasive species. This situation is regarded as unfortunate (Ellender *et al.*, 2014) because the NEM:BA A&IS Regulations point towards a mutually beneficial strategy, conserving indigenous biodiversity in key areas while allowing for the development of fisheries in others. It is unlikely that the conflict will be resolved soon, and the lack of acceptance of the proposed legislation by trout lobby groups creates potential for non-conformity and further spreading of these species to areas where they do not yet occur.

Finally, where data are available on the efficacy of the regulations it is at best in terms of outputs, i.e. the number of permits that were issued, refused, and the number of prosecutions that have resulted from non-compliance. However, an assessment of the effectiveness of the regulations would have to be on the basis of demonstrated impact on the status of biological invasions in terms of pathways, species, or areas (see Chapters 3–6), i.e. the outcomes. This will require some extrapolation, e.g. to estimate the invasion debt. For example, if a permit is not issued for a given species on the basis of a risk analysis, can the non-introduction of that species be deemed as one fewer invasive species in the country? Agreed methods need to be developed. The current assessment of the indicators for quality of assessment is presented in Table 7.14.

TABLE 7.14 An indicator for reporting on the effectiveness of regulations. For full details of how to calculate the indicator, see Appendix 1.

INDICATOR	METRIC BASIC ••••••••••••••••••••••	•ADVANCED	LEVEL OF CONFIDENCE	NOTES
13. Quality of regulatory framework (input)	**13.1.** Overall quality Substantial	**13.2.** Quality assessed for different agencies, and for collaboration Data not available	**13.1.** Moderate	Assessment was done by a semi-independent team of invasion scientists but the team did not include anyone from the legal profession

8

KNOWLEDGE AND INFORMATION GAPS IN UNDERSTANDING THE STATUS OF BIOLOGICAL INVASIONS

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Cotoneaster franchetii (cotoneaster) – A Barra

Chapter summary

This chapter highlights gaps in the available information on pathways of introduction and dispersal, the status of alien species and of areas invaded, and the effectiveness of interventions. The chapter further identifies key limitations and opportunities for enabling processes towards management of biological invasions in South Africa, key topics not covered in this report that should be prioritised for subsequent reports, and processes for future reports.

In particular three key areas of focus are identified: (1) the need for more research to determine and assess the impacts of alien species; (2) better monitoring of the effectiveness of current control measures; and (3) the development of methods to look at the impact of biological invasions and their management on society as a whole.

Harversting mass-reared biological control agents for release – Kim Weaver

8.1. APPROACH USED IN THIS CHAPTER

The previous chapters (one to seven) revealed that the management of biological invasions in South Africa is complex and inter-disciplinary. It is undertaken by multiple stakeholders, including national, provincial, and local government departments, various NGOs, and the private sector. A set of indicators has been developed to track trends in biological invasions and the effectiveness of their management, but in many cases it was not possible to confidently assign values to these indicators because of a lack of data. This chapter presents gaps in knowledge and information that limit our ability to report on the status and management of biological invasions.

Firstly, when writing this report, it became clear that some data were not available and so analyses could not be conducted. Secondly, other gaps were identified during consultations with experts and other groups – while soliciting inputs for the special issue of the journal *Bothalia: African Biodiversity and Conservation* (Wilson *et al.*, 2017); from comments received during the review process; and from other consultative processes where the team presented preliminary findings.

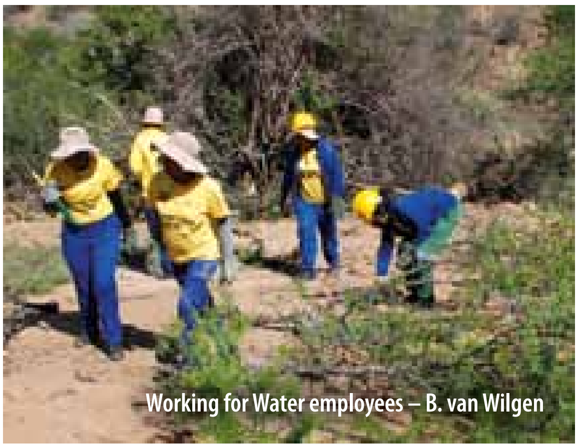
The first part of this chapter presents gaps in information needed to assign values to the indicators outlined in Chapter 2 – starting with the high level indicators, then specific indicators for *pathways* of introduction and dispersal, the status of alien *species* and *areas* invaded and then on the *effectiveness of interventions* (control measures and regulations).

In the second part of this chapter, broader questions beyond the framework developed in Chapter 2 are discussed. Specifically, gaps and opportunities in enabling processes and other cross-cutting issues are identified. The chapter ends with a discussion of some of the key gaps that would need to be addressed, and processes that could be followed, for producing future reports.

8.2. GAPS IN POPULATING THE INDICATORS FOR THE REPORT

8.2.1. High-level indicators

The high-level indicators were developed for use in national-level reporting on the status of biodiversity in South Africa. The four high-level indicators are intended to provide simple but informative information on: (A) the pathways of introduction and dispersal, (B) the status of alien species, (C) areas invaded and (D) the effectiveness of interventions (control measures and regulations). The gaps relating to these indicators and proposed solutions are outlined in Table 8.1.


Working for Water employees – B. van Wilgen


Micropterus dolomieu (smallmouth bass) – Cape Nature

TABLE 8.1. Data and information gaps relating to high-level indicators on the status of biological invasions.

HIGH-LEVEL INDICATOR	CURRENT LEVEL OF KNOWLEDGE AND INFORMATION GAPS	PROPOSED SOLUTION FOR SUBSEQUENT REPORT
A. Rate of introduction of new unregulated species (pathways)	Knowledge of rates of introductions is largely based on observations of alien species post-border, rather than interceptions at border. It is not always possible to determine dates of introduction based on dates of first record. Only data on inputs and not on outputs are recorded. Currently, the Department of Agriculture, Forestry and Fisheries (DAFF) is responsible for most surveillance with a focus on agricultural pests and diseases. Surveillance by the Department of Environmental Affairs is only done at one of the 72 entry points, and then only during working hours.	An integrated approach with other authorities that report and monitor the introduction of species at ports of entry is needed. Alignment by the DEA with the DAFF processes is needed to ensure adequate monitoring and reporting on the rates of introduction of new species, and that relevant interception data with both positive and negative results are curated and included in future reports.
B. Number of invasive species that have major impacts (species)	There are few data on the impacts caused by even the most widespread species, and so this indicator cannot be estimated reliably. There is generally a dearth of accessible studies documenting impacts of alien species across all taxa. Studies of the impacts on socio-economic issues (e.g. human and animal health, agriculture, livelihoods, values, and food security) are often entirely missing.	There is a need for a system of collating information on impact through formal EICAT and SEICAT assessments. The impacts associated with the most widespread and invasive species need to be confirmed and documented. The list might change over time, so procedures to obtain the first list are needed. Studies that document impacts of individual invasive species and/or taxa need to be promoted and funded, and in particular to explore taxa other than invasive alien plants. An integrated and coordinated approach in documenting and undertaking research and management of invasive species with impacts on socio-economic issues is needed. Efforts with other relevant departments where the impacts of invasive species are relevant at national, provincial and local levels [e.g. DAFF, Department of Health, Department of Water and Sanitation (DWS)] need to be aligned and co-ordinated.
C. Extent of area that suffers major impacts from invasions (areas)	There are some data available on the distribution (occurrence) of invasive alien plants and birds at the scale of quarter degree grid cells, but there is limited or no knowledge about the impacts caused by non-plant taxa. Even less is known about the abundance of invasions at sites where the relevant alien species occur. The lack of knowledge about (1) the impacts of individual species, and (2) their abundance precludes any sensible estimate of the area that experiences major impacts.	A systematic approach to documenting the level of non-plant invasions at sites is needed. Monitoring techniques to estimate the extent of invasions and models to go from this to projected impacts need to be developed. The extent of invasions at the scale of both biophysical (biomes, catchments or ecosystems) and administrative (provincial or municipal) areas need to be documented. Remote sensing tools should be used to provide a broad-scale analysis of areas that are heavily invaded.
D. Level of success in managing invasions (interventions – control measures and regulations)	The capacity and understanding exists to measure the degree of control achieved by plant biological control, but currently very little can be said about the effectiveness of other forms of management due to a lack of monitoring. The effectiveness of the Regulations (NEM:BA: Alien and Invasive Species Regulations, 2014) has not been assessed as it is too early to do so.	Adequate procedures, including goal-setting and monitoring, need to be in place for future assessments of management effectiveness to be meaningful. An integrated and coordinated approach and alignment with other programmes by other government departments and institutions is needed. Explore options to ensure adequate monitoring data are collected (e.g. clearing contracts are not paid out until there is a documented assessment of performance) The indicator needs to be assessed at different scales and areas and through simulations to explore how responsive it is to different behaviours. A system of setting up national or local goals and the strategies to achieve these is needed.

8.2.2. Pathways

This section deals with knowledge and information gaps on the introduction of alien species into the country and dispersal or spread within biomes and political boundaries. The report highlights the fact that aliens continue to get into the country through our 72 official ports of entry, and continue to spread within the country, but the rate at which introductions occur cannot be accurately quantified. There is a need for a monitoring system at ports of entry to reduce the risk of introductions, and a need to understand within-country dispersal across biomes and political boundaries. This also calls for a more integrated and coordinated approach at ports of entry to include efforts by different authorities (e.g. DAFF and DEA).

TABLE 8.2 Gaps in information and knowledge for pathways of introduction and dispersal.

PATHWAY INDICATOR	CURRENT LEVEL OF KNOWLEDGE AND GAPS	PROPOSED SOLUTION FOR SUBSEQUENT REPORT
1. Introduction pathway prominence	Socio-economic information is required to assess introduction pathway prominence. Some of the required data are available from global and local databases. However, for some of the pathways of introduction these data could not be obtained. Unfortunately, these data are often owned by companies or are regarded as sensitive and, therefore, it is often difficult or impossible to obtain the required information. In some instances, large sums of money need to be paid to the companies that own the information to gain access to these data (for an example see Faulkner *et al.*, 2017a). Finally, for some pathways it is difficult to obtain or collate relevant socio-economic data, simply because the description of the pathway is imprecise (e.g. 'other intentional release').	To lessen the gaps in our knowledge on the pathways of introduction and dispersal, research into specific pathways is required, particularly for inconspicuous pathways such as e-commerce (Humair *et al.*, 2015). It is important to note that research is currently being undertaken on a number of pathways of introduction, including the pet trade, the traditional medicine trade and the aquarium plant trade. This information needs to be incorporated into subsequent reports.
2. Introduction rates	To assess introduction rates for the pathways, pathway of introduction and date of introduction data for the species introduced to South Africa are required. These data are not available or have not been collated for many alien species, particularly for introduced plants and insects (Faulkner *et al.*, 2015). Additionally, the dataset used in this assessment (see Faulkner *et al.*, 2015) was collated a few years ago, and so data for very recently introduced species [e.g. the marine amphipod *Caprella mutica* (Japanese skeleton shrimp)] are not included (Peters & Robinson, 2017). The pathway of introduction data that are available was in some instances also not of sufficient quality or detail to designate pathways of introduction with certainty. Furthermore, the increased level of detail provided by the pathway categorisation scheme adopted by the CBD (CBD, 2014) has led to an increase in uncertainty when designating pathways of introduction (Tsiamis, Cardoso & Gervasini, 2017). This is because the differences between some of the pathway subcategories are unclear (Tsiamis, Cardoso & Gervasini, 2017). Although an effort was made to rate the confidence in the pathway categorisations and in the assessment as a whole, information on the quality and source of the original data (e.g. direct evidence vs. assumptions based on species traits or knowledge from other regions) are required to better rate confidence, and these data were often not available. Few introduction pathways have been researched in detail, but the work that has been done includes research into the aquatic plant trade (Martin & Coetzee, 2011), trade in traditional medicine (Wojtasik, 2013; Byrne, Williams & Wojtasik, 2017), and the unintentional introduction of contaminants on imported plant cuttings (Saccaggi & Pieterse, 2013).	The rates of species introduction into, and spread within, South Africa need to be quantified. One possible extension is to weight pathways according to the consequences of the species introduced, i.e. whether species introduced along a particular pathway led to particularly severe impacts. For example, in the Czech Republic species that were introduced intentionally seem to be more likely to have naturalised and become invasive, but invasive taxa that were accidentally introduced tend to be more widespread and have greater impacts, perhaps because they have been preselected for dispersal and competitive traits (Pyšek, Jarošík & Pergl, 2011).

PATHWAY INDICATOR	CURRENT LEVEL OF KNOWLEDGE AND GAPS	PROPOSED SOLUTION FOR SUBSEQUENT REPORT
3. Within-country pathway prominence	Limited knowledge on the spread of invasive species throughout the country from ports of entry.	An assessment of the relative prominence of dispersal pathways within South Africa is needed.
4. Within-country dispersal rates	Data on within-country dispersal have not been collated for alien species in South Africa. Such information is only available for a few groups of extralimital species [e.g. amphibians (Measey *et al.*, 2017) and fish (Picker & Griffiths, 2017)].	*Within-country dispersal rates* for the pathways of dispersal should be assessed using data on the pathways and dates of dispersal for introduced species and species that are indigenous to the country but that have been introduced to parts of the country where they are not indigenous (extralimital introductions).

8.2.3. Species

There is a disparity in the amount of information available on species occurrence, distribution and impact between different taxa. For example, the number and extent of occurrence is fairly well known for terrestrial and freshwater plants and for birds, but not for other taxa. There is almost a complete lack of information on the abundance and impact of alien species (Table 8.3).

TABLE 8.3 Knowledge and information gaps on the status of alien species

SPECIES INDICATOR	CURRENT LEVEL OF KNOWLEDGE AND GAPS	PROPOSED SOLUTION FOR SUBSEQUENT REPORT
5. Number and status of alien species	The numbers of alien terrestrial plant species and vertebrate species are well documented. The number of alien invertebrates, marine species and, especially, microbial species are much less well known. The same applies to introduction status, i.e. alien plant and vertebrate species are relatively well documented compared to other taxa. However, introduction status is not formally recorded anywhere, so this aspect cannot accurately be summarised and updated.	Databases should record introduction status, and the records should be updated regularly.
6. Extent of alien species	Reliable distribution data are available for terrestrial and freshwater plants and birds, but not for other taxa. This status report was only able to estimate the extent of 835 out of the 2033 species (section 5.2.1).	Databases for terrestrial and freshwater plants and birds should continue to be updated, and more effort will be needed to assemble reliable data on taxa other than terrestrial and freshwater plants and birds.
7. Abundance of alien species	The *Abundance of alien species* is very poorly known. For almost all species, there are no assessments of cover or density (for sessile organisms) or of population sizes or biomass (for mobile organisms). There is a mapping exercise under way to estimate the cover of invasive alien plants (Kotzé *et al.*, 2010), but it is limited to about half of the country and to selected taxa, and there are concerns that the methodology is not documented.	The use of remote sensing techniques should be explored. For mobile organisms, distribution and population size data could be used to model abundance, but this would require research.

8. Impact of alien species	For most species, there is almost no documented evidence of impact, and available evidence is mainly anecdotal (e.g. not available as peer reviewed research papers). There are some notable exceptions, for example for *Prosopis* species (see Box 4.2). Several taxa are listed at levels other than species (e.g. genus or family), but fundamentally biological invasions result from introduction events resulting in a population-level phenomenon. Impacts at the gene level can be particularly concerning (e.g. the loss of indigenous species through hybridisation), but have rarely been assessed.	An understanding of impacts of invasive species can be strengthened by new approaches, including assessments of the effects of the species concerned on ecosystem services, ecosystem resilience, human livelihoods, agriculture, and animal and human health. There is a need for a system of collating information on impact through formal EICAT and SEICAT assessments. There is a need to promote and fund studies that document impacts of individual invasive species, and in particular to explore species other than invasive alien plants. There needs to be an integrated and coordinated approach to documenting and undertaking research and management of invasive species with impacts on socio-economic issues, in addition to the biophysical or ecological effects. Efforts are needed to align the activities of relevant government departments (e.g. the DAFF, DEA, Department of Health, and the DWS), as invasive species have a variety of impacts across national, provincial and local levels. There will need to be a substantial on-going investment in impact studies for EICAT and SEICAT to be sufficiently reactive to allow the monitoring of trends on the scale of years rather than decades.

8.2.4. Areas

Obtaining accurate information on the presence, abundance and impact of a suite of co-occurring alien species in a particular area has been challenging due to many gaps in information (Table 8.4).

TABLE 8.4 Information and knowledge gaps in areas invaded

AREA INDICATOR	CURRENT LEVEL OF KNOWLEDGE AND GAPS	PROPOSED SOLUTION FOR SUBSEQUENT REPORT
9. Alien species richness	There are data on the extent of species that can be used to assess *Alien species richness* in areas using Geographic Information System (GIS) overlays. These data are much more comprehensive for terrestrial and freshwater plants and for birds than for other taxa.	Most provincial conservation departments should have information about invasions in their protected areas. These data were not available or accessible at the time of this assessment, and will need to be sourced for future reports.
10. Relative alien species richness	As above, plus there is a need for good spatial data on the distribution of indigenous species.	The processes of documenting distributions of indigenous species would need to be improved.
11. Relative invasive abundance	There are no reliable data to assess abundance. There are insufficient data to assign values of cover, biomass or population size to indigenous species, which would be needed if relative abundance is to be estimated.	More research is needed in priority areas to assess relative abundance At a finer scale it can be important to consider abundance in ecologically relevant sub-divisions, e.g. habitats or vegetation types.

AREA INDICATOR	CURRENT LEVEL OF KNOWLEDGE AND GAPS	PROPOSED SOLUTION FOR SUBSEQUENT REPORT
12. Impact of invasions	There are very few data on the impacts of co-occurring alien species in particular areas. There are a few studies on impacts on water resources at a catchment scale, and on rangeland productivity and biodiversity at a biome scale. These are coarse estimates, as many assumptions had to be made due to a lack of impact studies at a species scale. The choice of what to measure in terms of the *Impact of invasions* will be influential and the importance of different impacts will be context-dependent. A "minor" reduction in biodiversity in a biodiversity hotspot might be much more important than a "massive" reduction elsewhere; similarly providing the cost of an invasion in absolute terms might hide major and profound societal inequities.	More research is required to translate the species-level impact into ecosystem-level impacts, and protocols need to be developed that will allow for joint consideration of environmental and socio-economic impacts when making decisions. There are insufficient data to express the effects of reductions in ecosystem services in economic or social terms (De Lange & Van Wilgen, 2010). There is a need for a conceptual link with the EICAT and SEICAT scheme for species. Reductions in ecosystem services should be placed in the context of how critical those services are in particular areas.

8.2.5. The effectiveness of interventions (control measures and regulations)

An assessment of the effectiveness of regulatory and control interventions needs to consider inputs, outputs, and outcomes. Generally, inputs (money spent, resources deployed) should be relatively easy to assess, but an assessment of outputs requires at least a monitoring programme that collects data, which is not always the case. Finally, there was an almost complete lack of information that would allow for an assessment of outcomes, or that would allow the linking of an outcome to a particular intervention (Table 8.5).

TABLE 8.5 Information and knowledge gaps relating to the effectiveness of interventions

INTERVENTION INDICATOR	CURRENT LEVEL OF KNOWLEDGE AND GAPS	PROPOSED SOLUTION FOR SUBSEQUENT REPORT
13. INPUT: Quality of regulatory framework	The Alien and Invasive Species regulations are amongst the most comprehensive in the world, but are not explicit on pathway measures. The reason for listing or not listing particular species has not been adequately documented.	An independent assessment of the regulations would provide valuable insights. The evidence for including or excluding, adding or removing species from lists should be clearly documented, with both retrospective risk analyses conducted to underpin current listings, and a requirement for future changes to be supported by published risk analyses.
14. INPUT: Money spent	Data presented in the report are largely only available in terms of the spending by the Department of Environmental Affairs.	An assessment of the contributions from different departments at all spheres of government (national, provincial and local), and from the private sector, is needed.
15. INPUT: Planning coverage	Only 29 control plans were submitted (Appendix 4) covering ~4% of the country. Most of these control plans did not have explicit goals. Other plans exist, but these have shortcomings. For example, Van Wilgen *et al.* (2017) reported that high-level goals in protected area management plans are not effectively carried forward to 5-year implementation plans or annual plans of operation. As a result, there is a focus on only monitoring inputs and outputs rather than outcomes.	A greater emphasis of stating the goal of management at all levels of planning is required for management effectiveness to be assessed. Goals would need to be quantifiable and time-bound.

INTERVENTION INDICATOR	CURRENT LEVEL OF KNOWLEDGE AND GAPS	PROPOSED SOLUTION FOR SUBSEQUENT REPORT
16. OUTPUT: Pathways treated	Detailed data on the total number of imports or vessels per pathway and the number that have been subjected to a management intervention are required. Information is required on the exact procedure followed (e.g. random or targeted inspections, number of ports of entry covered), as well as the quality of the interventions.	Detailed information, from the various Governmental Departments involved, is needed on the pathways with control in place, the procedure followed and coverage. Also required are assessments of the quality of the intervention in place for each pathway or groups of similar pathways.
17. OUTPUT: Species treated	Currently, most control operations report on the *Area treated* (in the case of plants) or individuals removed (in the case of animals). The data are often not reliable, however, and the quality of treatment is typically not recorded at all (see, for example, Kraaij *et al.*, 2017).	Monitoring records should include an assessment of the quality and outcome of treatment interventions, accompanied by quality control to assure accuracy. This needs to be an integral part of control operations.
18. OUTPUT: Area treated	There is an almost complete lack of monitoring programmes that assess progress towards goals. What monitoring there is has a focus on inputs (money spent, jobs created), and arguably on *Area treated*, although this is uncritical as the quality of treatment is largely ignored.	Without the collection of primary monitoring data, future reports will be similarly limited. Changing this will require both training and a change in working practices. The need for such data must be clearly communicated to stakeholders. There are some specific areas where data can be collated and analysed. For example, it is important that there is an assessment of the scale and impact of herbicides used (Wagner *et al.*, 2017), as well as the effectiveness of herbicide application in terms of quantity and timing.
19. OUTCOME: Effectiveness of pathway treatments	Pathway interventions (regulation, inspection and interception) are intended to slow or halt the rate of new introductions. However, it is challenging to accurately quantify the rates of introductions, and even more so to attribute any changes in rates to a particular intervention.	A historical review of the effectiveness of pathway, species, and area-based management in South Africa is needed. For pathways it would be desirable to assess the outcomes of interventions in terms of their cost-effectiveness, and perhaps to explicitly separate efforts pre-border, at-border, and post-border, as different management goals are appropriate at different invasion stages (see Section 2.2). For example, for pathways it is important to get estimates of how much effort, where and when, should be placed in monitoring a given pathway (Bacon, Bacher & Aebi 2012, Faulkner *et al.*, 2016b).
20. OUTCOME: Effectiveness of species treatments	The effectiveness of biological control of invasive alien plants is well understood. The effectiveness of other control efforts is not understood due to an almost complete lack of monitoring. For terrestrial and freshwater plants, the Southern African Plant Invaders Atlas (SAPIA) has provided some indications that control efforts are not succeeding at a national scale (Henderson & Wilson, 2017).	Accurate national-scale monitoring of species populations needs to be improved, especially for taxa other than terrestrial and freshwater plants and birds. For plants, a review is needed of existing monitoring efforts (SAPIA and the National Invasive Alien Plant Survey, Kotzé *et al.*, 2010), and the use of other approaches (for example remote sensing), with a view to increasing the effectiveness of monitoring. It would be useful to conduct comparative studies in which invaded areas with and without the implementation of control measures are compared to assess control effectiveness.
21. OUTCOME: Effectiveness of area treatments	There is an almost complete lack of assessment of conservation and/or biodiversity outcomes in particular areas.	An assessment of the value and role of ecological restoration in managing biological invasions and contributing to conservation goals is needed.

8.3. ENABLING PROCESSES

It should be noted that the indicator framework discussed in Chapter 2 does not comprehensively cover all issues pertinent to the monitoring of biological invasions in South Africa. These include issues such as data acquisition, curation and accessibility; organisational and human capacity; the need for underpinning research; and public awareness and perceptions around the issue of biological invasions. These enabling processes need to be in place for the interventions to succeed. This section lists and briefly describes these processes, and proposes solutions (Table 8.6).

TABLE 8.6 Status of enabling processes to address key knowledge gaps

ENABLING PROCESS	CURRENT LEVEL AND GAPS	PROPOSED SOLUTION FOR SUBSEQUENT REPORT
Accessibility of data and information	There is an overall limitation in accessibility of data in the country. Some data and information are at various higher education institutions (as student theses), or at government institutions (as reports). Other grey literature is inaccessible even though funded by government.	The sourcing and collation of data will be an on-going effort that will continue to rely on inputs from stakeholders and data holders. The development of a national open access data and information repository for all information on biological invasions in South Africa sensitive to issues of intellectual property would assist with this. This could be linked to other global datasets that are open access.
Organisational and human capacity	Many institutions and organisations are involved in either general gathering of data or in managing biological invasions. While there are increasing numbers of qualified post-graduates, there are still major skills shortages. The capacity of implementing agencies (conservation departments, municipalities, and private landowners) to address the challenge of managing biological invasions, and of meeting the requirements of the NEM:BA regulations is severely limited by a shortage of funding.	There is a need for a coordinated approach and an understanding of institutional arrangements including roles and responsibilities across the country for management of biological invasions. There is a need for mapping of mandates including roles and responsibilities for a coordinated effort in managing biological invasions. There is a need for an assessment on the role of global and regional partnerships and multilateral agreements for knowledge and information sharing towards and understanding and managing invasions. An analysis of the history, dynamics, and impact of workshops, forums and working groups that address biological invasions in South Africa is needed.
Research	South Africa conducts world-class research in the fields of invasion science, the application of biological control of alien plants, and on invasive trees and diseases. The vast majority of research on these topics is produced by research-intensive universities, or by parastatal science councils. Funding cycles are typically of three years or less. The relative contribution of different funding sources (e.g. different governmental departments, private industry, and international bodies) has not been assessed in this report. Regulatory requirements for the submission of state-funded research proposals and findings to SANBI have gone unheeded.	There is a need to expand the current research structures and ensure long-term funding, with current funding cycles potentially restricting longer-term research. More effort should be made to strengthen institutional and human research capacity for better understanding and management of biological invasions in the country. There is a need to strengthen other effective and functioning networks of research. The submission of state-funded research proposals and findings is, however, likely to be of limited value and act as a disincentive for researchers to work on biological invasions. Consideration should be given to removing this regulatory requirement
Public awareness and engagements	There have been various awareness schemes, in some cases with significant investment, but the effectiveness of these schemes has rarely been assessed. A few key studies have explored perceptions and the social dimension in particular in relation to the A&IS Regulations (Shackleton & Shackleton, 2016, Cronin *et al.*, 2017).	There is a need to strengthen advocacy and communication across all relevant government departments and institutions for a common message on the impacts of biological invasions. There is a need to engage with social scientists to improve processes to report on public awareness and engagement.

8.4. KEY KNOWLEDGE GAPS THAT SHOULD BE PRIORITISED

There has been a considerable effort made to collect and synthesize information with a view to including it in this status report. Much of the information was published in the special issue of *Bothalia: African Biodiversity and Conservation* that is an additional product of the status-reporting process (Wilson *et al.*, 2017), as well as in papers published in other journals. During the process of soliciting papers for the special issue, colleagues were consulted regarding topics that would be worthy of research and synthesis. The list below contains topics that were identified as deserving of attention, but for which research did not come to fruition at the time. The list below is not comprehensive, and has not been ordered in terms of priority.

- A more detailed quantification of the rates of species introduction into, and dispersal within, South Africa.
- An assessment of the relative prominence of dispersal pathways within South Africa.
- A consolidated national inventory of introduced taxa, a physical reference specimen of each, and assessment and regular updating of the status documented according to the Unified Framework for Biological Invasions (Blackburn *et al.*, 2011). This will be a major undertaking, but is a priority, particularly given the uncertainty surrounding the status of species in this report (e.g. whether species are outside of captivity and cultivation or not).
- Systematic agreed methods for projecting future threats, i.e. a method for measuring and reporting on the invasion debt (Rouget *et al.*, 2016).
- A summary of the degree of invasion in South Africa: extent of areas invaded and the impacts caused by the various invasions on biodiversity and ecosystem services.
- History, status, and effectiveness of pathway, species, and area-based management in South Africa.
- History, dynamics, and impact of workshops, forums and working groups that address biological invasions in South Africa.
- The scale and impact of herbicides used (cf. Wagner *et al.*, 2017), as well as the effectiveness of herbicide application in terms of quantity and timing.
- The value and role of ecological restoration in managing biological invasions and contributing to conservation goals.

Substantial dedicated research will still be required for status to be better determined, and there are issues where there will need to be some theoretical development before it can be clear how status should be measured.

More broadly, this report does not consider the impact of interventions on other biodiversity and socio-economic indicators. This is an area where future collaboration will likely be fruitful, in particular so that the report on the status of biological invasions will feed into other processes (e.g. the National Biodiversity Assessments and the State of Environment Reports), and so that interventions can be adjusted to be appropriate in the context of South African society.

This report was initiated in response to a requirement under the NEM:BA, and as such the focus has been on the environment, but the use of the SEICAT Scheme to assess impacts offers the potential to look beyond environmental impacts. Future reports might be in a position to thereby consider all types of biological invasions (including diseases and agricultural pests). While this would substantially broaden the remit, given the phenomenon is the same and management challenges are similar, there would be substantial value to do this. The report would thereby serve to highlight the issue of biological invasions across government departments.

In future reports, it would also be desirable to explicitly separate efforts at different invasions stages (pre-introduction, incursion, expansion, and dominance), as different management goals are appropriate at different invasion stages (see Section 2.2). For example for pathways it is important to get estimates of how much effort, where and when, should be placed in monitoring a given pathway (Faulkner *et al.*, 2016b, Bacon, Bacher & Aebi 2012). A future report may seek to develop the indicators needed to cover all components of the 3 x 4 framework as outlined in Wilson, Panetta & Lindgren (2017).

This report focuses on species and to some extent on other taxonomic groups, but impacts are results of what the species do rather than where they are on the tree of life. So rather than broad taxonomic groups, it can be important to consider functional groups, or function itself, e.g. what proportion of photosynthesis in a given region is due to alien species (and how has this changed post-invasion). Metrics of functional diversity are increasingly used in ecology and environmental science, and it might be an important addition to the crude measures of species number and abundances used here. Similarly this report uses species as the primary biological unit in line with the majority of the taxa listed under the National Environmental Management: Biodiversity Act, Alien and Invasive Species Regulations (the NEM:BA A&IS Regulations). However, invasions can also occur at the gene level (e.g. resulting in the loss of indigenous species through hybridisation), but fundamentally biological invasions are a population-level phenomenon. Addressing issues at levels other than species is likely to be an on-going challenge.

8.5. PROCESS FOR FUTURE REPORTS

The framework and suite of indicators developed here did not go through a process of extensive consultation. In the light of this, it will be important to conduct structured stakeholder engagements to assess the feasibility and utility of the indicators. In particular, do the indicators incentivise the desired behaviours? The focus, however, should stay firmly on determining the outcomes (and ideally the broader impacts) of interventions, and future reports need to guard against adding indicators that contribute only tangentially to changes in the status of biological invasions themselves. Notably the indicators presented here are general, and this should be similar in future reports. For specific purposes or goals there might be more appropriate indicators, e.g. eradographs are used to track progress towards containment and eradication (Burgman *et al.*, 2013). While such project specific indicators might be valuable in calculating control effectiveness, they should not supplant broader status indicators.

The framework and suite of indicators were developed in order to report on the status of biological invasions. While the focus of the report should naturally continue to be on biological invasions, it would be valuable if data could be curated and presented in such a way that they can easily be used in other reporting processes. For example, the National Biodiversity Assessments are currently structured around environmental 'realms', e.g. terrestrial, freshwater, marine, and recently coastal. It will be important to ensure that future reports align with other reporting processes.

Future reports should also perhaps ensure that there is more time available for commenting on drafts. There were in essence two full rounds of review over a period of about 9 months, but Scholes, Schreiner & Snyman-Van der Walt (2017) recommend that the review process should be conducted over about 18 months, including a round of reviewing a zero-order draft (i.e. an expanded table of comments) and three drafts sent for review. Moreover, an independent review editor, who is tasked with checking that the drafting team responds appropriately to the comments received, should have been involved during the process. For this report, an independent review editor will be appointed to do a retrospective assessment of the process followed for this report and provide input into how things should be run for future reports.

Preliminary findings were presented to a variety of workshops, working groups and conferences. This will clearly be essential for future reports. It is unlikely that there will be sufficient material or interest to warrant another journal special issue in three years time, but clearly there should be some mechanism to incentivise scientists to provide input.

8.6. TARGETS AND PRIORITIES

While the indicators on their own have value, targets should be set for them to be effective. For example, Aichi Target 9 states that "By 2020, invasive species and pathways are identified and prioritized, priority species are controlled or eradicated and measures are in place to manage pathways to prevent their introduction and establishment". The first two indicators listed in Table 2.6 can be used to identify invasive species in the country and their pathways, and the appropriate planning should be in place. Similarly, control efforts will often need to be prioritised based on resource availability.

The setting of targets and priorities is outside the scope of this report, but the issue of which data should be collected to improve the value of the indicators for informing management decisions is important. Similarly, it might be important to weight some of the indicators by relevant priorities. For example, the importance of *Planning coverage* could be weighted by how important it is to have a plan in place, and given financial constraints it would be important for priority pathways, species, or areas to be covered by plans in preference to other components.

Finally, ensuring that future status reports are cognisant of relevant targets and priorities will be vital if they are to inform national and regional level strategies.

9 KEY POLICY-RELEVANT MESSAGES

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Chapter summary

This chapter provides a list of policy-relevant messages that have been distilled from the findings in the status report on biological invasions in South Africa. These provide a list of issues that could be used as a starting point for the development of a policy response by the Department of Environmental Affairs.

Historically, most invasive species were intentionally introduced into South Africa. However, the rate at which species are being unintentionally introduced is increasing as trade and tourism increase. Government capacity to deal with this threat is limited at present, but additional efforts in this regard would yield positive returns on investment.

Over 2000 alien species have established populations outside of captivity or cultivation in South Africa to date, at least one third of which have become invasive. Experts are of the opinion that more than 100 invasive species already cause major impacts. Both number of species causing major impacts, and the magnitude of the impacts themselves, are set to grow as further species become invasive, and as others enter a phase of exponential spread.

South Africa has achieved major successes in the field of biological control of invasive alien plants, and is regarded as a world leader due to the development and promulgation of comprehensive regulations to manage biological invasions.

South Africa has invested billions of rands into attempts to control invasive species, with some success in localised areas. However, due to the size of the problem, it has only been possible to reach a small proportion of the total invaded area (about 1–2% per year), and most invasive species continue to spread.

The lack of adequate planning and monitoring of the outcomes of control measures has been identified as a major weakness in South Africa, and leads to substantial management inefficiencies. Positive returns on investment from spending on invasive species control measures should still be possible, provided steps are taken to improve planning and management effectiveness.

THE SITUATION

The rate of introduction of new unregulated species is increasing in line with increases in trade and travel

The number currently stands at **7** NEW SPECIES PER YEAR

9.1. INTRODUCTION

This status report is the first in a series of such reports intended to inform the development and ongoing adaptation of appropriate policies and control measures, both to reduce the negative impacts of invasive species on ecosystems, the economy, and people, and to retain any benefits of invasive species where possible and desirable (Section 1.2).

Ideally, scientists and policy-makers should work together to ensure that evidence about issues that are relevant to policy-makers are appropriately considered when policy is formulated and implemented, but there are numerous factors that can hinder effective collaboration (Von der Heyden *et al.*, 2017). These include the fact that research takes time, and so relevant evidence is often not available when policies are formulated; there is often a mismatch in the language used by policy-makers and scientists; scientists are often unwilling to provide the certainty needed for policy-makers; and policy-makers need to consider the findings of scientists in the context of other needs and issues, such that the final decisions might be different from the recommendations (and desires) of the scientists.

This chapter is included in an attempt to bridge this gap, and it provides a list of policy-relevant messages that have been distilled from the findings in the status report. These messages provide a list of issues that could be used as starting point for the development of a policy response by the Department of Environmental Affairs (DEA).

The key messages are in the form of a single headline, followed by explanatory text. At the end of each headline are cross-references to the relevant sections of this report where the underlying evidence is presented in more detail. The messages themselves are grouped under three headings that cover the major policy issues, namely: (1) how do alien species get here, and spread?; (2) why does it matter?; and (3) how well are we dealing with this problem?

9.2. HOW DO ALIEN SPECIES GET HERE, AND SPREAD?

Opportunities for the introduction of high-risk alien species are increasing in line with increases in trade and travel. While effective protocols are being developed and implemented to prevent the legal introduction of high-risk alien species, there is little capacity in place to prevent unintentional and deliberate illegal introductions of high-risk alien species (see sections 3.3.1, 3.3.3, and 6.2.)

International visitors and imported goods currently enter South Africa through 72 official ports of entry (harbours, airports and border posts). The volume of trade and number of people that enter through these ports is increasing; the value of tourism, for example, has increased from around ZAR130 billion in 1995 to ZAR350 billion in 2017, and is predicted to increase to around ZAR530 billion by 2027. Greater volumes of trade and tourism can be accompanied by increasing rates of alien species introductions. The rate at which alien species are being introduced has been increasing steadily, from around 35 species per decade in the 1950s to 70 species per decade between 2000 and 2010. Historically, most species have entered South Africa from overseas, but the growth in trade across Africa over the past decade means that an increasing number of alien species are likely to be introduced to other countries in Africa and then subsequently spread from there to South Africa.

Intentional introductions of alien species have taken place for a range of reasons. Plants were imported for agriculture and for forestry, or as ornamentals for use in gardens and parks. Animals were imported for agriculture, aquaculture or mariculture, for recreational fishing or hunting, and to supply the pet trade. Some of the alien species that have become invasive were deliberately released into nature with the intention of establishing self-sustaining populations, for example trout and bass into streams and rivers. Others have simply escaped cultivation or captivity, for example pine and wattle trees introduced to establish commercial forestry plantations. Regulations are now in place to cover the future intentional importation of alien species, and procedures are being developed to analyse the risks posed before import permits are granted. If these procedures are adhered to, and if sufficient capacity is maintained in perpetuity, the risk posed by legal introductions will be substantially reduced.

Currently, however, the DEA only has a consistent presence at one of the 72 official ports of entry (occasional joint operations are carried out at other entry points, in conjunction with other departments), and the brunt of border inspections falls to the Department of Agriculture, Forestry and Fisheries (DAFF). The interception and prevention of import of potentially damaging invasive species might offset the cost of vigilance, and an increase in this capacity should deliver positive returns on investment.

FIGURE 9.1 Sniffer dogs are deployed at O.R. Tambo International Airport, where they assist in the detection of goods that are potentially illegal or harmful, including alien species.

Photograph: C. Mercado.

Once introduced into the country, alien species can disperse rapidly along South Africa's transport networks (see section 3.3.2)

South Africa has an extensive transport network along which commodity contaminants or stowaways can be dispersed. There is also a thriving internal trade in alien species for a variety of purposes. Managing the internal transport infrastructure for the purposes of preventing the dispersal of high-risk alien species is very difficult, and there has been no comprehensive analysis of the practicalities of this. This further emphasises the importance of preventing introduction in the first place.


Photographer: K. Faulkner.

FIGURE 9.2 South African roads provide many opportunities for the spread of alien species along a well-developed and heavily-used transport network.

Over 2000 alien species are present outside of captivity or cultivation in South Africa, and at least a third of these have become invasive. Many of these invasive species are now entering a phase of rapid expansion, so even if no further alien species are introduced, the problem will continue to grow due to the species already in the country (see sections 4.2 and 4.3)

Most recorded invasive species are plants (574 species); other important groups include terrestrial invertebrates (107 species) and marine invertebrates (46 species). Other groups (mammals, reptiles, birds, freshwater fish and amphibians) each contribute less than 20 species. For many groups of species (such as invertebrates, most marine species, and microbes) there are likely to be many alien species present that have not yet been detected and recorded. The number of invasive species is also expected to continue to increase as new species become invasive. Note: for the purposes of this report, alien species are considered to be invasive if they were formally reported to have survived, reproduced, and spread unaided over considerable distances/areas, rather than as having been recorded as causing significant negative impacts.

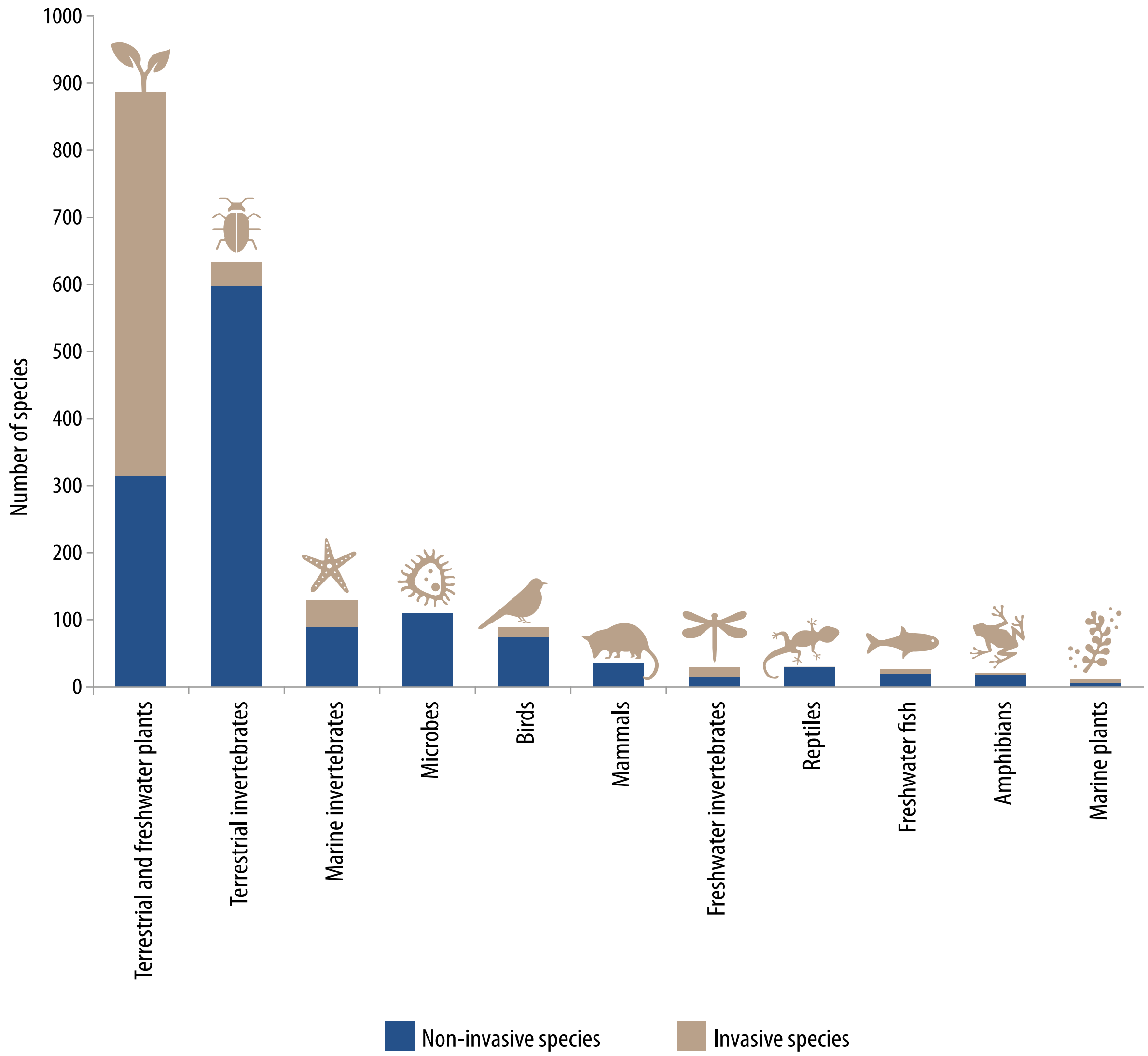

FIGURE 9.3 Terrestrial and freshwater plants and invertebrates currently make up the bulk of known alien species in the country. Other groups make up smaller numbers. A large proportion of naturalised alien plants have gone on to become invasive.

The rate of spread of invasive species is (typically) slow as the species establishes, then rapid as it colonises new areas, slowing down as the available habitat for expansion becomes limiting. Information from the Southern African Plant Invaders Atlas (SAPIA) – the most reliable source of information on the distribution of invasive plants in South Africa – reveals that all invasive alien plant species not subjected to biological control have increased their ranges over the past 15 years, some substantially. pompom weed (*Campuloclinium macrocephalum*, a herbaceous invader of grasslands) has increased in range by 670%; and famine weed (*Parthenium hysterophorus*, an annual invader of overgrazed rangelands and savannas) by 493%. Even long established invasive tree species, that might be expected to be nearing their range limits, such as mesquite (*Prosopis glandulosa*) and river red gum (*Eucalyptus camaldulensis*), have increased in range by 180% and 61% respectively. These species have large impacts, and the impacts grow as the species spread. Thus, even if no further introductions of potentially invasive species takes place, the problems associated with invasive species will increase, a phenomenon known as "invasion debt".

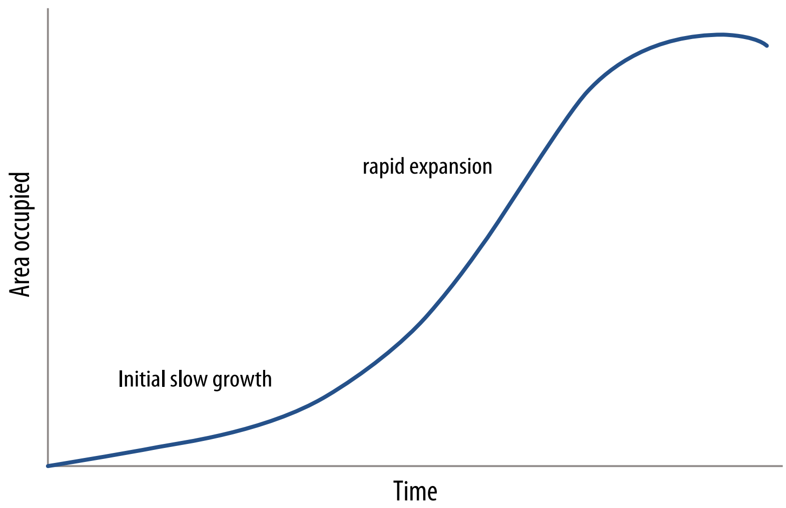

FIGURE 9.4 The area occupied by invasive species typically initially grows at a slow rate, and then accelerates until the majority of the available habitat is occupied. The time for species to enter a phase of rapid expansion is typically in the order of several decades to centuries. Given most invasive species were introduced to South Africa in the past 200 years, the majority of these species are in or are entering the phase of rapid expansion and thus the number of species with severe impacts is set to increase.

9.3. WHY DOES IT MATTER?

Over 100 invasive species are believed to have major negative impacts on ecosystem services, including on water resources, rangeland productivity and biodiversity (see section 4.6)

Surprisingly, there have been very few studies that formally document evidence on the impacts of invasive species, and consequently the level of confidence in estimates of the magnitude of these impacts is low, but it is clear that the invasive species that have major negative impacts are many and varied. Some examples are given in Table 9.1. Almost all of the estimated impacts of invasions in monetary terms (~ZAR6.5 billion per year) is due to these hundred or so invasive species that are believed to have major negative impacts. Country-level species-specific management strategies have only been developed for a very small number of invasive species, and none have been formally implemented.

TABLE 9.1. Examples of invasive species that are believed to have major or severe negative impacts in South Africa.

GROUP (NUMBER OF SPECIES WITH MAJOR OR SEVERE NEGATIVE IMPACTS)	EXAMPLE OF SPECIES AND THE IMPACTS THEY CAUSE
Plants (80)	North American mesquite trees (genus *Prosopis*) reduce grazing potential; deplete groundwater resources; and negatively impact on biodiversity. Australian wattle trees (genus *Acacia*) reduce grazing potential and surface water runoff; and negatively impact on biodiversity. North American and European pine trees (genus *Pinus*) reduce surface water runoff; negatively impact on biodiversity; and increase the fire intensity and damage done by wildfires. Herbaceous and succulent species (triffid weed - *Chromolaena odorata*; famine weed - *Parthenium hysterophorus*; pompom weed -*Campuloclinium macrocephalum*; and many cactus species) severely reduce rangeland productivity and thus the livelihoods of rural people.
Mammals (8)	Feral domestic cats (*Felis catus*) and house mice (*Mus musculus*) are serious threats to breeding marine birds on offshore islands.
Freshwater fish (5)	North American smallmouth bass (*Micropterus dolomieu*) decimate indigenous and endemic fish and invertebrates in streams, rivers and dams.
Terrestrial invertebrates (5)	Argentine ant (*Linepithema humile*) disrupts ant-plant mutualisms that are responsible for the seed dispersal of indigenous plants, and thus pose serious threats to indigenous vegetation survival.

FIGURE 9.5 Pine trees invading a Fynbos mountain catchment area. Several species of invasive pine trees have major impacts by reducing water resources, displacing globally unique biodiversity, and increasing fire hazard. *Photograph: B. van Wilgen.*

Invasive trees and shrubs reduce surface water resources by between 3 and 5%, and threaten up to 30% of the water supply of cities like Cape Town and Port Elizabeth (see section 5.5.1)

Invasive alien plants, particularly trees and shrubs, use more water than the indigenous plant species that they replace, because they are larger and deeper-rooted, and have different physiologies. At a national scale, the combined impacts of invasive alien plants on surface water runoff have been estimated at between 1 450 to 2 450 million m^3 per year (between 3 and 5% of the mean annual runoff for the country). Primary catchments most affected are in the Western and Eastern Cape, and KwaZulu-Natal, where reductions in mean annual runoff are greater than 5%. If no remedial action is taken, reductions in water resources could rise to between 2 600 and 3 200 million m^3 per year; and if fully invaded, catchments in the Western and Eastern Cape Provinces will deliver 30% less water to the cities of Cape Town, Mossel Bay, George, Knysna, Plettenberg Bay and Port Elizabeth. This severely constrains the prospects for economic growth, threatening the ongoing creation of new employment opportunities to millions of South Africans. Deep-rooted invasive species such as mesquite (*Prosopis* species) that invade arid areas also deplete groundwater resources, and lower the water table. Reducing the extent and abundance of water-consumptive invasive alien plants through efficient management can make a valuable contribution to water security and sustainable agriculture in South Africa.

THE SITUATION

The reductions in water resources if no remedial action is taken are estimated to be between

2600 & 3200 million m^3 per year

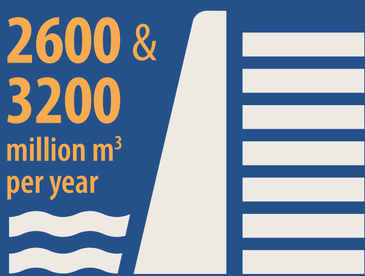

FIGURE 9.6 Invasive mesquite trees (*Prosopis* species) in the arid Northern Cape can substantially deplete groundwater reserves. Research has shown that savings of up to 70 m^3/month could be achieved in spring for each hectare of *Prosopis* cleared.

Photograph: R. Shackleton.

Invasive alien plants reduce the capacity of natural rangelands to support livestock production by over 100 000 large livestock units, thereby threatening rural livelihoods and food security (see section 5.5.2)

Invasive plants such as cacti, and several herbaceous weeds such as pompom weed (*Campuloclinium macrocephalum*), famine weed (*Parthenium hysterophorus*), and triffid weed (*Chromolaena odorata*), invade grassland, savanna and Karoo vegetation, where they displace palatable indigenous plants, and consequently these areas cannot support as many livestock as uninvaded areas. Invasive alien plant infestations reduce the amount of livestock that can be supported in South Africa by around 115 000 large stock units. This is just over 1% of the potential number of livestock that could be supported. However, these impacts could increase dramatically, more than halving the livestock production potential, if infestations of invasive plants spread into all suitable habitats.

FIGURE 9.7 Invasion of Highveld Grasslands by alien plants such as pompom weed (*Campuloclinium macrocephalum*) reduces the capacity of rangelands to support livestock by displacing palatable grasses and shrubs.

Photograph: L. Henderson.

FIGURE 9.8 The boxing glove cactus (*Cylindropuntia fulgida* var. *mamillata*) near Upington in the Northern Cape Province. The species is extremely damaging to rangelands, but fortunately can be controlled using biological control.

Photograph: T. Xivuri.

Biological invasions are the third-largest threat to South Africa's terrestrial biodiversity (after cultivation and land degradation), and currently account for 25% of all biodiversity loss (see section 5.5.3)

South Africa is one of the most biodiverse countries in the world, and this diversity underpins large parts of its economy, including fisheries, livestock production, harvesting of natural products, national and international tourism, and recreation. Invasive species have been identified as a significant threat to biodiversity throughout the country. Such losses of biodiversity have large negative knock-on effects on the economy and food security, among others. Note: biodiversity here refers to the variety of genes, species and their interactions, and ecosystems in a given area. Areas of high biodiversity are characterised by many species, and diverse ecosystems (such as forests, thickets, grasslands, wetlands, estuaries), and biodiversity is measured using standard international metrics.

FIGURE 9.9 Species-rich Fynbos vegetation is transformed into species-poor monocultures through invasion by alien trees such as pines (*Pinus* species), with substantial loss of biodiversity. ***Photographs: B. van Wilgen.***

The South African Department of Environmental Affairs (DEA) currently invests over ZAR 1.5 billion a year on managing biological invasions. The expenditure from other government agencies and the private sector is large but has not been precisely determined (see sections 6.4.1 and 6.4.2)

The DEA's Working for Water programme spent a total of ZAR 5.65 billion between 1995 and 2016, mainly on invasive plant control projects across the country (figure unadjusted for inflation). Annual expenditure has risen in real terms, from an initial investment of ZAR 27 million in 1995 to ZAR 1.55 billion in 2016. All figures that follow are expenditures over the duration of the project, adjusted for inflation and expressed in 2015 rands. Protected areas in the Cape Floristic Region comprise provincial nature reserves and national parks covering approximately 750 000 ha. Here, ZAR 564 million has been spent on the control of invasive alien trees and shrubs in the genera *Acacia* (Australian wattles), *Pinus* (North American and European pine trees) and *Hakea* (Australian shrubs). In the 8 000 ha catchment of the Berg River (Western Cape), ZAR 50 million has been spent on the removal of pine plantations, and of invasive pines and wattles in the upper catchment. In the 2 million ha Kruger National Park, ZAR 350 million has been spent, mainly on the control of the invasive shrubs *Lantana camara* (lantana) and *Chromolaena odorata* (triffid weed), as well as several species of annual herbaceous weeds. Many other government departments and agencies at all levels of government

THE SITUATION

Invading alien plants are the **3rd** largest threat to South Africa's unique biodiversity, WITH **1207** indigenous and endemic plant species being threatened by alien plant invasions (national, provincial and local) spend a significant amount of money on controlling biological invasions, including the DAFF on preventing the introduction of pests and diseases and managing organisms after introduction, and the Department of Health on human diseases and their vectors. Non-Governmental and civil society organisations and private landowners have also invested in control measures. One documented example comes from the 3 200 ha Vergelegen Estate in the Western Cape, where Anglo American have spent ZAR 43 million on management of invasive alien plants. These costs need to be quantified if the totals spend by South Africa on managing biological invasions are to be estimated.

9.4. HOW WELL ARE WE DEALING WITH THIS PROBLEM?

To date, South Africa has eradicated three species from the country, and it is likely that there will be more successes in the years to come, as funds and resources have recently been dedicated to eradication attempts (see section 6.3.1)

Eradication refers to the process of removing all individuals of an invasive species from the entire country and shutting down any pathways through which the species could be reintroduced. Eradication is therefore permanent, and avoids ongoing and costly control and impact reduction efforts. Of ten historical eradication attempts in South Africa, three have succeeded – the eradication of *Felis catus* (domestic cat) from Marion Island, *Otala punctata* (Mediterranean snail) from the Western Cape, and *Trogoderma granarium* (khapra beetle) at multiple sites, most recently near Upington in 1972. More species are being targeted for eradication, with several other assessments of eradication feasibility underway. More eradication of alien species from South Africa can thus be expected over the coming decade. It is also becoming increasingly clear that eradication measures need to be carefully considered before they are attempted, and that once they are initiated it is equally important that progress should be monitored and evaluated. Interactions with the South African public through citizen science and spotter schemes has greatly assisted in finding out where species are, and so have been a key part of eradication efforts.

FIGURE 9.10 House Crows (*Corvus splendens*) have been targeted for eradication from Cape Town and Durban and their numbers are been dramatically reduced. These invasive birds are responsible for substantial negative impacts in other African cities.

Photograph: City of Cape Town.

Plant invasions are estimated to cover 80 000 km^2 of South Africa, but current mechanical and chemical control measures only reach a small proportion of these areas (less than 5%) *(see sections 6.4.1 and 6.5)*

Control measures aimed at the most widespread invasive trees (Australian wattles, North American mesquite, Australian eucalypts and Northern Hemisphere pines) are only reaching between 2% and 3% of the estimated area invaded by these species each year. Given that annual spread rates without control are in the order of 5–10%, the rate of spread has slowed due to the control measures, but has certainly not stopped. The situation would have been worse had there been no control, and there are several very important examples of localised successes, but at present the problem is growing. A greater focus on priority areas, or priority species, will be needed to ensure that scarce funds are used optimally.

FIGURE 9.11 Invasive pines (*Pinus* species, background) and wattles (*Acacia* species, foreground) in a Western Cape catchment area. An effective use of triage could be to focus limited funds on the control of pines (which will ultimately cover much larger areas, and which have no effective biological control options), and leave the wattle species (which have effective biological control, and can be harvested for firewood).

Photograph: B. van Wilgen.

Current management planning falls short of what is optimum, but improved project-level planning could greatly improve efficiency (see sections 6.5 and 7.4.4, and Appendix 4)

Control projects targeting specific pathways, species or areas require careful planning, with clear goals and regular monitoring and evaluation of progress. Almost all management plans submitted in terms of the regulations were deficient in some way, as they did not clearly indicate the intended goals of control measures in particular areas, or did not propose effective monitoring and evaluation of the outcomes of control efforts. However, a small (but growing) number of case studies highlight what can be achieved. The cover of invasive plants has been reduced in some localised areas – the Table Mountain and Kruger National Parks, and several protected areas, catchments, and farms in the Cape Floristic Region. Almost all area-based control measures are aimed at alien plant species, and most have the goal of reaching a "maintenance level" (i.e. the achievement of a low level of invasion that could be contained at a relatively low cost in perpetuity), although this is seldom explicitly stated. Goals are typically set for the sums of money to be spent, the number of jobs to be created, and the area to be treated. With this set of measures of inputs and outputs, managers can meet their targets by creating employment and working anywhere to any standard.

EFFECTIVENESS OF RESPONSES

Given the enormity of the problem, and the limited funds available to address it, we are currently only able to get to a small proportion of the invasions **(2–3 % PER YEAR)**.

Given that the species are spreading at **5–10% PER YEAR**, it is clear that the problem cannot be addressed everywhere, and that to be effective we will have to focus limited funds on priority areas.

The management of invasive species and invaded areas can be cost-effective, provided the problem is addressed timeously using the most effective combination of control methods available (see sections 6.4 and 6.5)

Returns on investment from invasive species prevention, eradication, and control projects can be estimated by comparing the cost of the management to the value of avoided impacts (i.e. the impacts that would have come about in the absence of control). Several studies, in South Africa and elsewhere, have estimated that positive returns on alien species control should be possible. The findings of these studies are based on the assumption that the estimated costs of control are realistic, that the required funding will be available, and that the management will be carried out efficiently. These assumptions do not always hold. For example, a study in 1995 estimated the costs to clear invasive alien plants from the 8 000 ha Berg River catchment in the Western Cape, and to maintain the catchment in a cleared state in perpetuity. Expressed in 2015 rands, the net present value of this investment would have been ZAR 6 million. A study 20 years later estimated that the net present value of historical control measures in the Berg River catchment was ZAR 50 million, 8.3 times the original estimate, and without yet reaching the desired maintenance level. This situation can be substantially improved through adherence to professional management approaches, including better planning and monitoring, better training and equipping of workers, the reduction of bureaucratic constraints, and adherence to accepted best management practices. Returns on investment will also be substantially higher if the problems of invasion are addressed earlier rather than later, as costs escalate exponentially as the size of the invasions grows.

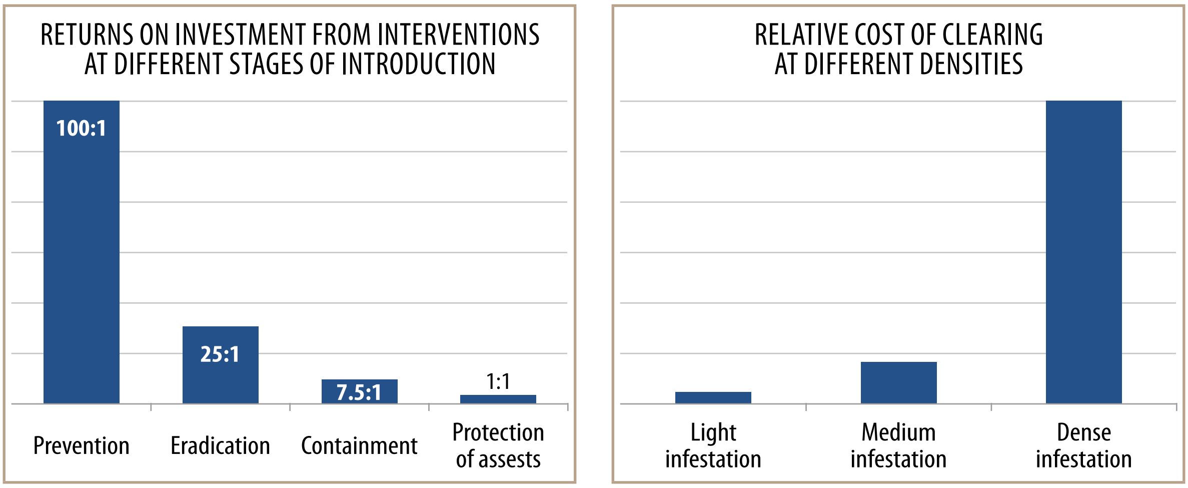

FIGURE 9.12 Returns on investment from invasive species control measures change substantially depending on the stage of invasion of the species. Preventing the arrival of species in the first place delivers the highest returns, followed by eradication where this is still possible, or containment at later stages when eradication is no longer possible. If the alien species should reach a dominant stage, the only option available is to protect selected assets from impacts.

The density of alien plant invasions increases the longer they are left unmanaged, and the cost of clearing invasions of increasing density rises exponentially with increasing density. It is thus imperative to initiate control operations as soon as possible to reduce costs and to improve returns on investment.

South Africa is a world leader in the biological control of invasive alien plants, with the use of the technology being one of the main success stories. It has led to significant and on-going positive economic returns (see sections 6.3.2 and 6.4.3)

Biological control agents have been used for over a century in South Africa to control invasive alien plants. South Africa has well-developed scientific and technical capacity to implement biological control and a rigorous risk analysis protocol that is implemented prior to any releases. As a result, biological control of invasive plants has an impeccable track record of safety, and has contributed to the control of 34 invasive plant species, 15 of which now require no additional herbicidal or mechanical control. The technology does not involve the use of chemicals or manual disturbance, is relatively cheap (once the initial costs of screening the agents is completed, the costs fall away), and is sustainable in the long term. Returns on investment from biological control are substantial, with estimates that for every ZAR 1 invested into establishing the biological control agent, between ZAR 8 and ZAR 3 726 was realised in the form of avoided costs of the invasions. These are exceptionally attractive returns.

FIGURE 9.13 Various biotypes of cochineal insects (*Dactylopius opuntiae*) have been established as biological control agents on both the invasive prickly pear cactus (*Opuntia ficus-indica*, left) and the Australian pest pear (*Opuntia stricta*, right). These agents were responsible for clearing thousands of invaded hectares in several parts of the country, restoring rangeland in both livestock production and conservation areas. ***Photographs: H. Klein.***

FIGURE 9.14 Sunset Dam in the Kruger National Park was heavily infested by invasive alien water lettuce (*Pistia stratiotes*), which was effectively eliminated by a combination of biological and chemical control. ***Photographs: L. Foxcroft.***

The regulation and control of a small number of invasive species (about 6%) has proved highly controversial as these species have both negative impacts and positive benefits to society (see Box 4.3)

Many alien species were introduced to provide benefits. However, if a beneficial alien species becomes invasive and spreads into natural ecosystems, the costs of negative impacts can grow to exceed the value of the benefits. Moreover, the benefits often accrue to a relatively small number of people, while society at large carries the costs, which are externalised. This assessment found no examples where the true costs of control were borne by the beneficiaries, and there are several cases where the listing of the invasive species continues to be contested. Examples include pine trees (*Pinus* species), which have been extensively planted since the early 20th century to provide timber. Planted pines have invaded the adjacent Fynbos in the Cape Floristic Region. The need to prevent biodiversity and water losses due to invasive pines, and to retain the economic benefits of pine-based forestry are becoming more acute, leading to polarised views regarding the advantages and disadvantages of pines. Rainbow trout (*Oncorhynchus mykiss*) were introduced for recreational fishing and aquaculture that have economic benefits, but they also impact negatively on indigenous and endemic aquatic fauna. Implementing control measures is complicated by the economic contributions of recreational fishing and aquaculture, and by the different cultural values expressed by recreational anglers and conservation agencies.

FIGURE 9.15 Pine trees (*Pinus* species) escaping from a formal plantation and invading surrounding fynbos vegetation. Given that pines are both valuable as a timber crop and harmful to biodiversity and water resources, their management is often a source of contention between foresters and conservationists.

Photograph: B. van Wilgen.

Proposals exist for the utilisation of alien plant biomass, both to extend the benefits and to offset the costs of alien plant control. Such projects could be beneficial, provided the unintended negative consequences can be avoided (see Box 6.3)

There have been several pilot projects and modelling exercises assessing whether alien plant clearing operations can be used to create value-added by-products. Biomass utilisation can potentially offset costs of control and create additional employment. However, the development of the infrastructure to process biomass could create a large dependency on a resource that is targeted for elimination; the plants that contribute most to spread and impact, are often high up on mountain-sides so are not utilisable or extractable; and the creation of an industry could result in the deliberate or accidental spread of the target invasive species. In addition, the way in which these activities will be coupled to alien plant control projects needs to be explicitly planned. Provided these issues are carefully managed, the inclusion of value-added by-products could increase the chances of gaining control of invasive alien plants.

FIGURE 9.16 Example of a prototype low-cost housing unit that utilises chipboard manufactured from invasive alien plant biomass. The structure is fire-resistant, and incorporates numerous features that conserve water and energy. If successfully implemented at a large scale, it could represent a substantial win-win situation.

Photograph: B. van Wilgen.

South Africa is a global leader in developing a comprehensive regulatory framework to specifically deal with invasive species. However, the feasibility of some aspects is not clear yet, and the management of pathways require more consideration. Overall, it is too early to assess the effectiveness of the regulations (See Chapter 7)

South Africa's Alien and Invasive Species Regulations (A&IS Regulations), 2014, cover alien species and invaded areas, and in this regard the country is a leader in attempting to regulate biological invasions. The Department of Environmental Affairs (DEA) has initiated several processes to implement these regulations, but there is a shortage of capacity to ensure widespread compliance (although the magnitude of the shortage has not been assessed). There have also been high levels of non-compliance with some regulations, for example the requirements of all organs of state to submit management plans, all landowners to submit lists of species occurring on their property, and all state-funded researchers to submit proposals and research results. This probably reflects a widespread lack of capacity to adequately address these issues, and a re-examination of the practicality and some of the requirements would be useful. While pathway-specific legislation is in place or is being put in place (e.g. the proposed Ballast Water Act and Plant Health Act), at present the A&IS Regulations do not explicitly deal with pathways of introduction and spread. The A&IS Regulations have been in place for less than three years, and it is probably premature to expect that their effectiveness could be assessed at this early stage. There are, as of yet, insufficient data to link the impact of all of the measures taken to the relevant outcome, for example the rate of introduction of alien species into the Republic. It is therefore not yet possible to assess their effectiveness, but it is vital that processes are put in place to monitor and evaluate them.

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APPENDIX 1

FACT SHEETS FOR THE PROPOSED INDICATORS FOR REPORTING ON THE STATE OF BIOLOGICAL INVASIONS AT A COUNTRY LEVEL.

These fact sheets are based on the guidelines of the Biodiversity Indicator Partnership (2011), with the addition of a section on how to define a confidence interval for each metric. There are several additional enabling processes that are vital for successful interventions, specifically accessibility of data and information, research, organisational and human capacity, and public awareness and engagement. However, indicators for these are not included as they are not used for measuring the outputs or outcomes of the interventions.

1 INTRODUCTION PATHWAY PROMINENCE

Use and interpretation

This indicator concerns the pathways that could facilitate the introduction of alien species to a country from another region. The indicator considers the size of the pathway of introduction but does not take into account how important the pathway is for the introduction of alien organisms. Depending on the available data, the indicator can be used to answer three questions:

- What is the size of the pathway of introduction?
- How prominent is the pathway of introduction relative to the other pathways?; and,
- How does the size of the pathway of introduction vary across space and time?

The indicator is important for measuring progress towards meeting Aichi Biodiversity Target 9 of the Convention on Biological Diversity (CBD, 2014).

Potential for aggregation

This indicator was developed for use at a national level. However, as data might be available at larger (e.g. regions or continents) or smaller (e.g. provinces or districts) spatial scales, the indicator can also be used at a wide range of scales.

Possible reasons for upward or downward trends

Upward or downward trends can be caused by changes to the routes travelled by vessels that transport goods and people. These changes could be due to factors such as the development of new, more favourable routes or political changes. Changes to the amount or type of goods being imported or the number of people entering a country could also result in upward or downward trends, and could be driven by political (e.g. trade agreements), socio-economic (e.g. consumer and travel trends) or environmental (e.g. droughts) factors.

An increase in the size or relative prominence of a pathway could mean that there has been an increase in the likelihood that alien organisms could be introduced through this pathway. However, this is not always the case, and various factors (e.g. the phytosanitary polices of the exporting nations and the size of the pool of potential invaders) will influence the strength of this link.

Implications for biodiversity management of change in the indicator

Upward or downward trends could lead to changes in the pathways that are prioritised for management [as required under Aichi Biodiversity Target 9 of the Convention on Biological Diversity (CBD, 2014)] and, as a consequence, to changes in the allocation of biosecurity resources (money and personnel).

Units in which it is expressed (from basic to advanced)

1.1	Five categories demonstrating the size of each pathway with pathways split along the CBD pathway categorisation (CBD, 2014). • Not known • Pathway not present • Minor • Moderate • Major
1.2	A ranked order of pathways in terms of their prominence.
1.3	Spatially explicit vectors that detail the amount, number and value of goods or vessels moving into the country per pathway, with information on the sources, routes, destinations, and timings.

Description of source data

Online global or national databases containing trade or transport data run by national governments, intergovernmental or global organisations and companies [e.g. the FAOSTAT database of the Food and Agricultural Organisation of the United Nations (http://www.fao.org/faostat/en/#data)]. Yearly data are, however, often not available the most recent years. Data can also be obtained from peer-reviewed journal articles and from the websites and reports of national governments, intergovernmental or global organisations and companies.

Calculation procedure

1.1	Experts use collected data to categorise each pathway as: • Not known • Pathway not present • Minor • Moderate • Major
1.2	For each pathway the amount, number and value of imported goods or vessels is calculated. Pathways are then ranked.
1.3	As above for different entry points and periods of time, no ranking.

Guide for applying confidence levels

1.1	HIGH	Data collated specifically on a particular pathway and recorded regularly (e.g. annually); and evaluated by at least three relevant experts with agreement in almost all cases.
	MEDIUM	Data available across larger time-scales (e.g. decades), or have to be interpreted based on other data sources; and/or evaluation by one expert; and/or a few cases of disagreement with multiple experts
	LOW	Few direct estimates of the data or estimated entirely based on expert opinion.
1.2	HIGH	Data collated for all pathways in comparable units and recorded regularly (e.g. annually).
	MEDIUM	Data available across larger time-scales (e.g. decades), or substantial interpretation across different data sources is required for comparisons.
	LOW	Few direct estimates of the data or ranks are based on expert opinion.
1.3	HIGH	Regularly recorded, detailed data for every pathway with the destination of the vessels or imports and date of arrival.
	MEDIUM	Data available across larger spatial (e.g. provinces) or temporal scales (e.g. decades), or have to be interpreted based on other data sources.
	LOW	Errors in data apparent or clear that some data are inconsistently recorded.

Most effective forms of presentation

1.1	A table with the CBD pathway subcategories and for each pathway the assigned pathway size
1.2	A table with the CBD pathway subcategories and the rank of each pathway, or a figure demonstrating the size of the pathways, with the pathways ordered according to their rank
1.3	Maps or figures demonstrating spatial and temporal variation in pathway size

TABLE A1.1 (Indicator 1.1) Introduction pathway prominence for South Africa. Data from Chapter 3 on the status of the pathways of introduction.

PATHWAY CATEGORY	PATHWAY SUB-CATEGORY	PATHWAY PROMINENCE
RELEASE IN NATURE	Biological control	Moderate
	Erosion control/dune stabilization (windbreaks, hedges, etc.)	Not known
	Fishery in the wild (including game fishing)	Major
	Hunting	Moderate
	Landscape/flora/fauna "improvement" in the wild	Pathway not present
	Introduction for conservation purposes or wildlife management	Not known
	Release in nature for use (other than the above, e.g. fur, transport, medicinal use, etc.)	Not known
	Other intentional release	Not known

ESCAPE FROM CONFINEMENT	Agriculture (including Biofuel feedstocks)	Major
	Aquaculture/mariculture	Minor
	Botanical garden/zoo/aquaria (excluding domestic aquaria)	Minor
	Pet/ aquarium/terrarium species (including live food for such species)	Minor
	Farmed animals (including animals left under limited control)	Major
	Forestry (including afforestation or reforestation)	Major
	Fur farms	Minor
	Horticulture	Moderate
	Ornamental purpose other than horticulture	Not known
	Research and ex-situ breeding (in facilities)	Minor
	Live food and live baits	Not known
	Other escape from confinement	Not known
TRANSPORT – CONTAMINANT	Contaminant nursery material	Moderate
	Contaminated bait	Not known
	Food contaminant (including of live food)	Major
	Contaminant on animals (except parasites, species transported by host/vector)	Major
	Parasites on animals (including species transported by host and vector)	Major
	Contaminant on plants (except parasites, species transported by host/vector)	Moderate
	Parasites on plants (including species transported by host and vector)	Moderate
	Seed contaminant	Moderate
	Timber trade	Major
	Transportation of habitat material (soil, vegetation, etc.)	Not known
TRANSPORT – STOWAWAY	Angling/fishing equipment	Major
	Container/ bulk	Moderate
	Hitchhikers in or on airplane	Moderate
	Hitchhikers on ship/boat (excluding ballast water and hull fouling)	Moderate
	Machinery/equipment	Not known
	People and their luggage/equipment (in particular tourism)	Major
	Organic packing material, in particular wood packaging	Not known
	Ship/boat ballast water	Moderate
	Ship/boat hull fouling	Moderate
	Vehicles (car, train, etc.)	Major
	Other means of transport	Not known
CORRIDOR	Interconnected waterways/ basins/seas	Minor
	Tunnels and land bridges	Minor
UNAIDED	Natural dispersal across borders of invasive species that have been introduced through the other pathways	Major

TABLE A1.2 (Indicator 1.2) An example of the ranking of pathway prominence. Data from the National Ports Authority of South Africa and Airports Company of South Africa, accessed 22 March 2017.

PATHWAY SUB-CATEGORY	RANK	RATIONALE
Hitch-hiker on or in airplane	1	In 2015, there were ~50 000 vessels entering South Africa from international destinations
Hitchhiker on ship/boad	2	In 2015, there were ~10 000 vessels entering South Africa from international destinations. While these ships or boats might tend to be larger than each airplane, this is unlikely to translate into a fivefold increase in opportunities for hitch-hikers.

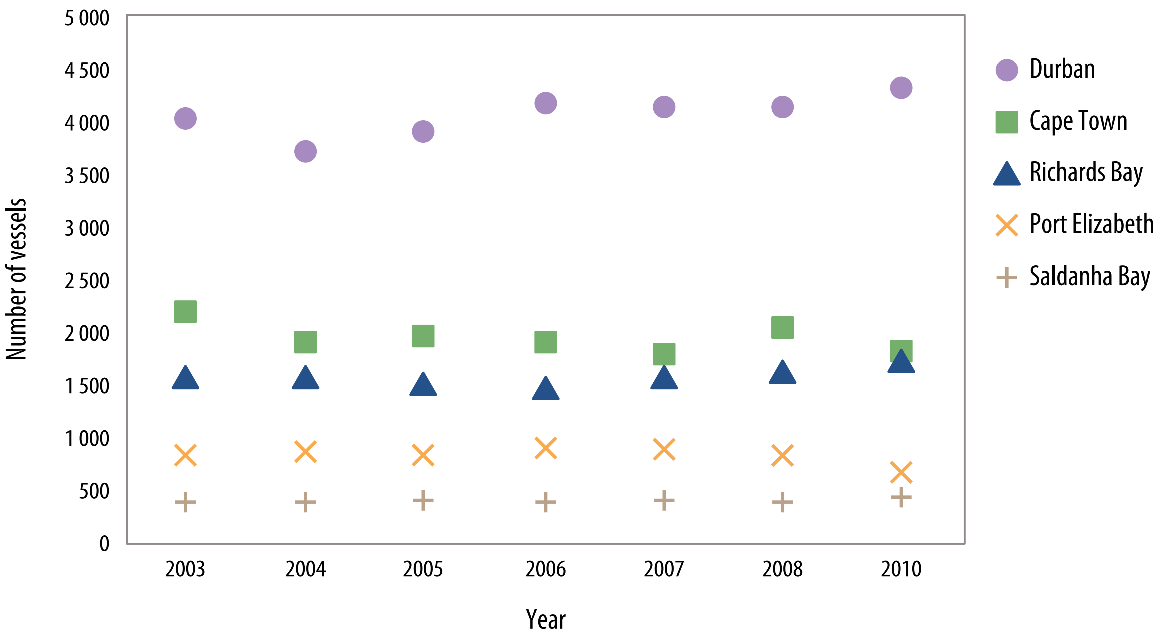


FIGURE A1.1 (Indicator 1.3) The number of ocean going vessels arriving at South African ports over time. Data from the National Ports Authority of South Africa.

Limits to usefulness and accuracy

This is reliant on data provided by national and global databases, for which data quality might not be known. Data quality may vary between countries, leading to more accurate assessments for some countries than others. Databases that are infrequently updated might cause difficulties when estimating upward or downward trends, or will not be useful if updated less frequently than the indicator is updated. Data that are only available at regional or larger scale, will be unsuitable for national scale assessments. Useful measures of pathway prominence might not be available for all pathways, particularly for less specific pathways such as 'other escape from confinement'. For some pathways there may be various types of data available, and this could lead to differing estimates. Often there is not a direct link between the data that are available and the pathway subcategories, such that it is difficult to aggregate or split data.

Updating the indicator

The indicator could be updated yearly or at coarser, but regular time intervals. At the least, the indicator should be updated as often as is required for reporting on the status of biological invasions.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
none	**2.** Introduction rates **3.** Within-country pathway prominence **A.** Rates of introduction of new unregulated species	**13.** Quality of regulatory framework **15.** Planning coverage **16.** Pathways treated **19.** Effectiveness of pathway treatments **D.** Level of success in managing invasions

Additional information and comments

For some pathways it might be difficult to access data. For example, some transport data are owned by companies and to gain access to the data or databases a fee is often required. Transport data can be commercially sensitive.

2 INTRODUCTION RATES

Use and interpretation

This indicator concerns the pathways that facilitate the introduction of alien species to a country from another region, and specifically the introduction of new alien species [i.e. from the introduction debt, Rouget *et al.* (2016)].

Depending on the available data, the indicator can be used to answer three questions:

- How many species have been introduced through each pathway?
- How has the number of species introduced through the pathway changed over time?; and
- How has the number of individuals (of a specific species) introduced through the pathway varied over time and space?

The indicator is of particular use for measuring progress towards meeting Aichi Biodiversity Target 9 of the Convention on Biological Diversity (CBD, 2014).

Potential for aggregation

This indicator was developed for use at a national level, however, as the national level data can be aggregated, the indicator can also be used at larger spatial scales (e.g. regions or continents). For example, the number of species introduced through a pathway to different countries could be summed to get an indication of the importance of the pathway for a region or continent. As data could be available at both large (e.g. regions or continents) or small spatial scales (e.g. provinces or districts), the indicator can be used at a wide range of scales.

Possible reasons for upward or downward trends

Upward or downward trends could be caused by political (e.g. changes to trade agreements), environmental and socio-economic changes (like consumer trends and changes in travel trends), as well as changes to the biosecurity or policies (e.g. phytosanitary policies) of the importing and exporting nations. Upward or downward trends could also be linked to changes in research interest in alien species and in the number or intensity of surveys for these organisms.

An upward trend in this indicator can mean that the number of species introduced to the country through the pathway has increased. A downward trend in this indicator demonstrates that the number of species introduced to the country through the pathway has decreased.

Implications for biodiversity management of change in the indicator

Upward or downward trends could lead to changes in the pathways that are prioritised for management (as required under Aichi Biodiversity Target 9 of the Convention on Biological Diversity (CBD, 2014)) and, as a consequence, to changes in the allocation of biosecurity resources (money and personnel).

Units in which it is expressed (from basic to advanced)

2.1	The total number of alien species introduced through each CBD pathway sub-category over all time (CBD, 2014).
2.2	Five categories demonstrating changes over a recent period of time (e.g. since the 1980s or in the past decade) in the number of species introduced through each pathway. • Not known • No introductions • Increase • Decrease (if there were no introductions then specify) • Minimal change (if there were no introductions then specify)
2.3	Number of individuals of each species introduced through the pathways and place and date of introduction

Description of source data

Published peer-reviewed journal articles, alien species lists, and databases. These could include local, national or global databases [e.g. the Global Invasive Species Database (http://www.iucngisd.org/gisd/), CABI Invasive Species Compendium (http://www.cabi.org/isc/)]. Some alien species databases are regularly updated (every few years), however, this is not always the case.

Calculation procedure

2.1	For each pathway, calculate the total number of alien species introduced.
2.2	For each pathway and time period, calculate the total number of alien species introduced that were not present in the country at the time of introduction. Ideally different alternative models are fitted to the data and compared in a Bayesian framework or using the Aikaike Information Criterion (Seebens *et al.*, 2016), but as a rule of thumb: • Not known • No introductions (during the last decade) • Increase (increase of ≥ 5 species over the last decade) • Decrease (decrease of ≥ 5 species over the last decade) • Minimal change (increase or decrease of < 5 species over the last decade)
2.3	For each entry point and period of time, calculate the number of individuals of each species introduced through each of the pathways

Guide for applying confidence levels

2.1	**HIGH**	Direct evidence of the introduction pathway for most alien species and the species can easily be assigned to the pathway subcategories
	MEDIUM	Pathway of introduction for most species can be inferred as the species appeared when and where a single pathway was in operation and there is no other explanation. Species can easily be assigned to pathway subcategories
	LOW	Pathway of introduction is inferred for most species based on information on species traits and information from other regions or species cannot easily be assigned to the pathway subcategories. Data are not available for many species, qualitative estimates or based on expert opinion
2.2	**HIGH**	Specific records exist for each pathway of all the introductions per year
	MEDIUM	Species introductions can be inferred from data on numbers of alien species introduced with knowledge of likely introduction dates (in the order of several years)
	LOW	The change in rate is from expert opinion, or data are not available for many species
2.3	**HIGH**	Detailed, regularly recorded records exist for each introduction for all pathways on the point of introduction and number of individuals introduced
	MEDIUM	Data available across larger spatial (e.g. provinces) or temporal scales (e.g. decades), or have to be interpreted based on other data sources
	LOW	Based on expert opinion

Most effective forms of presentation

2.1	A figure demonstrating the number of alien species introduced through each pathway
2.2	A table with the CBD pathway subcategories and for each pathway the assigned change in introductions (i.e. increase, decrease, minimal change, no introductions or not known)
2.3	Maps or figures demonstrating spatial and temporal variation in the number of individuals introduced through a pathway

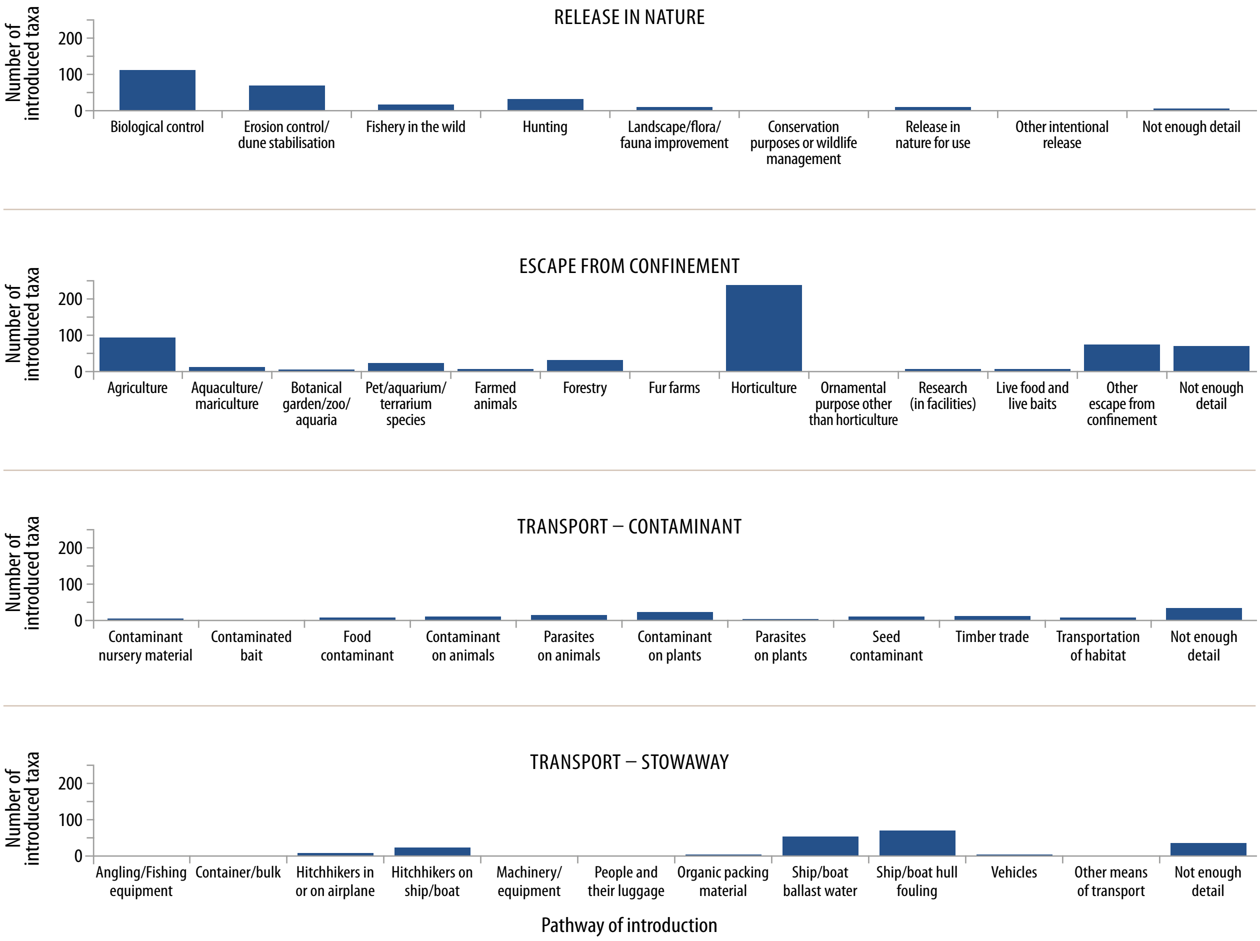


FIGURE A1.2 (Indicator 2.1) Number of alien taxa introduced to South Africa through the pathways of introduction, and the number for which designation at the pathway subcategory level was not possible due to insufficient information. The graphs show the results for the pathway subcategories from top to bottom, 'Release in nature', 'Escape from confinement', 'Transport – Contaminant' and 'Transport – Stowaway' pathway categories. Results for the unaided pathway are not shown. Figure from Chapter 3 of this report.

TABLE A1.1 (Indicator 2.2) Changes to the rates of introduction in the last full decade in comparison to that of the previous decade. Data from Chapter 3 of this report.

PATHWAY CATEGORY	PATHWAY SUB-CATEGORY	CHANGE IN INTRODUCTION RATES
RELEASE IN NATURE	Biological control	Decrease
	Erosion control/dune stabilization (windbreaks, hedges …)	Not known
	Fishery in the wild (including game fishing)	No introductions
	Hunting	Increase
	Landscape/flora/fauna "improvement" in the wild	No introductions
	Introduction for conservation purposes or wildlife management	No introductions
	Release in nature for use (other than the above, e.g. fur, transport, medicinal use …)	Not known
	Other intentional release	No introductions
ESCAPE FROM CONFINEMENT	Agriculture (including Biofuel feedstocks)	Not known
	Aquaculture/mariculture	No introductions
	Botanical garden/zoo/aquaria (excluding domestic aquaria)	No introductions
	Pet/aquarium/terrarium species (including live food for such species)	Minimal change
	Farmed animals (including animals left under limited control)	No introductions
	Forestry (including afforestation or reforestation)	Not known
	Fur farms	No introductions
	Horticulture	Not known
	Ornamental purpose other than horticulture	No introductions
	Research and ex-situ breeding (in facilities)	Not known
	Live food and live baits	No introductions
	Other escape from confinement	Not known
TRANSPORT – CONTAMINANT	Contaminant nursery material	Not known
	Contaminated bait	No introductions
	Food contaminant (including of live food)	Not known
	Contaminant on animals (except parasites, species transported by host/vector)	Minimal change
	Parasites on animals (including species transported by host and vector)	Minimal change
	Contaminant on plants (except parasites, species transported by host/vector)	Minimal change
	Parasites on plants (including species transported by host and vector)	Minimal change
	Seed contaminant	Not known
	Timber trade	Not known
	Transportation of habitat material (soil, vegetation …)	Minimal change
TRANSPORT – STOWAWAY	Angling/fishing equipment	No introductions
	Container/bulk	No introductions
	Hitchhikers in or on airplane	Not known
	Hitchhikers on ship/boat (excluding ballast water and hull fouling)	Minimal change
	Machinery/equipment	No introductions
	People and their luggage/equipment (in particular tourism)	No introductions
	Organic packing material, in particular wood packaging	Not known
	Ship/boat ballast water	Minimal change
	Ship/boat hull fouling	Increase
	Vehicles (car, train…)	Not known
	Other means of transport	No introductions
CORRIDOR	Interconnected waterways/basins/seas	No introductions
	Tunnels and land bridges	No introductions
UNAIDED	Natural dispersal across borders of invasive species that have been introduced through the other pathways	Minimal change

Limits to usefulness and accuracy

Difficulties associated with categorising species into the CBD pathway subcategories could lead to inaccuracies, these difficulties could be due to the similarity of some of the pathway subcategories, or as data are not of sufficient detail to make the designations. If pathway and date of introduction information are not available for many species, upward or downward trends in this indicator might be inaccurate. Trends may be influenced by the frequency or intensity of surveys for alien species. It does not consider whether such introductions are desirable or not. If the risk of an introduction was assessed and deemed acceptable prior to introduction, then that species is likely of less concern than accidental or unregulated intentional introductions.

Updating the indicator

The indicator should be regularly updated as data on alien species introductions become available, or as often as is required for reporting on the status of biological invasions.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species	**1.** Introduction pathway prominence **4.** Within-country dispersal rates	**13.** Quality of regulatory framework **15.** Planning coverage **16.** Pathways treated **19.** Effectiveness of pathway treatments **A.** Rates of introduction of new unregulated species **D.** Level of success in managing invasions

Additional information and comments

Species might use multiple pathways. Yearly data might be available on alien species introductions, but this temporal scale might be too fine to calculate introduction trends.

It would be useful to record large inter-annual variations in the numbers of introductions per pathway sub-category, but this is not explicitly dealt with here.

The cut-off for the difference between an increase or decrease and minimal change in introduction rates is in terms of absolute numbers of species, but relative measures could also be used.

3 WITHIN-COUNTRY PATHWAY PROMINENCE

Use and interpretation

This indicator concerns the pathways that facilitate the movement of alien species from one part of a country to another. The indicator considers the size of the pathway but does not take into account how important the pathway is for the dispersal of alien organisms. Depending on the available data, the indicator can be used to answer three questions:

- What is the size of the pathway?
- How prominent is the pathway relative to the other pathways?; and,
- How does the size of the pathway vary across space and time?

Potential for aggregation

This indicator was developed for use at a national level. However, as data might be available at large (e.g. regions or continents) or small (e.g. provinces or districts) spatial scales, the indicator can be used at a wide range of scales.

Possible reasons for upward or downward trends

Upward or downward trends could be caused by changes to the routes travelled by vessels that transport goods and people, these changes could be due to the development of new, more favourable routes or to local socio-economic changes (e.g. in the demand for certain products or travel trends). Changes to the number of people or the amount or type of goods being transported within the country could also influence these trends. These changes could possibly be driven by socio-economic or environmental factors.

An increase in the size or relative prominence of a pathway could mean that there has been an increase in the likelihood that alien organisms are being dispersed within the country through this pathway. However, this might not be the case as various factors (e.g. the number and type of alien species introduced to the country) will influence the strength of this link.

Similarly, a downward trend in this indicator could mean that there has been a decrease in the likelihood that alien organisms are being moved around the country through a given pathway.

Implications for biodiversity management of change in the indicator

Upward or downward trends could lead to changes in the pathways that are prioritised for management and, as a consequence, to changes in the allocation of resources (money and personnel).

Units in which it is expressed (from basic to advanced)

3.1	Five categories demonstrating the size of each pathway with pathways split along the CBD pathway categorisation (CBD, 2014). • Not known • Pathway not present • Minor • Moderate • Major
3.2	A ranked order of pathways in terms of their prominence.
3.3	Spatially explicit vectors that detail the amount, number and value of goods or vessels moving around the country per pathway, with information on the sources, routes, destinations and timings.

Description of source data

Online global or national databases containing trade or transport data run by national governments, intergovernmental or global organisations and companies [e.g. the FAOSTAT database of the Food and Agricultural Organisation of the United Nations (http://www.fao.org/faostat/en/#data)]. Yearly data are, however, often not available the most recent years. Data can also be obtained from peer-reviewed journal articles and the websites and reports of national governments, intergovernmental or global organisations and companies. Spatial data on transportation networks are available.

Calculation procedure

3.1	Experts use collected data to categorise each pathway as: • Not known • Pathway not present • Minor • Moderate • Major
3.2	For each pathway the amount, number and value of imported goods or vessels is calculated. Pathways are then ranked.
3.3	As above for different routes and periods of time, no ranking

Guide for applying confidence levels

3.1	**HIGH**	Data collated specifically on a particular pathway and recorded regularly (e.g. annually). Evaluated by at least three relevant experts with agreement in almost all cases
	MEDIUM	Data available across larger time-scales (e.g. decades), or have to be interpreted based on other data sources and/or evaluation by one expert; and/or a few cases of disagreement with multiple experts
	LOW	Few direct estimates of the data or estimated entirely based on expert opinion.
3.2	**HIGH**	Data collated for all pathways in comparable units and recorded regularly (e.g. annually).
	MEDIUM	Data available across larger time-scales (e.g. decades), or substantial interpretation across different data sources is required for comparisons.
	LOW	Few direct estimates of the data or ranks based on expert opinion.
3.3	**HIGH**	Regularly recorded, detailed data for every pathway with the destination of the vessels or goods and date of arrival.
	MEDIUM	Data available across larger spatial (e.g. provinces) or temporal scales (e.g. decades), or have to be interpreted based on other data sources.
	LOW	Errors in data apparent or clear that data are inconsistently recorded.

Most effective forms of presentation

3.1	A table with the CBD pathway subcategories and for each pathway the assigned pathway size.
3.2	A table with the CBD pathway subcategories and the rank of each pathway, or a figure demonstrating the size of the pathways, with the pathways ordered according to their rank.
3.3	Maps or figures demonstrating spatial and temporal variation in pathway size.

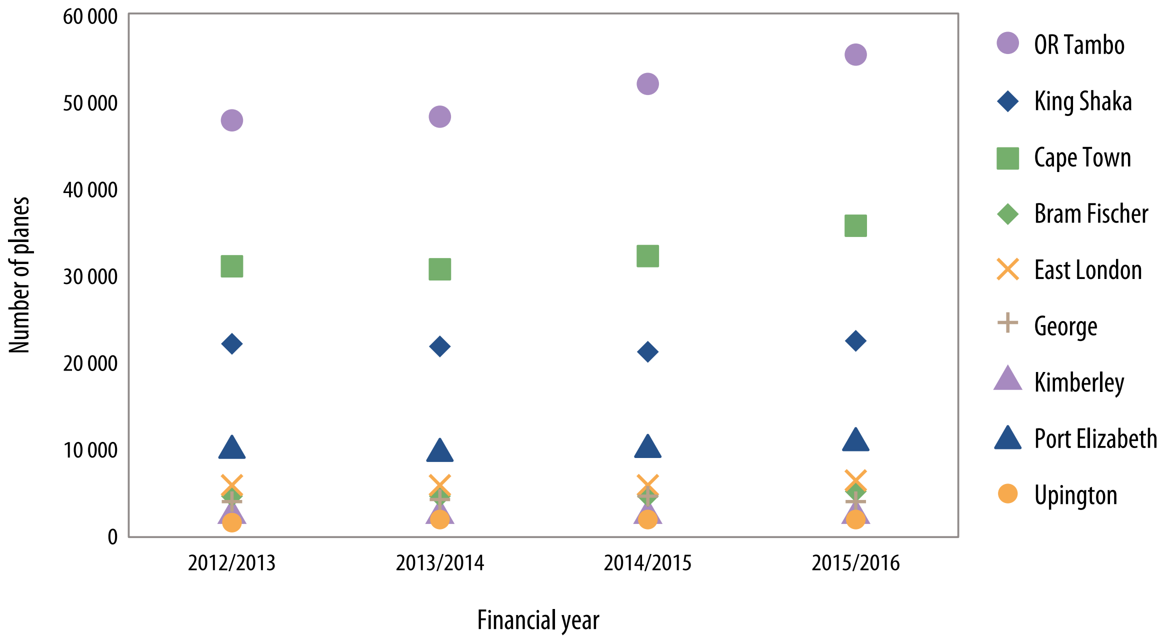


FIGURE A1.3 (Indicator 3.3) Number of domestic flight arrivals at South African airports. Data were obtained from Airports Company South Africa, accessed 22 March 2017.

Limits to usefulness and accuracy

Reliant on data provided by national and global databases, for which data quality might not be known. Data quality might vary between countries leading to more accurate assessments for some countries than others. Databases that are infrequently updated might cause difficulties when estimating upward or downward trends, or will have only sporadic value if updated less frequently than the indictor is updated. Data that are only available at regional or larger scales will be unsuitable for national scale assessments. Useful measures of pathway prominence might not be available for all pathways, particularly for less specific pathways such as 'other escape from confinement'. For some pathways there might be various types of data available, and this could lead to differing estimates.

Updating the indicator

The indicator could be updated yearly or at coarser, but regular time intervals. At the least, the indicator should be updated as often as is required for reporting on the status of biological invasions.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
none	**1.** Introduction pathway prominence **4.** Within-country dispersal rates	**13.** Quality of regulatory framework **15.** Planning coverage **16.** Pathways treated **19.** Effectiveness of pathway treatments **A.** Rate of introduction of new unregulated species **D.** Level of success in managing invasions

Additional information and comments

For some pathways it might be difficult to access data. For example, some transport data are owned by companies and to gain access to the data or databases a fee is often required. Transport data can be commercially sensitive.

4 WITHIN-COUNTRY DISPERSAL RATES

Use and interpretation

This indicator concerns the pathways that facilitate the dispersal of alien species within a country, and in particular, the importance of the pathway for the dispersal of alien organisms. Depending on the available data, the indicator can be used to answer three questions:

- How many species have dispersed through the pathway?
- How has the number of species dispersing through the pathway changed over time?; and
- How has the number of individuals (of a specific species) dispersing through the pathway varied over time and space?

The indicator is of particular use for measuring progress towards meeting Aichi Biodiversity Target 9 of the Convention on Biological Diversity (CBD, 2014).

Potential for aggregation

This indicator was developed for use at a national level, however, as the national level data can be aggregated, the indicator can also be used at larger spatial scales (e.g. regions or continents). For example, the number of species dispersing through a pathway within different countries could be summed to get an indication of the importance of the pathway for dispersal in a region or continent. As data could be available at both large (e.g. regions or continents) and small spatial scales (e.g. provinces or districts), the indicator can be used at a wide range of scales.

Possible reasons for upward or downward trends

Upward and downward trends could be caused by environmental and socio-economic changes (like changes to consumer or travel trends). Variations in the trends could also be linked to changes to research interest in alien species and to the number or intensity of surveys for these organisms.

An upward trend in this indicator demonstrates that the number of species dispersing through the pathway has increased. A downward trend in this indicator demonstrates that the number of species dispersing through the pathway has decreased.

Implications for biodiversity management of change in the indicator

Upward or downward trends could lead to changes in the pathways that are prioritised for management and, as a consequence, to changes in the allocation of resources.

Units in which it is expressed (from basic to advanced)

4.1	The total number of alien species dispersing through each pathway over all time, with pathways split along the CBD pathway categorisation (CBD, 2014).
4.2	Five categories demonstrating changes over a recent period of time (e.g. since the 1980s or in the past decade) in the number of species dispersing through each pathway. • Not known • No dispersal • Increase • Decrease (if there was no dispersal then specify) • Minimal change (if there was no dispersal then specify)
4.3	Number of individuals of each species dispersing through the pathways, and sources and destinations and timings of dispersal

Description of source data

Published peer-reviewed journal articles, alien species lists and databases. These could include local, national or global databases (e.g. the Global Invasive Species Database (http://www.iucngisd.org/gisd/), CABI Invasive Species Compendium (http://www.cabi.org/isc/)). Some alien species databases are regularly updated (every few years), however, this is not always the case.

Calculation procedure

4.1	For each pathway, calculate the total number of alien species that have dispersed though the pathway.
4.2	For each pathway and time period, calculate the total number of alien species dispersing through the pathway. Ideally different alternative models are fitted to the data and compared in a Bayesian framework or using the Akaike Information Criterion (Seebens *et al.*, 2016), but as a rule of thumb: • Not known • No dispersals (over the last decade; note it can also be a decrease or minimal change) • Increase (increase of ≥ 5 species over the last decade) • Decrease (decrease of ≥ 5 species over the last decade) • Minimal change (increase or decrease of < 5 species over the last decade)
4.3	For each period of time, calculate the number of individuals of each species dispersing through each of the pathways, and map the various routes followed.

Guide for applying confidence levels

4.1	**HIGH**	Direct evidence of the dispersal pathway for most alien species and the species can easily be assigned to the pathway subcategories.
	MEDIUM	Pathway of dispersal for most species can be inferred as the species appeared when and where a single pathway was in operation and there is no other explanation. Species can easily be assigned to pathway subcategories.
	LOW	Pathway of dispersal is inferred for most species based on information on species traits and information from other regions or species cannot easily be assigned to the pathway subcategories. Data are not available for many species, qualitative estimates or based on expert opinion.
4.2	**HIGH**	Specific records exist for each pathway for all the dispersal events per year.
	MEDIUM	Inferred from data on numbers of alien species with knowledge of likely dispersal dates (in the order of several years).
	LOW	The change in rate is from expert opinion, or data are not available for many species.
4.3	**HIGH**	Detailed, regularly recorded records exist for each dispersal event for all pathways on the point of introduction and number of individuals dispersing.
	MEDIUM	Data available across larger spatial (e.g. provinces) or temporal scales (e.g. decades), or have to be interpreted based on other data sources.
	LOW	Based on expert opinion.

Most effective forms of presentation

4.1	A figure demonstrating the number of alien species dispersing through each pathway
4.2	A table with the CBD pathway subcategories and for each pathway the assigned trend in the number of species dispersing through the pathway (i.e. increase, decrease, minimal change, no dispersal or not known)
4.3	Maps or figures demonstrating spatial and temporal variation in the number of individuals dispersing through a pathway

No examples provided here.

Limits to usefulness and accuracy

Poor data quality (e.g. no direct evidence of the dispersal pathway) might lead to inaccurate designation of the pathways of dispersal. Difficulties associated with categorising species into the CBD pathway subcategories could lead to inaccuracies, these difficulties could be due to the similarity of some of the pathway subcategories, or as data are not of sufficient detail to make the designations. If pathway and date of dispersal information are not available for many species, upward or downward trends in this indicator might be inaccurate. Trends may be influenced by the frequency or intensity of surveys for alien species.

A positive value will not necessarily be undesirable (e.g. for biological control agents), as the redistribution of effective and safe biological control agents is desirable.

Species might use multiple pathways.

Updating the indicator

The indicator should be regularly updated as data on the dispersal of alien species becomes available, or as often as is required for reporting on the status of biological invasions.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species **6.** Extent of alien species	**2.** Introduction rates **3.** Within-country pathway prominence	**13.** Quality of regulatory framework **15.** Planning coverage **16.** Pathways treated **19.** Effectiveness of pathway treatments. **A.** Rate of introduction of new unregulated species **D.** Level of success in managing invasions

Additional information and comments

None

5 NUMBER AND STATUS OF ALIEN SPECIES

Use and interpretation

The basis for constructing lists of alien species for a country.

Such information is important for biosecurity to be able to target species which are not yet present and to identify threats based on what is already in the country. If the status is known this can be used to estimate the establishment part of the invasion debt, i.e. how many species are likely to naturalise in future.

Potential for aggregation

Can be presented per taxonomic group or aggregated across all species. Can be used at a variety of spatial scales, depending on the scale at which data are available.

Possible reasons for upward or downward trends

Increases can be due to new taxa being introduced; taxa that were already introduced being detected for the first time; or improvements in identification or taxonomic revision.

Increases in status can be the result of species exiting a lag phase (e.g. there was a mechanistic reason preventing naturalisation or invasion that has been lifted); having sufficient time in a country for them to exhibit their invasive potential; or a new record.

Decreases can be due to eradications as a result of active management; populations being unintentionally wiped out (e.g. by the removal of habitat); as individuals and populations naturally die and collapse; or again due to revisions in identifications.

Implications for biodiversity management of change in the indicator

Biosecurity resources can be reallocated to prevent the introduction of taxa which are no longer in the country.

If status increases it might indicate a need to reassess the invasive risk of an alien taxa, or to precipitate an incursion response.

It gives an indication of the effectiveness of species-focused control measures.

Units in which it is expressed (from basic to advanced)

5.1	Number of invasive species
5.2	Number of alien species in one of three categories: • Alien but not naturalised; • Naturalised but not invasive; • Invasive
5.3	Number of species at different stages of the Unified Framework (Blackburn *et al.*, 2011). Ordered factor with 12 categories, note in Blackburn *et al.* (2011) there are 11 categories, we have split and rephrased category A so it is with reference to South Africa, and distinguishes species that are no longer in South Africa from those were never introduced to South Africa. If there is some uncertainty a range can be given or a number omitted. In the original scheme the term "in the wild" was used, but the term "outside of captivity or cultivation" is preferred here (F. Essl, pers. com. Sep. 2017) • **A0:** Never introduced beyond limits of indigenous range to South Africa; • **A1**: Has been introduced beyond limits of indigenous range to South Africa, but no longer present; • **B1:** Individuals transported beyond limits of indigenous range, and in captivity or quarantine (i.e. individuals provided with conditions suitable for them, but explicit measures of containment are in place); • **B2:** Individuals transported beyond limits of indigenous range, and in cultivation (i.e. individuals provided with conditions suitable for them but explicit measures to prevent dispersal are limited at best); • **B3:** Individuals transported beyond limits of indigenous range, and directly released into novel environment; • **C0:** Individuals released outside of captivity or cultivation in location where introduced, but incapable of surviving for a significant period; • **C1:** Individuals surviving outside of captivity or cultivation in location where introduced, no reproduction; • **C2:** Individuals surviving outside of captivity or cultivation in location where introduced, reproduction occurring, but population not self-sustaining; • **C3:** Individuals surviving outside of captivity or cultivation in location where introduced, reproduction occurring, and population self-sustaining; • **D1:** Self-sustaining population outside of captivity or cultivation, with individuals surviving a significant distance from the original point of introduction; • **D2:** Self-sustaining population outside of captivity or cultivation, with individuals surviving and reproducing a significant distance from the original point of introduction; • **E:** Fully invasive species, with individuals dispersing, surviving and reproducing at multiple sites across a greater or lesser spectrum of habitats and extent of occurrence. Introduced but not naturalised corresponds to B1–C2. Naturalised but not invasive corresponds to C3. Invasive corresponds to D1–E.

Description of source data

Physical samples lodged in collections. DNA barcodes linked to a field collection. Field observations. Archival records. Results from assessments of the status of alien populations.

Calculation procedure

5.1	The total number of species known to be invasive. There must be evidence for alien status (i.e. that it is not indigenous), presence (i.e. there is a confirmed record in the location), and invasiveness (i.e. there is some natural spread from sites of introduction).
5.2	As above, with additional field observations as to the status of populations, in the absence of information the assumption is made that taxa have not naturalised, or are not invasive.
5.3	As above, with detailed field observations using appropriate protocols (e.g., Wilson *et al.*, 2014, Robinson *et al.*, 2016).

Guide for applying confidence levels

5.1	**HIGH**	Physical sample lodged in recognised collection identified by expert or molecular sample confirmation in the last 50 years; and All databases state that the taxon is alien and there is no evidence of debate about nativity; and Field notes in the past decade confirming invasiveness based on biogeographic definition of invasive (Blackburn *et al.*, 2011).
	MEDIUM	No physical sample, or sample but collected over 50 years ago with no field confirmation in the last decade; and/or Categorised as alien in most authoritative source, although some references report as indigenous with no detailed published analysis confirming nativity; and/or Invasiveness inferred from records.
	LOW	Recorded as present but record either questioned or last record from a substantial time ago (e.g. not in the most recent update); and/or Nativity in dispute.
5.2	**HIGH**	Based on recent published field observations
	MEDIUM	Based on recent unpublished field observations
	LOW	Based on expert opinion only with no clear indication of last field observations
5.3	**HIGH**	Based on recent field observation specifically using the coding of the Unified Framework
	MEDIUM	Based on historical field observations with enough information to code populations according to the Unified Framework.
	LOW	Interpreted from distribution data in a data-set

Most effective forms of presentation

5.1	As a number
5.2	In a bar chart
5.3	As a table, or as a bar chart (can be plotted as a bar chart noting changes)

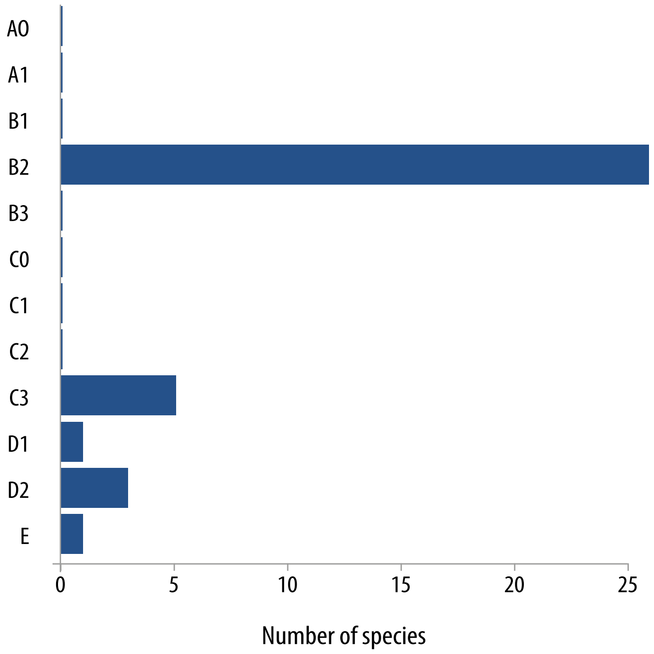


FIGURE A1.4 (Indicator 5.3) The status of introduced *Melaleuca* species in South Africa as per the Unified Framework. Only species that are known to still be in South Africa are included, so A0 and A1 not quantified here. Data from Jacobs *et al.* (2017).

Limits to usefulness and accuracy

It can be highly sensitive to search effort and taxonomy, so for under-studied taxonomic groups, the number of alien species in a country will be a function of how much material has been collected and whether taxonomists have worked on it.

It assumes an equivalency between species, e.g. one alien tree species is the same as one mite species. It also relies on species being well defined concepts and similarly does not encapsulate invasion at a gene level (Petit, 2004).

There can be inconsistencies in the use of the terminology, e.g. in some databases the definition of "invasive" requires populations to be found in "natural" areas or that a negative impact of some sort has been recorded.

Updating the indicator

Should be done on an on-going basis as new detections are made and new instances of naturalisation or invasions are noted. However, it might be necessary for a specific effort to be made to update records according to the Unified Framework, and guidelines for scoring different taxa are still needed. The Unified Framework and protocols for the framework might develop over time.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
6. Extent of alien species (for 5.3) **7.** Abundance of alien species (for 5.3)	None	**2.** Introduction rates **4.** Within-country dispersal rates **6.** Extent of alien species **7.** Abundance of alien species **8.** Impact of alien species **9.** Alien species richness **10.** Relative alien species richness **11.** Relative invasive abundance **12.** Impact of invasions **13.** Quality of regulatory framework **14.** Money spent **15.** Planning coverage **16.** Pathways treated **17.** Species treated **19.** Effectiveness of pathway treatments **20.** Effectiveness of species treatments **21.** Effectiveness of area treatments **A.** Rate of introduction of new unregulated species **B.** Number of invasive species that have major impacts **C.** Extent of area that suffers major impacts from invasions **D.** Level of success in managing invasions

Additional information and comments

At a basic level, the metric is the number of invasive species rather than the number of alien species. This is because for many groups only invasive species will be known with any level of accuracy (they tend to be much more detectable). However, it does require additional information that taxa are actually invasive.

Species which are both indigenous and alien to a region, and cryptic invasions need to be dealt with consistently.

It should link to various databases, e.g. the Global Register of Introduced and Invasive Species that provide checklists of alien species in a country. Such checklists are often taxon specific, but the data should be aggregated across all taxonomic groups.

While regulatory lists can provide some indication of alien species, it is often difficult to trace these to verified physical records, and they might be the result of some prioritisation exercise (so are only a subset of species that have undesirable impacts).

6 EXTENT OF ALIEN SPECIES

Use and interpretation

Provides an indication of how widespread alien species are and provides information that can be used for metrics of how invaded areas are and where impacts might be occurring.

Species that are more widespread or that are increasing in range might be considered to be of greater concern (Parker *et al.*, 1999), though there can often be a weak link between extent and impact across species (Hulme, 2012).

Potential for aggregation

It can provide an overall picture of which alien species are the most widespread. It can be split along taxonomic or functional lines to provide an indication of which are the most widespread alien taxa.

Possible reasons for upward or downward trends

The extent will increase with greater survey effort and species dispersing (either naturally or particularly through human-mediated within country dispersal at broader spatial scales).

The extent will decrease as populations die out (either through natural means, e.g. stochastic climatic events and directional shifts in climate, or through control measures leading to extirpation). It is possible that errors in reporting could also lead to declines in species extents.

Implications for biodiversity management of change in the indicator

It provides an indication of the area over which management interventions are needed for a given species. Declines (or a relative reduction in spread rates) can indicate the effectiveness of control interventions.

Units in which it is expressed (from basic to advanced)

6.1	Number of large-scale national subdivisions (provinces, primary catchments or bioregions as appropriate) occupied per species
6.2	Number of finer-scale national subdivisions (quarter-degree grid cells or hectads) occupied per species
6.3	Range size for each species (e.g. km^2 or ha)

Description of source data

Data are used from atlas projects, or distribution surveys.

Calculation procedure

6.1	Data are collected at large-scale resolution or point data need to be interpreted in terms of which large-scale areas are occupied (e.g. using a GIS)
6.2	As for 6.1
6.3	A technique is applied to observation data in a GIS using an appropriate projection. In some cases a convex hull approach might be sufficient, but might need to use an alpha-hull approach for species with disjunct distributions (likely for many aliens).

Guide for applying confidence levels

6.1	**HIGH**	Included in a formal verified atlas or mapping project based on recent surveys with adequate ground-truthing. There is some indication that there have been surveys in areas that are marked as absent.
	MEDIUM	Data from an atlas project, though it is not explicit that absences would have been recorded / some areas might not have been surveyed.
	LOW	Interpreted from expert opinion
6.2	**HIGH**	As for 6.1
	MEDIUM	As for 6.1
	LOW	As for 6.1
6.3	**HIGH**	Data based on a project within the last decade specifically designed to map the range of the taxon in question, with search effort explicit and sufficient to determine where taxa are and where they are not. Might include citizen science component for easily identified taxa. Appropriate statistical technique used to estimate total range size (particular if disjunct distributions)
	MEDIUM	Data from atlas project or general mapping project with indication of sampling effort, but data not complete or not recent (e.g. >10 years old)
	LOW	No absence data, no clear statistical methodology for estimating range size, or very broad estimate.

Most effective forms of presentation

6.1	Bar chart showing frequency distribution of range per taxon; plot of how ranges have changed over time
6.2	As for 6.1
6.3	As for 6.1

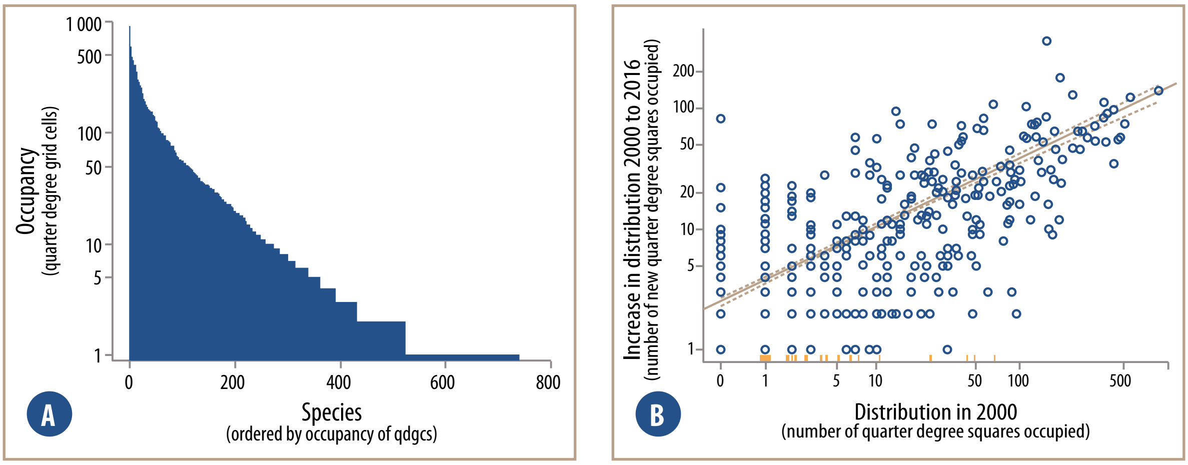


FIGURE A1.5 (Indicator 6.2) In panel a is the extent of naturalised plants in South Africa in 2010 based on the Southern African Plant Invaders Atlas (SAPIA) as a frequency distribution of occupancy per species (Wilson *et al.*, 2013); panel b shows changes in the distribution of occupancy of naturalised plants in South Africa from 2000 to 2016 from SAPIA (Henderson & Wilson, 2017). In panel b taxa with no change in range size are shown as tick marks on the x-axis, declines in range were not recorded in SAPIA (but could have happened).

Limits to usefulness and accuracy

An alien taxa might be present in an area but restricted to particular environments (in some cases human influenced), or at very low density, so the indicator does not map directly to impact.

The accuracy of the data will depend on large-scale repeated surveys. Often need to assume absences, and in many databases these are not recorded.

Updating the indicator

This can be done ad hoc, but ideally should be linked to set survey frequency or at least with respect to repeat surveys.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species	None	**4.** Within-country dispersal rates **5.** Number and status of alien species **7.** Abundance of alien species **8.** Impact of alien species **9.** Alien species richness **10.** Relative alien species richness **11.** Relative invasive abundance **12.** Impact of invasions **13.** Quality of regulatory framework **14.** Money spent **15.** Planning coverage **16.** Pathways treated **17.** Species treated **18.** Area treated **19.** Effectiveness of pathway treatments **20.** Effectiveness of species treatments **21.** Effectiveness of area treatments **A.** Rate of introduction of new unregulated species **B.** Number of invasive species that have major impacts **C.** Extent of area that suffers major impacts from invasions **D.** Level of success in managing invasions

Additional information and comments

At a finer-scale it can be important to consider presence in ecologically relevant sub-divisions, e.g. habitats or vegetation types.

The abundance can be used in concert with the extent to look at dynamics across scales, e.g. (Kunin, 1998). Such area-occupancy curves can be used to explore mechanisms affecting dispersal dynamics (Veldtman, Chown & McGeoch 2010, Donaldson, Richardson & Wilson 2014).

7 ABUNDANCE OF ALIEN SPECIES

Use and interpretation

Provides an indication of how many individuals there are of particular species. It can be used as part of prioritisation efforts for species-specific control measures.

Potential for aggregation

It can be split into taxonomic groups.

Possible reasons for upward or downward trends

Changes can be due to population growth or decline; more survey work; or changes in survey techniques.

Implications for biodiversity management of change in the indicator

Variations in the abundance of alien species are used to assess the effectiveness of species-based interventions. Changes could lead to the reallocation of resources.

Units in which it is expressed (from basic to advanced)

7.1	Categorical measure of abundance per species per locality in one of five categories: • not known • absent • rare • occasional • abundant
7.2	Number of individuals for mobile organisms or condensed area occupied for sessile organisms.
7.3	Abundance estimates divided into appropriate stage or age cohorts. At a basic level numbers of individuals which are reproductive or not.

Description of source data

Field or remotely sensed observations, some representative sub-sampling of populations that are then used to extrapolate total population estimates (e.g. mark-recapture), or direct counts of individuals.

Calculation procedure

7.1	Based on expert opinion or crude broad-brush observations
7.2	Sub-sampling and extrapolation using models; or direct total counts
7.3	As for 7.2

Guide for applying confidence levels

7.1	HIGH	Recent survey, technique used well documented, and several people confirming the value obtained (e.g. included in a formal verified atlas or mapping project based on recent surveys with adequate ground-truthing)
	MEDIUM	Data from an atlas project, or recent survey but only one person
	LOW	Interpreted from expert opinion, or no clear basis for the value given, or over 10 years ago.
7.2	HIGH	Accurate and recent population census, using appropriate statistical techniques.
	MEDIUM	Estimation based on sampling that uses assumptions and makes extrapolations
	LOW	Expert opinion
7.3	HIGH	As for 7.2
	MEDIUM	As for 7.2
	LOW	As for 7.2

Most effective forms of presentation

7.1	Bar chart of different species/tables
7.2	Frequency histogram of different species
7.3	Size distribution graphs for each taxon, with indications of which individuals are reproductively active.

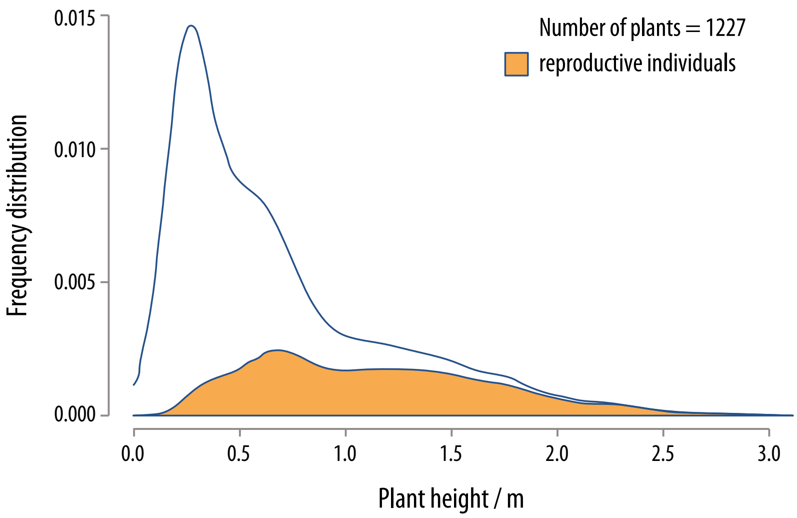


FIGURE A1.6 (Indicator 7.3) Size frequency distribution from naturalised populations of *Genista monspessulana* in South Africa in 2012 (Geerts *et al.*, 2013a). Data are pooled from several sites, and roughly a tenth of the total population estimate (~10 000 plants) were measured. In addition, *G. monspessulana* was estimated to have a seed-bank of several million.

Limits to usefulness and accuracy

Without stage-structured information (7.1 and 7.2), coarse numbers can be a bit misleading as there might be a large number of juveniles and few reproductively active adults (so population growth will at least initially be slow).

As for extent, abundance does not necessary map on to impact.

Updating the indicator

It can be updated after individual surveys and might be part of annual progress reports.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species **6.** Extent of alien species	None	**5.** Number and status of alien species **8.** Impact of alien species **9.** Alien species richness **10.** Relative alien species richness **11.** Relative invasive abundance **12.** Impact of invasions **13.** Quality of regulatory framework **14.** Money spent **15.** Planning coverage **17.** Species treated **18.** Area treated **20.** Effectiveness of species treatments **21.** Effectiveness of area treatments **A.** Rate of introduction of new unregulated species **B.** Number of invasive species that have major impacts **C.** Extent of area that suffers major impacts from invasions **D.** Level of success in managing invasions

Additional information and comments

The abundance can be used in concert with the extent to look at dynamics across scales, e.g. (Kunin, 1998). Such area-occupancy curves can be used to explore mechanisms affecting dispersal dynamics (Veldtman, Chown & McGeoch 2010, Donaldson, Richardson & Wilson 2014).

8 IMPACT OF ALIEN SPECIES

Use and interpretation

Identify which alien species are causing the largest negative impacts.

Helps identify which types of impacts are most common (i.e. the impact mechanisms).

If the current impact level is less than the maximum impact level ever recorded this provides an indication that any interventions to reduce impacts might have been successful.

Potential for aggregation

Can be scaled up, i.e. if impact is massive at a local scale it will be massive at a global scale. However, it can be difficult to scale down as it might be unclear where the impacts are.

Possible reasons for upward or downward trends

Better reporting of impacts. Mitigation or management effective in reducing impacts. Changes to the extent and abundance of alien species leading to greater impacts. Impacts accruing over time due to lagged biodiversity responses (Essl *et al.*, 2015b).

Implications for biodiversity management of change in the indicator

There might be a change in which species should be prioritised for management. If the impact of a species declines, then it might be indicative of effective control.

Units in which it is expressed (from basic to advanced)

8.1	Categorical factor with eight levels. A single value is presented which is the maximum current recorded impact in the region. The impact will be the highest of either the Environmental Impact Classification of Alien Taxa (EICAT) or Socio-economic Impact Classification of Alien Taxa (SEICAT) schemes (Bacher *et al.*, 2018, Blackburn *et al.*, 2014) • **NE**: Not evaluated • **NA**: No alien populations in the region • **DD**: Data deficient • **MC**: Minimal Concern (note: there is no category for no impact) • **MN**: Minor • **MO**: Moderate • **MR**: Major • **MV**: Massive
8.2	The current and maximum ever recorded EICAT and SEICAT scores for each possible impact mechanism in South Africa.

Description of source data

Published literature on impacts of alien species.

Calculation procedure

8.1	See Hawkins *et al.* (2015) for EICAT and Bacher *et al.* (2018) for SEICAT. The current maximum recorded impact might be different from the maximum ever recorded.
8.2	As for 8.1, but current and maximum ever impact recorded for all impact mechanisms.

Guide for applying confidence levels

8.1	**HIGH**	See guideline in Hawkins *et al.* (2015) for EICAT and Bacher *et al.* (2018) for SEICAT. Impact assessment formally conducted for the relevant country and reviewed by IUCN EICAT team (a similar SEICAT team is still to be set up). To be based on data within the last decade.
	MEDIUM	As above, with evidence that the impact assessment was conducted according to EICAT procedure, but not formally reviewed; and/or data within the last 50 years was used.
	LOW	As above, and it is not clear how the assessment was arrived at, it was entirely extrapolated from impacts in other regions, or the data are over 50 years old.
8.2	**HIGH**	As for 8.1.
	MEDIUM	As for 8.1.
	LOW	As for 8.1.

Most effective forms of presentation

8.1	A histogram or table of species per category.
8.2	A histogram showing which mechanisms are most frequently recorded for a given group at a given level of impact.

TABLE A1.2 (Indicator 8.1) Global impact assessment for selected alien frog species. This is based on a combination of EICAT and SEICAT assessments (Bacher *et al.*, 2018)

SPECIES	IMPACT OF ALIEN SPECIES (CONFIDENCE)
Rhinella marina	**MR** (high)
Duttaphrynus melanostictus	**MR** (low)
Eleutherodactylus coqui	**MO** (high)
Eleutherodactylus planirostris	**MN** (low)
Hyla meridionalis	**MO** (low)

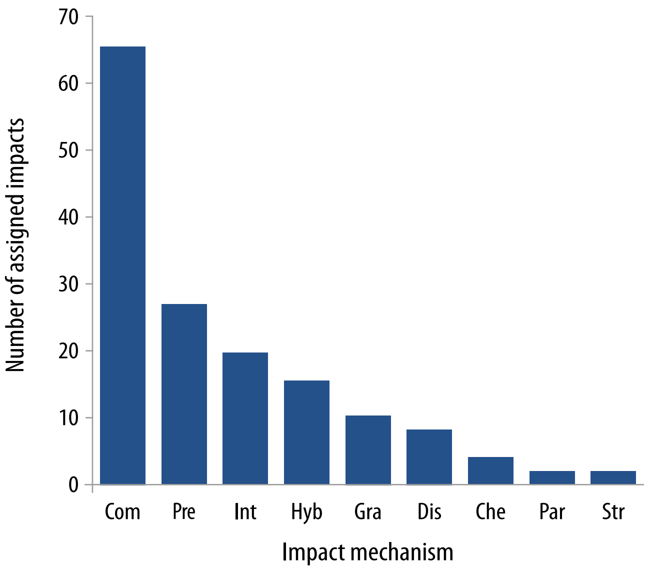


FIGURE A1.7 (Indicator 8.2) – The number of impact mechanisms recorded for alien birds (Evans, Kumschick & Blackburn 2016). Com, Competition; Pre, predation; Int, interaction with other alien species; Hyb, hybridization; Gra, grazing/herbivory/browsing; Dis, transmission of disease to indigenous species; Che, chemical impact on ecosystem; Par, parasitism; Str, structural impact on ecosystem.

Limits to usefulness and accuracy

It is highly dependent on the availability of published assessments of impact. As such it will normally represent an observed minimum, and underestimate impacts. It only represents observed historical impact and not future threat.

EICAT and SEICAT assessments are only possible for well-studied species.

Updating the indicator

It can be updated as new studies are published.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species **6.** Extent of alien species **7.** Abundance of alien species **10.** Relative alien species richness **11.** Relative alien abundance	**13.** Quality of regulatory framework **14.** Money spent **17.** Species treated	**12.** Impact of invasions **15.** Planning coverage **17.** Species treated **20.** Effectiveness of species treatments **21.** Effectiveness of area treatments **B.** Number of invasive species that have major impacts **C.** Extent of area that suffers major impacts from invasions **D.** Level of success in managing invasions

Additional information and comments

The IUCN has adopted EICAT and is considering adopting SEICAT, but the process for formally approving assessments is still to be finalised. Global assessments might be slightly different from assessments at the scale of South Africa. There will need to be a substantial ongoing investment in impact studies for this indicator to be sufficiently reactive to allow the monitoring of trends on the scale of years rather than decades.

9 ALIEN SPECIES RICHNESS

Use and interpretation

This is an indicator of the number of alien species in a particular area. Higher numbers of invasive species indicate the number of issues to be addressed, while higher numbers of all alien species indicate a higher risk of invasion, as a proportion of these species can be expected to become invasive over time. The indicator can be used at a range of scales to track invasion debt.

Potential for aggregation

This indicator is expressed at a particular spatial scale (for example a country, a province, or a municipality; or at primary, secondary or tertiary catchment scales) and can be aggregated upwards from data collected at finer scales.

Possible reasons for upward or downward trends

Upward trends are to be expected as more alien species are introduced and spread around the region. Downward trends would occur if alien species were extirpated from a region, or failed to establish self-sustaining populations and disappeared locally. Changes to taxonomy or survey efforts might affect values.

Implications for biodiversity management of change in the indicator

As alien species richness increases, the number of species that need to be managed will increase. As resources to manage all species over the whole area would probably be limiting, species would need to be prioritised in terms of potential impacts on biodiversity.

If the invasion stages of alien species are known, they be used to identify potential hotspots of future invasions.

Units in which it is expressed (from basic to advanced)

9.1	The total number of invasive species per large-scale national sub-division.
9.2	The total number of invasive species per finer-scale national sub-division.
9.3	The number of alien species in different stages of the Unified Framework per finer-scale national sub-division

Description of source data

Records of alien species distribution at scales suitable for upward aggregation. In South Africa, the prominent example is the Southern African Plant Invaders Atlas (SAPIA), in which presence and absence are recorded at the scale of quarter degree grid cells (QDGCs), and these can be examined at higher spatial scales.

Calculation procedure

9.1	A count of invasive species within a large-scale national subdivision.
9.2	A count of invasive species within a finer-scale national subdivision.
9.3	A count of alien species at different stages of the Unified Framework within a finer-scale national subdivision.

Guide for applying confidence levels

9.1	HIGH	Based on recent (within the past 5 years) data from across the entire area, populations are formally recorded as invasive.
	MEDIUM	Based on recent data from surveys that cover portions of all or most habitat types within the area and/or there is documentation that some populations are invasive.
	LOW	Based on older data (collected more than five years ago), or data gathered from some, but not all, habitat types within the area.
9.2	HIGH	Based on data in which at least 80% of the finer-scale units have been surveyed over the past five years.
	MEDIUM	Based on data in which at least 40% of the finer-scale units have been surveyed over the past five years.
	LOW	Based on data in which less than 40% of the finer-scale units have been recently surveyed, or where data from finer-scale units are older than five years
9.3	HIGH	As for 9.2 with confidence level for alien species status from 5.3
	MEDIUM	As for 9.2 with confidence level for alien species status from 5.3
	LOW	As for 9.2 with confidence level for alien species status from 5.3

Most effective forms of presentation

9.1	A table or map of invasive species richness per large-scale national subdivision.
9.2	A table or map of invasive species richness per finer-scale national subdivision.
9.3	Tables or maps of alien species at different stages of the Unified Framework within finer-scale national subdivisions.

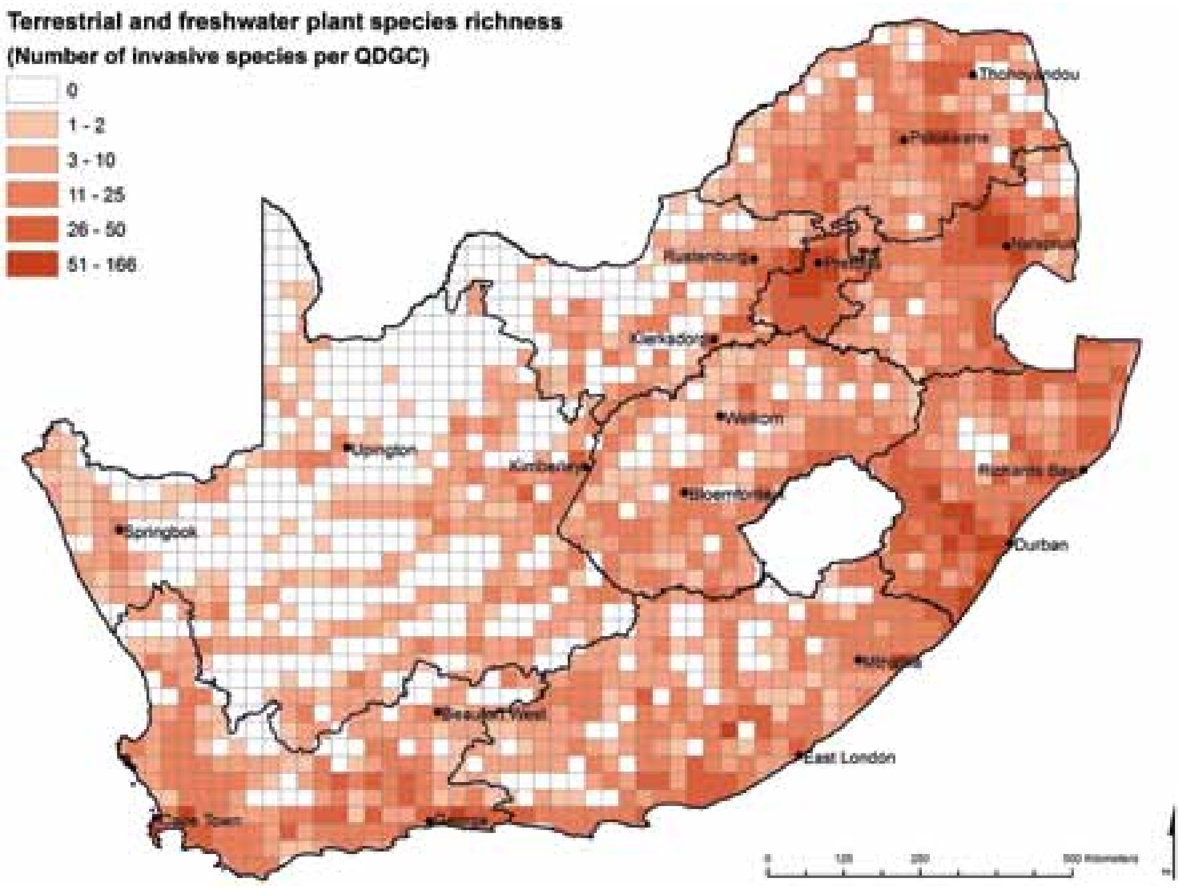


FIGURE A1.8 (Indicator 9.2) Invasive plant species richness at a quarter-degree grid cell scale in South Africa. Data are from the Southern African Plant Invaders Atlas extracted May 2016, figure from Chapter 5 of this report.

Limits to usefulness and accuracy

Large areas would have to be covered on a regular basis to detect trends.

The indicator works well for highly visible taxa (terrestrial and freshwater plants, birds), but not for others.

In some cases it is not clear if records represent invasive populations or presence within captivity or cultivation.

Updating the indicator

Can in theory be updated dynamically, but likely only done for reports on status, e.g. three years at a national level for South Africa. This would be useful for highly visible taxa, but for other taxa a longer period between updates would be more appropriate.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species **6.** Extent of alien species **7.** Abundance of alien species	none	**10.** Relative alien species richness **12.** Impact of invasions **13.** Quality of regulatory framework **15.** Planning coverage **17.** Species treated **20.** Effectiveness of species treatments **21.** Effectiveness of area treatments **C.** Extent of area that suffers major impacts from invasions **D.** Level of success in managing invasions

Additional information and comments

The indicator at lower levels does not make a distinction between records of invasive populations and alien populations. Most data, however, are collected on invasive populations (e.g. excluding plants in people's gardens).

10 RELATIVE ALIEN SPECIES RICHNESS

Use and interpretation

This indicator is the relative proportion of the species richness of an area which is alien. High levels might tend to indicate locations that are particularly threatened.

Potential for aggregation

Species identities must be known if values are to be scaled up.

Possible reasons for upward or downward trends

Changes in the *Relative alien species richness* could arise from:

- Increases in indigenous species richness, e.g. new species descriptions, new observations, or shifts in indigenous ranges;
- Decreases in indigenous species richness (for a range of reasons);
- Increases in *Alien species richness* in particular due to ongoing introduction and spread of alien species; and
- Decreases in the number of alien species due to population trends or management leading to the extirpation of populations.

Implications for biodiversity management of change in the indicator

Areas with a high *Relative alien species richness* would be less likely to recover after restoration efforts, given that removal of one alien species could lead to replacement by others. Comparison of relative richness for broad taxonomic groupings, or for functional guilds, could lead to the identification of those aspects of ecosystem function that are most at risk. For example, invasion of treeless landscapes by alien trees could change the hydrology and grazing potential.

Units in which it is expressed (from basic to advanced)

10.1	The proportion of invasive and indigenous species in a spatial unit that is invasive.
10.2	The proportion of all species (indigenous and alien) that are at different stages of the Unified Framework per finer-scale national sub-division

Description of source data

Records of alien and indigenous species occurrences at scales suitable for upward aggregation, e.g. from atlas projects.

Calculation procedure

10.1	The number of invasive species divided by the total number of indigenous and invasive species. Species which are alien but not invasive are not included to reduce the impact of taxa in captivity or cultivation and so the biodiversity in an area is more closely represented.
10.2	As for 10.1, but including all aliens at different invasion stages.

Guide for applying confidence levels

10.1	**HIGH**	Based on recent (past 5 years) data from across the entire area.
	MEDIUM	Based on recent data from surveys that cover portions of all or most habitat types within the area
	LOW	Based on older data, or data gathered from some, but not all, habitat types within the area.
10.2	**HIGH**	As for 10.1
	MEDIUM	As for 10.1
	LOW	As for 10.1

Most effective forms of presentation

10.1	Bar chart or map
10.2	Bar chart or map

No example presented here.

Limits to usefulness and accuracy

This indicator will be useful for taxonomic groups that are well known, and relatively easily detected, for example higher plants and vertebrate species. For groups that are less well known, or not easily detected (for example invertebrates, or marine species), the indicator is likely to be less accurate.

However, it can be misleading, as it does not provide information on abundance, and the scaling with indigenous biodiversity means that areas that are invaded by many species might be hidden. As such it needs to be used in concert with *Alien species richness* (i.e. absolute rather than relative values) and *Relative invasive abundance* (Catford *et al.*, 2012).

Updating the indicator

This indicator should be updated as part of national reporting cycles, provided that the frequency and coverage of species surveys has been sufficient to justify a re-assessment.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species	**17.** Species treated	**8.** Impact of alien species
6. Extent of alien species	**18.** Area treated	**12.** Impact of invasions
7. Abundance of alien species		**15.** Planning coverage
9. Alien species richness		**20.** Effectiveness of species treatments
		21. Effectiveness of area treatments
		C. Extent of area that suffers major impacts from invasions
		D. Level of success in managing invasions

Additional information and comments

None

11 RELATIVE INVASIVE ABUNDANCE

Use and interpretation

This indicator measures the degree to which an area is invaded by considering the combined abundance of all invasive populations present relative to the abundance of indigenous and invasive organisms. *Relative invasive abundance* is a useful indicator of the degree of stress on an ecosystem, and it can be used at a range of spatial scales.

Potential for aggregation

It can be split into taxonomic groupings.

Possible reasons for upward or downward trends

Changes in the relative proportion of area in different categories would indicate trends in the abundance of invasive species along a continuum from alien free to dominated by invasives. Increases in area in low-level categories should be accompanied by decreases in high-level categories, and vice-versa, providing a means for assessing the effectiveness of control measures.

Implications for biodiversity management of change in the indicator

Management would presumably seek to reduce the *Relative invasive abundance* in priority areas. If trends indicate that management is not effective, it would inform decisions about the prioritisation and allocation of scarce funds to areas where they would be more effectively used.

Units in which it is expressed (from basic to advanced)

11.1	The proportion of the abundance (measured as cover, biomass, or number of individuals depending on the taxonomic group under consideration) that is invasive expressed at six levels for a given spatial unit • not known • invasive-free • minor • moderate • extensive • dominant
11.2	A quantitative estimate of the percentage abundance that is invasive for a given spatial unit

Description of source data

The *Relative invasive abundance* would be assessed for particular areas. The data required would depend on the basis of measurement chosen. For example, the use of plant cover could be derived from mapping exercises, or from remote sensing; estimating numbers of individuals would require a population census; and estimating biomass would require physical sampling or remote sensing. Ideally these kinds of data should be assembled during the development of management plans, and tracked through regular monitoring of progress towards management goals.

Calculation procedure

11.1	Basic information for this indicator should be collected at the scale of management units, for example protected areas or tertiary or quaternary catchments. Each unit is assigned to a single category of relative abundance based on the proportion of the total abundance of species that is alien, as follows: • Invasive-free: No invasive populations occur in the area • Minor: Invasive plants cover < 2% of the area that is covered by plants; or invasive species make up < 2% of the biomass of the entire community; or populations of invasive animals make up < 2% of all individual animals in the area. • Moderate: Invasive plants cover 2–10% of the area covered by plants, or invasive species make up 2–10% of the biomass of the area; populations of invasive animals make up 2–10% of all individual animals in the area. • Extensive: Invasive plants cover 10–50% of the area covered by plants, or invasive species make up 10–50% of the biomass of the area; populations of invasive animals make up 10–50% of all individual animals in the area. • Dominant: Invasive plants cover > 50% of the area covered by plants; invasive species make up > 50% of the biomass of the area; or populations of invasive animals make up > 50% of all individual animals in the area.
11.2	As above, but with a quantitative estimate

Guide for applying confidence levels

11.1	**HIGH**	Cover estimates are based on mapping or the use of remote sensing that samples > 80% of the area; biomass estimates are made on the basis of sampling a representative set of habitats, and extrapolated on the basis of reliable habitat maps; population estimates are made on the basis of sampling that covers > 80% of the area.
	MEDIUM	Cover estimates are based on mapping or the use of remote sensing that samples 20–80% of the area; biomass estimates are made on the basis of limited sampling, and/or extrapolated on the basis of coarse habitat subdivisions; population estimates are made on the basis of sampling that covers 20–80% of the area.
	LOW	All estimates are based on local knowledge of the area concerned, or on limited sampling that covers < 20% of the area.
11.2	**HIGH**	As for 11.1
	MEDIUM	As for 11.1.
	LOW	As for 11.1

Most effective forms of presentation

11.1	Bar chart or map
11.2	Bar chart or map

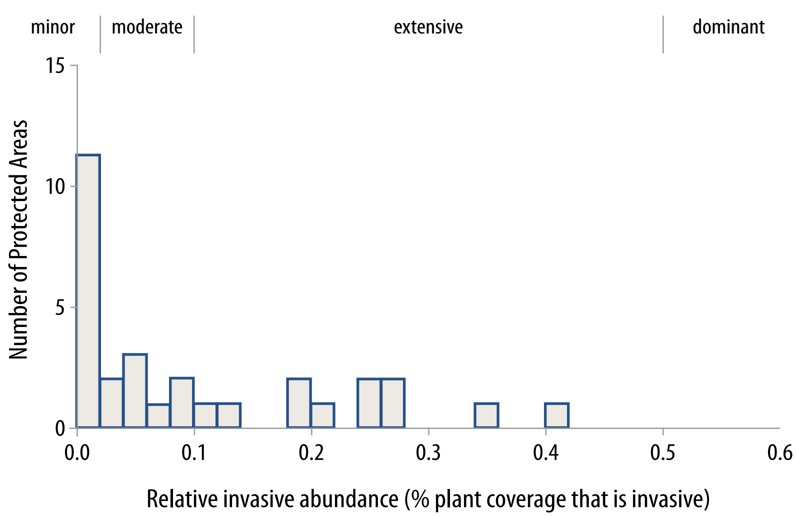


FIGURE A1.9 (Indicator 11.2) The *Relative invasive abundance* of plants in provincial protected areas in the Western Cape Province, South Africa. Based on extrapolations from mapping exercises and assuming that indigenous plant cover would be 100% in the absence of invasion (although there is both bare ground and different vegetation structural layers at the sites). Data from CapeNature.

Limits to usefulness and accuracy

This indicator requires detailed mapping. It is thus most likely to be used at smaller spatial scales. It will nevertheless be useful for assessing the levels of invasion in particular types of areas, for example protected areas.

It requires information on indigenous abundances as well, and when dealing with coverage data, the total coverage might either be much greater than 100% (i.e. overlapping canopies), or less than 100% (i.e. bare rock).

The impact of different levels of relative abundance will also vary. So an understory shrub at 50% coverage might have much lower impacts than a vine that overtops and smothers vegetation which is also at 50% coverage.

Updating the indicator

This indicator would be assessed at the scale for which management plans are available, and where goals are set to achieve reductions in the relative abundance of alien species. Monitoring and updating of the database on which this indicator is based should be continuous, as management is ongoing, likely as part of annual planning updates. In South Africa it is proposed to update indicators every three years.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species **6.** Extent of alien species **7.** Abundance of alien species	None	**8.** Impact of alien species **12.** Impact of invasions **15.** Planning coverage **19.** Effectiveness of pathway treatments **20.** Effectiveness of species treatments **21.** Effectiveness of area treatments **B.** Number of invasive species that have major impacts **C.** Extent of area that suffers major impacts from invasions **D.** Level of success in managing invasions

Additional information and comments

The data can be linked to other GIS layers to look at possible interactions, e.g. with human footprint.

Rather than broad taxonomic groups, it can be important to consider functional groups, or function itself, e.g. what proportion of photosynthesis in a given region is due to alien species (and how has this changed post-invasion).

12 IMPACT OF INVASIONS

Use and interpretation

This indicator assesses the combined impact of all invasive species within a particular area on the delivery of selected ecosystem services, or on biodiversity. It should have a focus on those ecosystem services that are important in the context of the area concerned (for example on water resources in dry regions, livestock production in rangelands, or biodiversity in protected areas) and can be used to prioritise areas for management interventions. At a more advanced level, the value of impacts can be expressed in monetary terms and so used for calculations of costs and benefits of control.

Potential for aggregation

Impacts on ecosystem services that are made at finer scales can be aggregated upwards at larger scales.

Possible reasons for upward or downward trends

Increases in impact (decreases in ecosystem service delivery) can be associated with the physiological or competitive consequences of invasions. For example, displacement of plants that are able to conserve water with species that are less efficient water users can reduce streamflow and deplete groundwater resources; and unpalatable or thicket-forming species can displace palatable grass species in rangelands, reducing the livestock carrying capacity.

Upward trends can also be the result of increases in the spread of alien species; shifts in which alien species are invasive towards more damaging species; or due to the accrual of impact over time, as even if extent or abundance of invasions do not change over time, biophysical thresholds can be crossed leading to ecosystem level impacts (Suding & Hobbs, 2009).

Implications for biodiversity management of change in the indicator

The size and value of impacts would be important factors to consider when allocating scarce management resources to address and hopefully reduce, or slow the growth of, harmful impacts. Management resources should be directed to those areas where attractive returns on management interventions could be realised (potentially, but not necessarily) including areas where the impacts are greatest.

Units in which it is expressed (from basic to advanced)

12.1	Factor with five levels of impact: • Not known • Minor • Moderate • Major • Massive
12.2	The reduction caused by the invasions expressed quantitatively in the units in which the ecosystem service is measured (for example, water yield expressed in m^3 per ha, and rangeland carrying capacity in livestock units per ha).
12.3	Net present monetary values of the reduction in the relevant ecosystem service or biodiversity indicators.

Description of source data

The use of this indicator requires data on the spatial distribution and magnitude of ecosystem services, and on the impact of invasions on that service. While the magnitude of a wide range of ecosystem services can be assessed, good information on the impacts of invasions on those services are scarce, as relatively few studies have been conducted.

Calculation procedure

12.1	Ecosystem services should be mapped at appropriate scales, and this is more easily achieved for some services (for example water or timber extraction, or livestock or fish production) than for others (for example aesthetic or cultural values). The impact of invasions on these services should be modelled based on research results where they are available, and extrapolated. • Not known: there has been no estimate of whether there has been a reduction in the relevant ecosystem service or biodiversity indicators attributable to the invasions. • Minor: there has been a < 2% reduction in the relevant ecosystem service or biodiversity indicators attributable to invasions. • Moderate: 2–10% reduction. • Major: 10–50% reduction. • Massive: > 50% reduction.
12.2	As for 12.1 but where the data are of sufficient resolution and models of sufficient reliability that a quantitative percentage can be obtained.
12.3	Conversion of ecosystem services to monetary values would require further research in which the value of sustainable yields (of water, livestock, or harvested products) would have to be estimated for the scale concerned.

Guide for applying confidence levels

12.1	**HIGH**	Based on well-documented impacts of particular alien species combined with quantitative information on relative invasive species abundance with a medium or high level of confidence (see 11.2)
	MEDIUM	Based on well-documented impacts of particular alien species combined with qualitative information on *Relative invasive abundance* (see 11.1)
	LOW	Based on expert opinion
12.2	**HIGH**	Based on levels of ecosystem services that have been measured and quantified across the region; and on robust studies that quantify the impact of invasions on these services
	MEDIUM	Based on levels of ecosystem services that have been measured for representative parts of the region, with well-tested spatial models used to extrapolate to the whole region.
	LOW	Based on estimates of ecosystem services derived from spatial modelling, and/or on modelled estimates of the impact of alien species on these services.
12.3	**HIGH**	Based on direct valuation of measured and quantified ecosystem goods and services in the area concerned.
	MEDIUM	Based on indirect estimations of the market value of modelled levels of ecosystem services (for example, by comparison to values for similar services estimated elsewhere).
	LOW	Based on market values of ecosystem services derived from expert opinion.

Most effective forms of presentation

12.1	Spatially (on maps) or graphically by means of bar graphs showing trends over time or under different scenarios of invasion.
12.2	As for 12.1
12.3	Tables

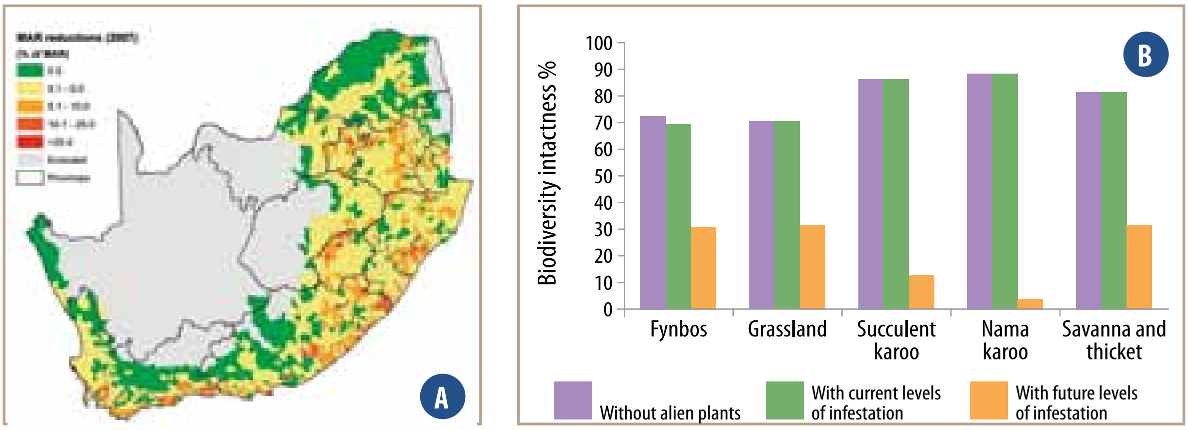


FIGURE A1.10 (Indicator 12.2) Estimates of the *Impact of invasions* on water resources in South Africa. In panel a) are estimates of the reductions in mean annual runoff (MAR) due to invasive alien plants in the quaternary catchments of South Africa. The quaternary catchments where data were not available to estimate impact are shown in grey; in panel b) are estimates of the current and potential impacts of invasive alien plants on surface water runoff in five terrestrial biomes in South Africa (Le Maitre *et al.*, 2016; Van Wilgen *et al.*, 2012).

Limits to usefulness and accuracy

The extent to which this indicator can be used is constrained by limited spatial information on a wide range of ecosystem services (although information on some of the more important services are available at a range of scales), accurate distribution maps for biological invasions, and studies that have accurately quantified impacts, and on which models can be based. However, as better information becomes available, this could become an influential indicator for informing policy-makers of the consequences of invasion.

Updating the indicator

This indicator should be updated at the same frequency at which levels of invasion are assessed.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species **6.** Extent of alien species **7.** Abundance of alien species **8.** Impact of alien species **9.** Alien species richness **10.** Relative alien species richness **11.** Relative invasive abundance	**13.** Quality of regulatory framework **14.** Money spent **15.** Planning coverage	**15.** Planning coverage **20.** Effectiveness of species treatments **21.** Effectiveness of area treatments **B.** Number of invasive species that have major impacts **C.** Extent of area that suffers major impacts from invasions **D.** Level of success in managing invasions

Additional information and comments

The choice of what to measure in terms of the impact of invasions will be influential and the importance of different impacts will be context dependent. A "minor" reduction in biodiversity in a biodiversity hotspot might be much more important than a "massive" reduction elsewhere; similarly providing the cost of an invasion in absolute terms might hide major and profound societal inequities.

13 QUALITY OF REGULATORY FRAMEWORK

Use and interpretation

This is an input indicator that helps address three key questions:

- What regulatory framework is in place to manage biological invasions?
- What is the level of completeness of this regulatory framework?; and,
- What mechanisms are in place to enable implementation, update, review, and appeal?

At a country level, this indicator provides an assessment of the degree to which authorities are able to regulate the cultivation or use of alien species, their transport or trade, and to what extent citizens are required to take steps to control problematic invasive species. Voluntary agreements should also be considered as relevant here.

Potential for aggregation

This indicator would assess the quality of the regulatory framework at a national level, and there would be no need for aggregation. Can be assessed at lower spatial administrative levels.

Possible reasons for upward or downward trends

The indicator would change if new regulations are enacted or agreements reached.

Implications for biodiversity management of change in the indicator

Increases or decreases in the quality of the regulatory framework would affect the ability of managers to address the negative effects of invasive species.

Units in which it is expressed (from basic to advanced)

13.1	Factor with four levels at a national level: • None [there are no regulations (or voluntary agreements) on biological invasions]; and • Partial (regulations are enacted and have clear mechanisms for implementation and enforcement, but only cover some of the aspects of the problem); and • Substantial (regulations are enacted dealing with most aspects of the problem and/or responsibilities are mostly clearly assigned/most mechanisms for implementation, update, review, and appeal are clear); and • Complete (comprehensive legislation governs biological invasions in a holistic way, with responsibilities clearly assigned and clear mechanisms for implementation, update, review, and appeal).
13.2	As for 13.1 but for a range of different administrative entities, and incorporating an evaluation of inter-agency co-operation

Description of source data

Gazetted legislation applicable to biological invasions; and published codes of conduct.

Calculation procedure

13.1	Assessments by experts on the quality of legislation based on completeness (covers all aspects of pathways, species and areas); mechanisms for implementation; update; and review; and appeal processes
13.2	As for 13.1 at different administrative levels and incorporating an evaluation of inter-agency co-operation

Guide for applying confidence levels

13.1	**HIGH**	Assessment of regulation quality provided by an independent team of experts that includes both invasion scientists and members of the legal profession
	MEDIUM	Assessment of regulation quality provided by either an independent or semi-independent team. The team includes invasion scientists or members of the legal profession but not both
	LOW	Assessment provided by a team who either come from the institution responsible for developing or enforcing the regulations and/or do not contain assessors qualified in invasion science or law
13.2	**HIGH**	As for 13.1
	MEDIUM	As for 13.1
	LOW	As for 13.1

Most effective forms of presentation

13.1	Table providing a breakdown of coverage of the regulatory framework across all aspects of the problem, on which the assignment to one of the levels is based
13.2	As for 13.1

TABLE A1.3 A table proposed for assessing the quality of regulations pertaining to biological invasions.

ASPECT OF REGULATIONS	ASPECT OF BIOLOGICAL INVASIONS		
	PATHWAYS (incl. subcategories)	SPECIES (incl. different taxonomic groups)	AREAS (incl. different spatial scales and ownership)
Is there a mandate for management interventions?	Detailed /Partial/None		
Is there provision for enforcement of non-compliance?			
Is there a requirement for regular assessment of performance, and review?			

Limits to usefulness and accuracy

Politically sensitive indicator, might be slow to change in response to pressures.

Updating the indicator

It will be updated in response to the legislative process (e.g. amendments or new regulations).

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
1. Introduction pathway prominence	**8.** Impact of alien species	**15.** Planning coverage
2. Introduction rates	**12.** Impact of invasions	**16.** Pathways treated
3. Within-country pathway prominence	**14.** Money spent	**17.** Species treated
4. Within-country dispersal rates		**18.** Area treated
5. Number and status of alien species		**19.** Effectiveness of pathway treatments
6. Extent of alien species		**20.** Effectiveness of species treatments
7. Abundance of alien species		**21.** Effectiveness of area treatments
9. Alien species richness		**D.** Level of success in managing invasions

Additional information and comments

Can be a long process to change or amend regulations involving public consultations and changes have to be gazetted to take effect.

14 MONEY SPENT

Use and interpretation

The indicator that measures the monetary inputs into the management of biological invasions. It provides a basis on which to estimate one of the main metrics for measuring the outcome of management interventions, namely return on investment.

Potential for aggregation

This indicator can be aggregated across any spatial scale for all of the management interventions at that scale.

Possible reasons for upward or downward trends

Changes in political or economic conditions, resulting in changes to the budget allocated to managing biological invasions.

Implications for biodiversity management of change in the indicator

Increased allocation can lead to an increased amount of resources to undertake interventions and decreased allocation can lead to a decrease in the number of interventions implemented. Decreases will also lead to the need for prioritisation, and for conservation triage, so that sufficient resources can be allocated to priority areas to achieve the goals of management.

Units in which it is expressed (from basic to advanced)

14.1	Annual government expenditure at a national scale
14.2	Annual government expenditure separated into expenditure on the relevant components of pathways, species and areas
14.3	As for 14.2 including expenditure by private individuals/organisations, and detailed accounts of the sources of funding

Description of source data

Records of expenditure from various government departments. Reports of money spent by private individuals/organisations.

Calculation procedure

14.1	Addition of expenditure from different sources to obtain a total. When compared over multiple years, it would be useful to inflate annual totals to net present values in the current year. This would facilitate meaningful comparisons, especially in countries that experience high levels of inflation.
14.2	As above, split into different units.
14.3	As above, split into different units.

Guide for applying confidence levels

14.1	**HIGH**	Records of expenditure on biological invasions are available from all participating agencies
	MEDIUM	Records of expenditure from all participating agencies do not differentiate clearly between expenditure on biological invasions and other activities, leading to the need for assumptions
	LOW	Records of expenditure are available for some, but not all participating agencies
14.2	**HIGH**	Records of expenditure are available from all participating agencies, with clear breakdowns of expenditure into projects that can be assigned easily to relevant components of pathways, species and areas
	MEDIUM	Records of expenditure are available from all participating agencies, but they do not differentiate clearly between expenditure on biological invasions and other activities, and/or they do not differentiate between expenditure on pathways, species, and areas, leading to the need for assumptions
	LOW	Records of expenditure are available for some, but not all participating agencies, and/or it is very difficult to ascribe known expenditure to different aspects of biological invasions
14.3	**HIGH**	As for 14.2, but with the additional requirement that records are available for money spent by private individuals/companies
	MEDIUM	As for 14.2, but with the additional requirement that records are available for money spent by private individuals/companies
	LOW	As for 14.2, but with the additional requirement that records are available for money spent by private individuals/companies

Most effective forms of presentation

14.1	Graphic presentation of annual expenditure over time
14.2	Tables of expenditure per component; with graphical summary of how this has changed over time
14.3	As for 14.2

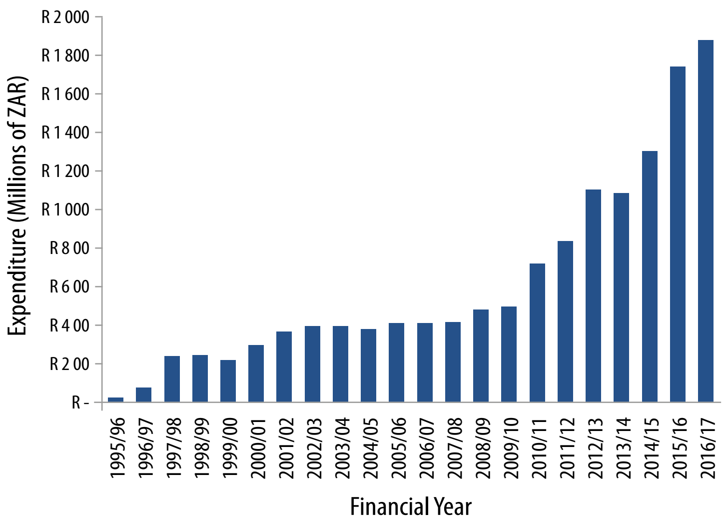


FIGURE A1.11 (Indicator 14.1) Annual expenditure by South Africa's Working for Water Programme, the main programme for government control of biological invasions (does not include spending on agricultural pests, or animal and human pests or diseases). Data from WfW planning site (https://sites.google.com/site/wfwplanning/), downloaded July 2017. Values are as reported per year, and not adjusted for inflation to give a net present value.

Limits to usefulness and accuracy

Government expenditure data will be hard to collate as expenditure will be in multiple departments some of which will not view the costs as relevant to invasions or separate these from other costs (human health in particular). Contributions from the private sector, and private landowners are unlikely to be readily available, are difficult to estimate, but could be substantial. The indicator is therefore likely to be an underestimate of inputs.

Updating the indicator

This indicator could be updated annually.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
None (though ultimately of course all aspects of pathways, species, and areas could come into the calculation) e.g. 5. Number and status of alien species; 6. Extent of alien species and 7. Abundance of alien species	**8.** Impact of alien species **12.** Impact of invasions **13.** Quality of regulatory framework **15.** Planning coverage **16.** Pathways treated **17.** Species treated **18.** Areas treated	**19.** Effectiveness of pathway treatments **20.** Effectiveness of species treatments **21.** Effectiveness of areas treatments **B.** Number of invasive species that have major impacts **D.** Level of success in managing invasions

Additional information and comments

None

15 PLANNING COVERAGE

Use and interpretation

Adequate levels of planning are an essential input into the management of biological invasions. This indicator gauges the level of planning input, which should include the setting of goals, and monitoring and assessment of progress towards those goals. The degree to which management interventions are covered by adequate planning provides a basis for explaining the degree to which outputs and outcomes are achieved.

Potential for aggregation

Plans are drawn up for individual pathways, species, and areas, and can be aggregated across the components that require management. For example, ballast water management plans for individual harbours; and passenger, luggage, and cargo monitoring plans for individual airports.

Possible reasons for upward or downward trends

Increases in planning coverage would come about as a result of improvements in management plans or by allocating additional resources to that activity to allow for a greater scope of planning. Decreases could come about as a result of funding cuts.

Changes in regulatory requirements can affect the planning coverage.

Implications for biodiversity management of change in the indicator

A lack of planning, or inadequate planning, could lead to major inefficiencies in management, as a result of uncertainty relating to the goals of management, the allocation of funding to various activities, as well as a lack of clarity regarding progress towards goals.

Units in which it is expressed (from basic to advanced)

15.1	The proportion of each component (pathways, species, and areas) that has a regulatory requirement for a management plan that has a management plan in place.
15.2	As for 15.1, but including an assessment of the quality of plans as gauged against a minimum set of criteria for adequate plans.
15.3	The presence and quality of management plans for each component (pathways, species, and areas) that have been ranked in terms of their priorities

Description of source data

Management plans developed by authorities responsible for the management of various aspects of biological invasions.

Calculation procedure

15.1	The number of pathways, species, and areas requiring management is taken to be pre-determined by any existing regulatory framework. Each component is then assessed as to whether a plan is in place. From this an overall percentage is determined (average of % in place for pathways, species, and areas).
15.2	For the advanced indicator, each plan needs to be assessed with respect to the degree to which the plan meets a minimum set of criteria (e.g. Department of Environmental Affairs, 2015). Each plan should be placed into one of three categories, as follows: • Adequate: Information required in terms of all of the criteria is included, and is of excellent standard; • Partially adequate: Information for most required criteria (> 50%) is included, and is of an adequate to good standard; and • Inadequate: Information required is mostly lacking from the control plan or is mostly of a poor standard
15.3	First a risk analysis is conducted for each component of pathways, species, and areas to determine where management is needed (regardless of resource constraints). Second for those components where management is needed, the proportion that has plans in place is determined. Finally, plans that are in place are assessed in terms of their quality.

Guide for applying confidence levels

15.1	**HIGH**	Plans are explicit as to their coverage with details such that gaps can be identified. Comparison across plans is easy as plans are curated in transferable formats. Guidelines meet international best-practice standards are reviewed externally and cover all relevant situations.
	MEDIUM	The coverage and gaps in the plans can be inferred from details of what is covered, and/or the comparison across plans is made difficult by a variety of formats.
	LOW	Coverage based on expert opinion
15.2	**HIGH**	Plans are produced in enough detail to allow assessment of their quality and the assessment is conducted by someone experienced in project management of biological invasions.
	MEDIUM	Plans are produced in enough detail to allow assessment of their quality or the assessment is conducted by someone experienced in project management or biological invasions (not both).
	LOW	Quality of plans difficult to assess and assessor not suitably experienced.
15.3	**HIGH**	As for 15.2 with some assessment of the confidence in the risk analyses conducted.
	MEDIUM	As for 15.2 with some assessment of the confidence in the risk analyses conducted.
	LOW	As for 15.2 with some assessment of the confidence in the risk analyses conducted.

Most effective forms of presentation

15.1	Bar diagrams showing the proportion of pathways, species, and areas for which management plans have been prepared. Numbers above the bars indicate the number of pathways or species being managed, and the area being managed.
15.2	Bar charts or tables
15.3	Bar charts or tables

No example presented here.

Limits to usefulness and accuracy

This indicator does not measure whether, or how well or comprehensively, the plans are actually implemented. This could limit usefulness, as effective implementation is an important output. There might also be implementation without plans in place.

At a basic level it assumes that the regulatory requirements are an appropriate indication of actual need. At a more advanced level it does not take into account the fact that the planning might be appropriate given the resource constraints, i.e. prioritised things are well covered.

Updating the indicator

Potentially annually, linking to annual plans of operation.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
1. Introduction pathway prominence	**12.** Impacts of invasions	**16.** Pathways treated
2. Introduction rates	**14.** Money spent	**17.** Species treated
3. Within-country pathway prominence		**18.** Area treated
4. Within-country dispersal rates		**19.** Effectiveness of pathway treatments
5. Number and status of alien species		**20.** Effectiveness of species treatments
6. Extent of alien species		**21.** Effectiveness of area treatments
7. Abundance of alien species		**D.** Level of success in managing invasions
8. Impact of alien species		
9. Alien species richness		
10. Relative alien species richness		
11. Relative invasive abundance		
12. Impact of invasions		
13. Quality of the regulatory framework		

Additional information and comments

Might need to weight the *Planning coverage* by how important it is to have a plan in place i.e. that given financial constraints, priority pathways, species, and areas should be covered by plans in preference to other components.

16 PATHWAYS TREATED

Use and interpretation

This indicator concerns the management of pathways that could facilitate the introduction of new alien species to a country or the dispersal of alien species within the country after introduction. The indicator is concerned with the outputs of pathway-focused control measures and provides an indication of the degree to which pathways are being managed (including aspects like regulation, inspection, and enforcement).

Potential for aggregation

This indicator was developed for use at a national level, however, as the national level data can be aggregated, the indicator can also be used at larger spatial scales (e.g. regions or continents). For example, information on the total amount of goods or vessels entering different countries or moving within countries, and the amount subjected to a management intervention, could be used to get an indication of the proportion of the goods or vessels for different pathways that are subjected to management at a regional or continental scale. As data could be available at larger (e.g. regions or continents) spatial scales, the indicator can be used at these scales.

Possible reasons for upward or downward trends

Upward or downward trends could be caused by political (e.g. changes to trade agreements), environmental and socio-economic changes (like consumer trends), as well as changes to the biosecurity (e.g. change to resources such as funds or personnel) or policies (e.g. phytosanitary policies) of the importing nation.

An upward trend in this indicator demonstrates that there has been an increase in the proportion of pathways or goods and vessels that are subjected to a management intervention.

A downward trend in this indicator demonstrates that there has been a decrease in the proportion of pathways or goods and vessels that are subjected to a management intervention.

Downward trends are not necessarily undesirable, and might reflect the reallocation of resources to more high priority pathways. Similarly, upward trends could reflect the allocation of resources to many low priority pathways rather than a small number of high priority pathways.

Implications for biodiversity management of change in the indicator

Upward or downward trends could lead to changes in the allocation of resources for biosecurity (money and personnel), and the pathways to which these resources are allocated (e.g. increase allocation to high priority pathways).

Units in which it is expressed (from basic to advanced)

16.1	Factor with five categories depending on the degree to which the pathway sub-categories are subjected to a management intervention. • Not known • None • Partial • Substantial • Complete
16.2	Proportion of vectors that are subjected to a management intervention per pathway sub-category.
16.3	As for 16.2, with an assessment of the quality of the interventions.

Description of source data

Global or national databases containing trade data collected by national governments, intergovernmental or global organisations and companies. Yearly data are, however, often not available for the most recent years. Data can also be obtained from peer-reviewed journal articles and from the websites and reports of national governments, intergovernmental or global organisations and companies.

Detailed data on management interventions will need to be obtained from the relevant government departments.

Calculation procedure

16.1	For each pathway sub-category determine if management interventions are needed (as per indicator 15) and are in place, then categorise as follows: • Not known • None (pathway sub-category is not managed) • Partial (< 75% of the pathway sub-category has some management) • Substantial (> 75% of the pathway sub-category has some management) • Complete (100% of pathway sub-category is managed)
16.2	For each pathway sub-category, calculate the proportion of the goods or vessels that are subjected to a management intervention using information on the amount of goods or vessels and the amount that are subjected to regulation or inspections.
16.3	As above, with the interventions assessed against set standard operating criteria: • Not known; • Inadequate (less than half the criteria addressed); • Partially adequate (more the half the criteria addressed); and • Adequate (all criteria met).

Guide for applying confidence levels

16.1	HIGH	Detailed data on all of the interventions in place and the pathways to which they are relevant
	MEDIUM	Inferred from the types of introductions and/or the vectors that are managed or interpreted from other data sources
	LOW	Qualitative estimate or based on expert opinion
16.2	HIGH	Detailed data on the total number of imports or vessels per pathway and the number that have been subjected to a management intervention
	MEDIUM	Inferred from the types of introductions and/or the vectors that are managed or interpreted from other data sources
	LOW	Qualitative estimate or based on expert opinion
16.3	HIGH	Detailed data on the proportion of imports or vessels that are managed per pathway with enough information to assess the quality of interventions, and assessment of interventions carried out by a relevant expert
	MEDIUM	Inferred from the types of introductions and/or the vectors that are managed and some information on how interventions are carried out
	LOW	Qualitative estimates or based on expert opinion

Most effective forms of presentation

16.1	A table showing the degree to which each pathway sub-category is managed
16.2	A table or bar chart showing the proportion of pathways treated
16.3	A figure demonstrating the proportion treated to different levels

No example presented here.

Limits to usefulness and accuracy

Reliant on data provided by governments and found in national and global databases. Data quality might not be known and can vary between countries, leading to more accurate assessments for some countries than others. Databases that are infrequently updated might cause difficulties when estimating upward or downward trends, or will be of less value if updated less frequently than the indicator is updated. Data that are only available at regional or larger scales will be unsuitable for national scale assessments. Useful measures of the amount of goods and vessels might not be available for all pathways, particularly for less specific pathways such as 'other escape from confinement'. For some pathways there might be various types of data available, and this could lead to differing estimates.

Updating the indicator

The indicator could be updated yearly or at courser, but regular time intervals. At the least, the indicator should be updated as often as is required for reporting on the status of biological invasions.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
1. Introduction pathway prominence **2.** Introduction rates **3.** Within-country pathway prominence **4.** Within-country dispersal rates **5.** Number and status of alien species **6.** Extent of alien species (required for within-country dispersal rates) **13.** Quality of the regulatory framework (needed for planning coverage) **15.** Planning coverage	**14.** Money spent **17.** Species treated **18.** Areas treated	**19.** Effectiveness of pathway treatments **A.** Rate of introduction of new unregulated species **D.** Level of success in managing invasions

Additional information and comments

The level of treatment required should be proportionate to the rate of introduction and thus should not be consistent across pathways. For some pathways it might be difficult to access data. For example, some transport data are owned by companies and to gain access to the data or databases a fee is often required.

Some pathways might not need treatment (see indicator 15).

17 SPECIES TREATED

Use and interpretation

This output indicator provides an indication of the degree to which alien species that need to be managed are being managed.

Potential for aggregation

It can be aggregated across taxonomic groups.

Possible reasons for upward or downward trends

The proportion of known alien species that are being subjected to management could increase if available funds are increased, but could also increase if the funding remains unchanged, but is spread across more species. Decreases could signal either a decrease in funding, or a decision to focus available funds on fewer species. Changes could also be the result of changes in the total number of alien species.

Implications for biodiversity management of change in the indicator

Managing a higher proportion of alien species could be interpreted as advantageous, but it could also signal a dilution of scarce funds, leading to less effective management per species. At advanced levels of this indicator, it would therefore be necessary to examine whether the level of funding is adequate to make a difference. Changes then will more closely correspond to changes in desired levels.

Units in which it is expressed (from basic to advanced)

17.1	Proportion of regulated species that are being subjected to a management intervention
17.2	Five categories for the degree to which populations of an alien species identified as requiring management are actually being managed • Not known; • None; • Partial; • Substantial; • Complete.
17.3	As for 17.1 with each intervention (per population or relevant area) assessed as • Not known; • Inadequate; • Partially adequate; • Adequate.

Description of source data

Species-specific management plans, including funds allocated per species; estimates of the amount of funding needed to achieve control, usually from research projects.

Calculation procedure

17.1	The number of alien species requiring management is obtained from indicator 15. The indicator is the proportion of these where management is being implemented.
17.2	As for 17.1 with an assessment of the degree to which populations of an alien species are being managed as: • Not known; and • None (no populations are managed); and • Partial (< 75% of populations have some management); and • Substantial (> 75% of populations have some management); and • Complete (100% of populations have some management).
17.3	As for 17.1, with the quality of the implementation assessed against standard criteria (e.g. all individuals/ stages addressed, and best practice followed) as: • Not known (there is no monitoring and reporting in place); and • Inadequate (none of the criteria are adequately fulfilled); and • Partially adequate (not all of the criteria are adequately fulfilled); and • Adequate (all criteria fulfilled).

Guide for applying confidence levels

17.1	**HIGH**	Management plans readily available, up-to-date, with progress reports that are less than two years old. List of invasive species known with high confidence.
	MEDIUM	Not clear if all management plans obtained, and/or the majority of management plans are not up-to-date. Progress report available but somewhat out of date (e.g. 2–5 years old). Alternatively, the list of invasive species known with medium confidence.
	LOW	Over 50% of management plans are out of date, with the last progress report greater than 5 years ago, with no indication that the plan has been wrapped up. Alternatively, the list of invasive species known with low confidence.
17.2	**HIGH**	As for 17.1, in addition with detailed reporting on populations treated and not treated (e.g. > 90%)
	MEDIUM	As for 17.1, in addition with some direct data indicating coverage
	LOW	As for 17.1, in addition with the level of coverage extrapolated from some data
17.3	**HIGH**	As for 17.1, in addition there has been a reliable (e.g. peer-reviewed) assessment of the adequacy of the treatments for almost all (> 90%) species
	MEDIUM	As for 17.1, in addition there has been a reliable (e.g. peer-reviewed) assessment of the adequacy of the treatments for most (50–90%) species
	LOW	As for 17.1, in addition there has been a reliable (e.g. peer-reviewed) assessment of the adequacy of the treatments for less than half of high priority species

Most effective forms of presentation

17.1	Proportion for different taxonomic groups
17.2	Bar chart
17.3	Bar chart

No example presented here.

Limits to usefulness and accuracy

This output indicator simply measures the number of species that are being managed, unless the indicator is at an advanced level that includes an assessment of the quality of the control measures. At this advanced level, accuracy will depend on an understanding of what represents appropriate standards of control.

Updating the indicator

Can potentially be linked to annual reports, but will likely only be done as part of national reporting cycles (e.g. three years for South Africa).

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species **6.** Extent of alien species **7.** Abundance of alien species **9.** Alien species richness **13.** Quality of regulatory framework **15.** Planning coverage	**8.** Impact of alien species **10.** Relative alien species richness **14.** Money spent **16.** Pathways treated **18.** Area treated	**20.** Effectiveness of species treatments **B.** Number of invasive species that have major impacts **D.** Level of success in managing invasions

Additional information and comments

The species that need to be treated might include species that are not introduced yet (i.e. pre-border). In general the treatments should be with the goal of prevention, eradication, containment or impact reduction.

18 AREA TREATED

Use and interpretation

Output indicator that provides an indication of the area over which alien species control operations took place.

Potential for aggregation

It can be aggregated from areas with management plans to larger spatial scale.

Possible reasons for upward or downward trends

The invaded area that is subjected to management could increase if available funds increase, but it could also increase if the funding remains unchanged, but if management is shifted from densely-invaded areas to less densely invaded areas. Decreases could signal either a decrease in funding, or a decision to focus available funds on more densely invaded areas. The area that can be treated also depends on the number of times an area needs to be treated before the management can move to new areas. Some areas require numerous follow-up treatments (for example to remove seedlings after felling mature plants), and this will slow the rate at which new areas can be treated.

Implications for biodiversity management of change in the indicator

Area treated is an output indicator that can be used to gauge the proportion of the problem that is being addressed. This, in turn, provides an idea of whether or not the invasion can be reduced to an acceptable level within a reasonable timeframe. However, *Area treated* is not an indicator of success, as the outcome of treatment is not assessed.

Units in which it is expressed (from basic to advanced)

18.1	The proportion of areas that need to be managed that are being managed
18.2	As for 18.1, with the quality of the implementation of each management plan assessed as: • Not known; • Inadequate; • Partially adequate; and • Adequate.

Description of source data

Management plans from government institutions, non-governmental organisations and private landowners

Calculation procedure

18.1	The area requiring management is calculated (as per indicator 15), and then the proportion where management plans are being implemented is assessed.
18.2	As for 18.1, with the quality of the implementation of each management plan assessed against standard criteria (e.g. funding sufficient to reach goal of effective control; all areas addressed; introduction and dispersal pathways considered; and best practice followed) as: • No plan in place; • Inadequate (none of the criteria are adequately fulfilled); • Partially adequate (not all of the criteria are adequately fulfilled); • Complete (all criteria fulfilled).

Guide for applying confidence levels

18.1	**HIGH**	Management plans readily available, up-to-date, with progress reports that are less than two years old. Areas requiring management known with high confidence.
	MEDIUM	Not clear if all management plans obtained, and/or the majority of management plans are not up-to-date. Progress report available but somewhat out of date (e.g. 2–5 years old). Alternatively, the area requiring management is known with medium confidence.
	LOW	Over 50% of management plans are out of date, with the last progress report greater than 5 years ago, with no indication that the plan has been wrapped up. Alternatively, the area requiring management is known with low confidence.
18.2	**HIGH**	As for 18.1, and assessment based on clear goals in management plans, and on regular and verifiable monitoring of progress
	MEDIUM	As for 18.1, and assessment based on irregular monitoring of progress
	LOW	As for 18.1, and assessment based on expert local knowledge

Most effective forms of presentation

18.1	Maps of different areas, displayed according to appropriate administrative or biogeographical units.
18.2	Bar chart

No example presented here.

Limits to usefulness and accuracy

It relies on the availability of reports on monitoring and evaluation of control operation.

Updating the indicator

Annually, in line with annual project reporting.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
6. Extent of alien species	**10.** Relative alien species richness	**21.** Effectiveness of area treatments
7. Abundance of alien species	**14.** Money spent	**C.** Extent of area that suffers major impacts from invasions
13. Quality of the regulatory framework	**16.** Pathways treated	**D.** Level of success in managing invasions
15. Planning coverage	**17.** Species treated	

Additional information and comments

It does not examine whether these treatments were effective.

19 EFFECTIVENESS OF PATHWAY TREATMENTS

Use and interpretation

This indicator concerns the effectiveness of managing pathways that facilitate the introduction of alien species to a country from another region, and the dispersal of alien species within a country after introduction. The indicator is concerned with the outcomes of pathway-focused control measures and in particular, the degree to which pathway treatments is reducing the rate of introduction and within-country dispersal of alien species. Depending on the available data, the indicator can be used to answer two questions:

- What proportion of pathways that require management are effectively managed?; and,
- What is the return on investment for pathway-focused control measures?

Potential for aggregation

Although this indicator was developed for use at a national level it can be used at a wide range of spatial scales, depending on the scale at which data are available (e.g. regions or continents).

Possible reasons for upward or downward trends

Upward or downward trends could be caused by changes to the rate at which alien species are being introduced to the country or dispersing within the country. Additionally, changes to the policies of the country or the resources available for biosecurity (funds and personnel), and how these resources are allocated, could cause upward or downward trends.

An upward trend indicates that the effectiveness of pathway-focused control measures has increased, while a downward trend indicates a decrease in the effectiveness of control measures.

Implications for biodiversity management of change in the indicator

Upward or downward trends could lead to changes in the resources allocated to pathway-focused control measures, and could influence the pathways that are managed.

Units in which it is expressed (from basic to advanced)

19.1	Number of pathways in six categories of control effectiveness: • Not known; and • Counter-productive. Intervention has exacerbated the problem; and • None/ineffective. There has been no intervention, or there has been an intervention but it is ineffective; and • Partial. Somewhat effective intervention; and • Effective. The treatment has reduced the problem to below a desired management threshold. On-going control is required; and • Permanent. The problem has been reduced to a sustainably low level (or zero), and so no on-going management is required. **AND** An assessment of any negative impacts of control.

19.2	Quantitative measure of impact on introduction pathway prominence, introduction rates, within-country pathway prominence, and within-country dispersal rates. **AND** A formal environmental and social assessment of non-target impacts of the interventions.
19.3	Return on investment expressed as a ratio of the amount spent on control to the value of avoided cost of impact for pathway treatments. **AND** Include non-target impacts as a cost.

Description of source data

Reports on monitoring and evaluation of control interventions obtained from the relevant government departments. Information on the rate at which alien species are being introduced to the country and dispersing within the country obtained from assessments of the status of the introduction pathways and within-country dispersal pathways and data from interventions (e.g. interception data).

For more advanced metrics, economic costings and back-casts from the relevant government departments, as well as estimates of avoided costs from models.

Calculation procedure

19.1	Data on control effectiveness from published reports, data on rates of introduction or expert opinions are used to categorise the effectiveness of treatment for each pathway as: • Not known; and • Counter-productive. Evidence that there are more introductions or spread; and • None/ineffective. There is no discernible change in the rate of introductions or within-country dispersal; and • Partial. Rates of introduction and dispersal have decreased; and • Effective. Rates of introduction and dispersal are below an explicitly defined management threshold, management is continuing; and • Permanent. Active management is no longer required, as there are no more introductions or dispersal. **AND** Expert assessment informed by data collected on any collateral damage (e.g. details of legal claims and reports of direct non-target damage to indigenous species and damage to ecological infra-structure, with such data ideally collected in the region of interest).
19.2	A counter-factual model is produced that is used to project values with and without control interventions. Using this, a percentage change in relevant indicators (e.g. introduction rates) is calculated. **AND** An impact assessment (both environmental and social) is conducted as per standard guidelines for the relevant country.
19.3	Estimates of the costs of control are calculated for different management scenarios with the models used in the calculation 19.2 together with quantitative estimate of the impact of the introductions or dispersal combined to give a ratio such that it is: > 1 where cost of control is less than the value of impacts avoided through effective control or negative; < 1 where control costs exceed the value of impacts avoided through effective control. **AND** The costs of non-target impacts are included in costs of control.

Guide for applying confidence levels

19.1	HIGH	There has been a published peer-reviewed quantitative assessment of the degree of control achieved.
	MEDIUM	There is a report that is based on monitoring data.
	LOW	Expert opinion.
19.2	HIGH	As for 19.1 in addition, the models used are published in peer-reviewed journals and have been extensively tested in similar situations.
	MEDIUM	As for 19.1 in addition, the models used are published in peer-reviewed journals, but only recently or this is one of only a few examples of their implementation.
	LOW	As for 19.1 in addition, the models used have not been published.
19.3	HIGH	As for 19.2
	MEDIUM	As for 19.2
	LOW	As for 19.2

Most effective forms of presentation

19.1	A table with number of pathways in different categories
19.2	A box-plot showing the degree to which different interventions have reduced specific indicators of biological invasions
19.3	A table

No example presented here.

Limits to usefulness and accuracy

It relies on accurate and up to date data obtained from pathway management plans that are at present only available for a limited number of pathways. Poor data quality (e.g. poor estimates of rate of introduction or cost-benefit ratio) might lead to an inaccurate assessment.

Updating the indicator

The indicator could be updated yearly or at coarser, but regular time intervals. At the least, the indicator should be updated as often as is required for reporting on the status of biological invasions.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
1. Introduction pathway prominence **2.** Introduction rates **3.** Within-country pathway prominence **4.** Within-country dispersal rates **5.** Number and status of alien species **6.** Extent of alien species **11.** Relative invasive abundance **13.** Quality of the regulatory framework (needed for planning coverage) **14.** Money spent **15:** Planning coverage **16.** Pathways treated	none	**A.** Rate of introduction of new unregulated species **D.** Level of success in managing invasions

Additional information and comments

Return on investment is not relevant if there is no control and there should have been, this is dealt with in the quality of the planning framework. Return on investment is only relevant if measured using an indicator that is related to control outcomes (e.g. rate of introductions rather than some metric of how many inspections were carried out).

20 EFFECTIVENESS OF SPECIES TREATMENTS

Use and interpretation

Outcome indicator of the number of alien species that require management brought under different degrees of control, based in part on that developed for assessing the efficacy of classical biological control programmes (Klein, 2011). This indicator could inform the allocation of future management and research resources.

Potential for aggregation

It can be aggregated across different taxonomic groups.

Possible reasons for upward or downward trends

Increases in the number of species brought under effective control could result from the development of improved management techniques, the adoption and implementation of effective best-practice control measures, or increased funding or other resources.

Decreases could be due to reductions in resources for control or changes away from effective treatments, and if more species start to require management.

Implications for biodiversity management of change in the indicator

If the number of species brought under effective control increases, then scare funds could be freed up for controlling additional species.

Units in which it is expressed (from basic to advanced)

20.1	Number of species in six categories of control effectiveness • Not known; and • Counter-productive. Intervention has exacerbated the problem; and • None/ineffective. There has been no intervention, or there has been an intervention but it is ineffective; and • Partial. Somewhat effective intervention; and • Effective. The treatment has reduced the problem to below a desired management threshold. On-going control is required; and • Permanent. The problem has been reduced to a sustainably low level (or zero), and no on-going management is required. **AND** An assessment of any negative impacts of control.
20.2	Quantitative measure of impact on population size, extent or impact due to control **AND** A formal impact assessment of the interventions
20.3	Return on investment expressed as a ratio of the amount spent on control to the value of avoided cost of impact. **AND** Non-target impacts as costs

Description of source data

This indicator is determined on the basis of data on the number of species management plans obtained from literature, academic and government institutions, and on the success of such management obtained from literature, academic and government institutions.

Calculation procedure

20.1	Data on control effectiveness from published reports and sources or expert opinions are used to categorise the control effectiveness for each species as: • Not known; and • Counter-productive. There is evidence that control has led to further spread; has caused increases in abundance; and/or has made subsequent treatments more difficult without reducing the invasion; and • None/ineffective. There is no discernible change to the rate at which the extent of the invasion or the abundance of the species is increasing; and • Partial. Rate of increase in extent or abundance has slowed; and • Effective. Extent or abundance is decreasing or has ended up below a management threshold, management is continuing; and • Permanent. There is no more active management and despite this the population remains below the management threshold. **AND** Expert assessment informed by data collected on any collateral damage (e.g. details of legal claims and reports of direct non-target damage to indigenous species and damage to ecological infra-structure, with such data ideally collected in the region of interest).
20.2	A counter-factual model is produced that is used to project values with and without control interventions. A percentage change in relevant indicators (e.g. population size after a given time) is calculated. **AND** An impact assessment is conducted as per standard guidelines for the relevant country.
20.3	Estimates of the costs of control are calculated for different management scenarios with the models used in the calculation of 20.2 together with a quantitative estimate of the impact of the invasions combined to give a ratio such that it is: > 1 when the cost of control is less than the value of impacts avoided through the control; and < 1 when the control costs exceed the value of impacts avoided through the control applied **AND** The costs of non-target impacts are included in costs of control.

Guide for applying confidence levels

20.1	HIGH	There has been a published peer-reviewed quantitative assessment of the degree of control achieved.
	MEDIUM	There is a report that is based on monitoring data.
	LOW	Expert opinion.
20.2	HIGH	As for 20.1 in addition, the models used are published in peer-reviewed journals and have been extensively tested in similar situations.
	MEDIUM	As for 20.1 in addition, the models used are published in peer-reviewed journals, but only recently or this is one of only a few examples of their implementation.
	LOW	As for 20.1 in addition, the models used have not been published.
20.3	HIGH	As for 20.2
	MEDIUM	As for 20.2
	LOW	As for 20.2

Most effective forms of presentation

20.1	A table with the number of species in different categories
20.2	A box-plot showing the degree to which different interventions have reduced specific indicators of biological invasions
20.3	A table

No example presented here.

Limits to usefulness and accuracy

It relies on accurate and up to date data obtained from species management and control plans that are at present only available for limited number of species.

Updating the indicator

Annually

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species **6.** Extent of alien species **7.** Abundance of alien species **8.** Impact of alien species **9.** Alien species richness **10.** Relative alien species richness **11.** Relative invasive abundance **13.** Quality of the regulatory framework (needed for planning coverage) **14.** Money spent **15.** Planning coverage **17.** Species treated	none	**D.** Level of success in managing invasions

Additional information and comments

None

21 EFFECTIVENESS OF AREA TREATMENTS

Use and interpretation

The outcome indicator that assesses the effectiveness of area-focused control measures.

Potential for aggregation

Data at smaller spatial scales can be aggregated to larger scales.

Possible reasons for upward or downward trends

Effectiveness would be improved through the development and implementation of more effective treatment technologies, through more strategic application of existing technologies, through increased funding and other resources, or through a decrease in the area requiring treatment (and vice versa for decreases).

Implications for biodiversity management of change in the indicator

Increases imply that management is decreasing the size of future problems. In this instance resources could be directed to other areas.

Units in which it is expressed (from basic to advanced)

21.1	Number of areas in six categories of control effectiveness • Not known; and • Counter-productive. Intervention has exacerbated the problem; and • None/ineffective. There has been no intervention, or there has been an intervention but it is ineffective; and • Partial. Somewhat effective intervention; and • Effective. The treatment has reduced the problem to below a desired management threshold. On-going control is required; and • Permanent. The problem has been reduced to a sustainably low level (or zero), and no on-going management is required. **AND** An assessment of any negative impacts of control.
21.2	Quantitative measure of control on *Alien species richness* or *Relative invasive abundance* **AND** Conduct a formal impact assessment of the interventions.
21.3	Return on investment expressed as a ratio of the amount spent on control to the value of avoided cost of impact. **AND** Include non-target impacts as costs.

Description of source data

This indicator is determined on the basis of data on the number of areas that have management plans in place; and species status reports that were obtained from literature, academic and government institutions.

Calculation procedure

21.1	Data on control effectiveness from published reports and sources or expert opinions are used to categorise control effectiveness in areas as: • Not known; • Counter-productive. Evidence that *Relative invasive abundance* is increasing as a result of the intervention; • None/ineffective. There is no discernible change in the degree to which *Relative invasive abundance* is increasing; • Partial. The *Relative invasive abundance* has decreased; • Effective. The *Relative invasive abundance* has decreased to below a management threshold, management is continuing; • Permanent. There is no more active management, despite this *Relative invasive abundance* remains below a management threshold. **AND** Expert assessment informed by data collected on any collateral damage (e.g. details of legal claims and reports of direct non-target damage to indigenous species and damage to ecological infra-structure, with such data ideally collected in the region of interest).
21.2	A counter-factual model is produced that is used to project values with and without control interventions. Using this a percentage change in relevant indicators (e.g. *Relative invasive abundance*) is calculated. **AND** An impact assessment is conducted as per standard guidelines for the relevant country.
21.3	Estimates of the costs of control are calculated for different management scenarios with the models used in the calculation in 21.2 together with quantitative estimate of the impact of the invasions combined to give a ratio such that it is: > 1 when the cost of control is less than the value of impacts avoided through the control; and < 1 when the control costs exceed the value of impacts avoided through the control applied **AND** The costs of non-target impacts are included in costs of control.

Guide for applying confidence levels

21.1	**HIGH**	There has been a published peer-reviewed quantitative assessment of the degree of control achieved.
	MEDIUM	There is a report that is based on monitoring data.
	LOW	Expert opinion.
21.2	**HIGH**	As for 19.1 in addition, the models used are published in peer-reviewed journals and have been extensively tested in similar situations.
	MEDIUM	As for 19.1 in addition, the models used are published in peer-reviewed journals, but only recently or this is one of only a few examples of their implementation.
	LOW	As for 19.1 in addition, the models used have not been published.
21.3	**HIGH**	As for 19.2
	MEDIUM	As for 19.2
	LOW	As for 19.2

Most effective forms of presentation

21.1	A table with number of areas in different categories
21.2	A box-plot showing the degree to which different interventions have reduced specific indicators of biological invasions
21.3	A table

No example presented here.

Limits to usefulness and accuracy

It relies on accurate and up to date data obtained from management and control plans for areas that are at present only available for limited number of areas.

Updating the indicator

In line with reporting processes.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species **6.** Extent of alien species **7.** Abundance of alien species **8.** Impact of alien species **9.** Alien species richness **10.** Relative alien species richness **11.** Relative invasive abundance **12.** Impact of invasions **14.** Money spent **13.** Quality of the regulatory framework **15.** Planning coverage **18.** Area treated	none	**C.** Extent of area that suffers major impacts from invasions **D.** Level of success in managing invasions

Additional information and comments

None

A RATE OF INTRODUCTION OF NEW UNREGULATED SPECIES

Use and interpretation

This provides an indication of potential future biological invasions (i.e. species-based invasion debt).

Species which have been introduced following a proper detailed and independently assessed risk analysis are not included.

Potential for aggregation

This is a high-level indicator, already aggregated at a national level.

Possible reasons for upward or downward trends

Upward trends are to be expected as the volume of trade and travel is increasing. Downward trends in the rate of arrival could come about as a result of effective regulation of imports, and better at-border incursion response efforts.

Technically if the country is saturated with alien species then the rate of new introductions will be zero. However, globally there is little evidence of saturation (Seebens *et al.*, 2016) except for very specific and historic pathways (Liebhold, Brockerhoff & Kimberley 2017).

Implications for biodiversity management of change in the indicator

Unregulated (or poorly regulated) introductions indicate that prevention methods have not succeeded.

Unregulated introductions might manifest in a greater number of invasive species, and ultimately of the area that they occupy. This in turn would increase the magnitude and complexity of management needed to prevent impact.

Units in which it is expressed

A	Number of species introduced per year.

Description of source data

Data would be sourced from ongoing mapping and monitoring projects (such as atlas projects for various taxonomic groups), as well as from periodic surveys and studies.

Calculation procedure

A	Observations of new species are added up. Species which were deliberately introduced are assessed. If a formal detailed risk analysis that was subject to independent expert review was conducted and as a result their introduction was officially sanctioned, these species are not included.

Guide for applying confidence levels

A	**HIGH**	There are good systems in place to detect new introductions, so that the putative time between an introduction and it being detected will always be < 5 years; the risk analysis process is transparent and documented in enough detail to allow proper review.
	MEDIUM	The majority of introductions are detected within 10 years of probable date of introduction; and/or the risk analysis process is well laid out, though the process is not entirely clear.
	LOW	It is likely there is a substantial delay between introduction and detections (such that the indicator will not be responsive). For example, if a large number of new detections are found following an ad hoc sampling trip (e.g. by a visiting international taxonomist) then it is likely the increase is not due to new introductions but to sampling effort; and/or the risk analysis process and decisions are not available for scrutiny.

Most effective forms of presentation

A	Graph of new introductions over time

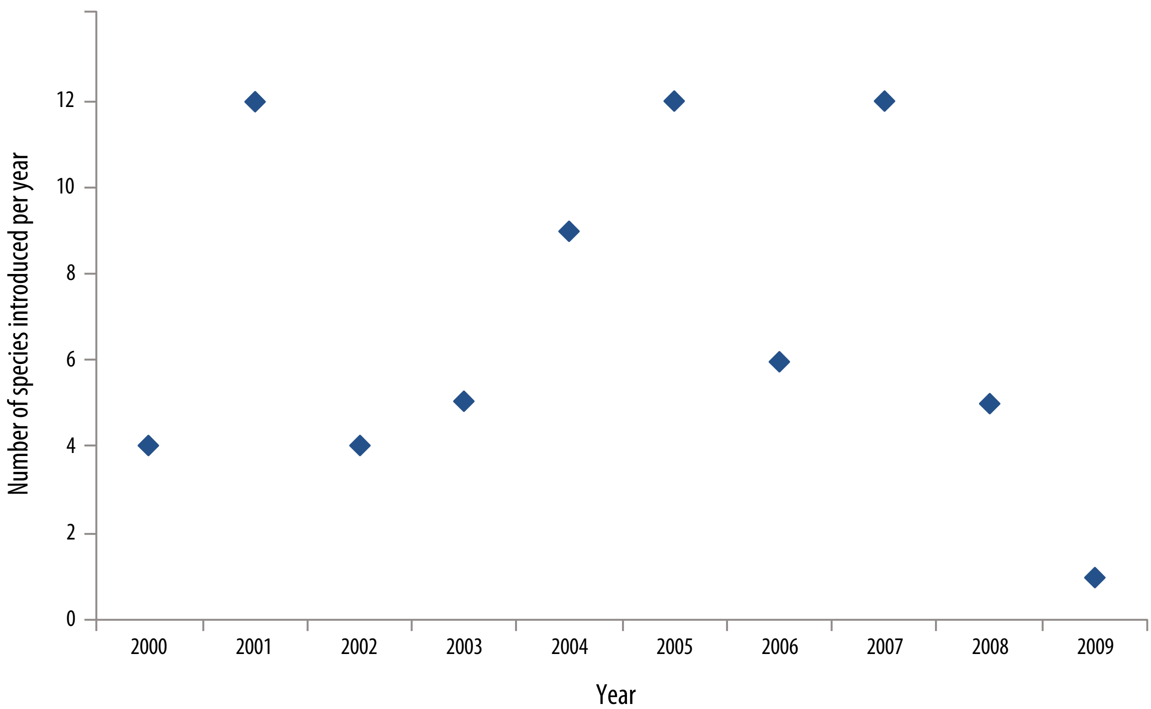


FIGURE A1.12 (Indicator A) Number of alien taxa introduced to South Africa each year during the last full decade (2000–2009). During this period the average rate of introduction of new species was 7 species per year. Data from Chapter 3 of this report.

Limits to usefulness and accuracy

This indicator is sensitive to survey effort and the availability of sufficient taxonomists to confirm identification of species. A change can be an indication of better survey effort.

New introduced species might pose little risk, and so ultimately not be of concern. Likewise, taxa introduced after risk analysis might still cause impacts.

It only looks at new species, but the introduction of new individuals can be problematic for several reasons (e.g. introduction to new areas, introduction of new genetic material).

Updating the indicator

In South Africa it is proposed to update indicators every three years.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
2. Introduction rates **3.** Within-country pathway prominence **4.** Within-country dispersal rates **5.** Number and status of alien species **6.** Extent of alien species **7.** Abundance of alien species **16.** Pathways treated **19.** Effectiveness of pathway treatments	**1.** Introduction pathway prominence **D.** Level of success in managing invasions	none

Additional information and comments

It includes reintroductions after species have been eradicated or died out from a region.

B NUMBER OF INVASIVE SPECIES THAT HAVE MAJOR IMPACTS

Use and interpretation

The total number of alien species that have been reported to have a Major (**MR**) or Massive (**MV**) impact under either the EICAT or SEICAT schemes provides an indication of the current size and complexity of the problem. A growth in the number of species would indicate an increase in consequences and management complexity (as the number of species grows, so too will the range of impacts, and the need for species-specific management solutions).

Potential for aggregation

This is a high-level indicator, already aggregated at a national level.

Possible reasons for upward or downward trends

Species brought under control through biological control or impacts reduced through successful impact reduction or control efforts will result in a downward trend.

Upwards trends can be due to increases in the impacts of invasive species over time; alien species already present becoming invasive and having impacts; the introduction of new species that become widespread damaging invaders; or as a result of improved documentation of impacts

Implications for biodiversity management of change in the indicator

An increase would generally mean there is a greater cost of biological invasions to society. The number of species requiring detailed management plans will change.

Units in which it is expressed

B	Number of species

Description of source data

Published literature on impacts.

Calculation procedure

B	Species are assessed through the EICAT and SEICAT schemes. The numbers of species that currently have major or massive impacts in any impact mechanism are added together.

Guide for applying confidence levels

B	HIGH	For a particular group at least 90% of known invasive species have been assessed using both EICAT and SEICAT with a medium or high level of confidence (see 8.1) and were not found to be data deficient.
	MEDIUM	For a particular group at least 50–90% of known invasive species have been assessed using both EICAT and SEICAT with a medium or high level of confidence (see 8.1) and were not found to be data deficient; or 90% of the most widely distributed invasive species have been assessed.
	LOW	25–50% of all known invasive species have been assessed with at least a low level of confidence (see 8.1) or 70–90% of the most widely distributed species have been assessed with at least a medium level of confidence (see 8.1).

Most effective forms of presentation

B	Trend over time as a line graph. Potentially the turnover in which species are added or are removed from the list

No example presented here.

Limits to usefulness and accuracy

This indicator would be dependent on regular and ongoing surveys and documentation of impacts. If repeat work is not conducted it can quickly become out of date.

Updating the indicator

In South Africa it is proposed to update indicators every three years.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species **6.** Extent of alien species **7.** Abundance of alien species **8.** Impact of alien species **11.** Relative invasive abundance **12.** Impact of invasions **14.** Money spent **17.** Species treated **20.** Effectiveness of species treatments	**C.** Extent of area that suffers major impacts from invasions **D.** Level of success in managing invasions	none

Additional information and comments

A species which has a major impact based on one mechanism will be rated as of more concern than a species which has a moderate impact based on several impact mechanisms.

C EXTENT OF AREA THAT SUFFERS MAJOR IMPACTS FROM INVASIONS

Use and interpretation

The extent of invaded area that suffers major impacts is and indicator of the overall extent of impacts of biological invasions. Invaded areas are expected to deliver fewer or diminished ecosystem services, and/or to support lower levels of biodiversity.

Potential for aggregation

This is a high-level indicator, already aggregated at a national level.

Possible reasons for upward or downward trends

Upward trends would reflect the growth of populations of invasive species, spread to previously un-invaded areas, and increases in the impacts. Downward trends would result from control measures reducing the cover or population sizes of the most dominant invaders, or reassessments indicating that invasions have otherwise declined or were previously over-estimated.

Implications for biodiversity management of change in the indicator

Increases in the extent of the invaded area that suffers major impacts would indicate increasing pressure on biodiversity and the delivery of ecosystem services. Given that the resources required to manage the problem will almost certainly be insufficient to control all species effectively, areas would need to be prioritised and managed accordingly. Management should focus on those areas that are of high priority, and where invasions have not yet reached severe proportions, as the likelihood of success of control measures would be higher in less severely invaded areas.

Unit in which it is expressed

C	Area or proportion of the country

Description of source data

Assigning values to this indicator requires the assessment of invasion severity at fine scales across the whole country, and aggregation to a national level. Currently in South Africa, this is only possible for alien plants at the scale of quarter-degree grid cells, where species presence and levels of invasion are recorded. Even then, estimates are coarse as severe invasions recorded within grid cells do not necessarily cover the entire grid cell.

Calculation procedure

C	Data on indicator 12. Impact of invasions is used, and the total area with major or massive impacts calculated

Guide for applying confidence levels

C	HIGH	As for indicator 12
	MEDIUM	As for indicator 12
	LOW	As for indicator 12

Most effective forms of presentation

C	A map showing areas that have major or massive impacts; a single figure stating the proportion of the area of the country assessed as having major or massive impacts.

No example presented here.

Limits to usefulness and accuracy

Currently, for South Africa, this indicator can only be based on plant species. The inclusion of additional taxa would make the indicator more meaningful.

The areas that have major impacts might not be those that should be prioritised for management as returns on investment might be greater in areas where there are currently low levels of invasion or that are responsible for higher rates of spread (i.e. to prevent future invasions and impacts).

Updating the indicator

In South Africa it is proposed to update indicators every three years**.**

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
5. Number and status of alien species **6.** Extent of alien species **7.** Abundance of alien species **8.** Impact of alien species **9.** Alien species richness **10.** Relative alien species richness **11.** Relative invasive abundance **12.** Impact of invasions **18.** Area treated **21.** Effectiveness of area treatments	**B.** Number of invasive species that have major impacts **D.** Level of success in managing invasions	none

Additional information and comments

It will be important to link this indicator to other data on biodiversity and ecosystem functioning.

D LEVEL OF SUCCESS IN MANAGING INVASIONS

Use and interpretation

The level of success achieved by control measures will vary from place to place, and this indicator is intended to provide an assessment of overall control effectiveness across all projects. High levels of effectiveness would indicate that control measures are appropriate and that the goals of management are realistic and achievable. Low levels of effectiveness would indicate inefficiencies in management, or unrealistic expectations and goals, or both. It should trigger a thorough examination of the component projects with a view to re-allocating national-level resources to projects where the goals are more likely to be achieved, or to re-defining more-realistic goals.

Potential for aggregation

This is a high-level indicator, already aggregated at a national level.

Possible reasons for upward or downward trends

There would be many reasons for upward or downward trends. These would include the ability of managers to assess the magnitude and complexity of the problem leading to unrealistic goal-setting, the extent to which best-practice control measures are adhered to, unforeseen fluctuations in funding, unforeseen events (fires, floods, droughts), bureaucratic inefficiencies, and a lack of understanding of the ecology of target species (e.g., Shackleton *et al.*, 2016a).

Implications for biodiversity management of change in the indicator

Change to management approaches would be required if the indicator suggests high levels of inefficiency. This would be in line with the philosophy of adaptive management, where the methods employed could be improved, or the funding could be moved to new areas or species where success would be more likely, or the goals of management could be changed.

Units in which it is expressed (from basic to advanced)

D	% efficacy

Description of source data

Data would be sourced from regular monitoring of progress towards the goals listed in formal management plans.

Calculation procedure

D	First the proportion of pathways, species, and areas that require management and where a plan is in place is calculated (see indicators 15, 16, 17 and 18). Second for pathways, species, or areas treated, treatments are assessed based on their effectiveness (see indicators 19, 20, and 21) and scored as: • *Counter-productive*. -100% • *None/ineffective/not known*. 0% • *Partial*. 20% • *Effective* or *Permanent*. 100% Then the proportions which are treated are multiplied with the proportions that are effective to give an overall percentage success for pathways, species and areas. Finally the percentage efficacy of pathway, species, and area interventions are averaged to give an overall figure.

Guide for applying confidence levels

D	**HIGH**	All the relevant indicators are assessed with at least medium confidence
	MEDIUM	All the relevant indicators are assessed but some with low confidence
	LOW	Some of the relevant indicators are not assessed, so assumptions are made/the analysis is not complete, or all of the relevant indicators are assessed with low confidence.

Most effective forms of presentation

D	% (that at maximum will be 100%, but can be negative if interventions are on balance exacerbating invasions)

No example presented here.

Limits to usefulness and accuracy

This indicator will be limited to the area for which management plans are available. Currently, South African legislation requires all protected areas to develop management plans, and that would provide a useful starting point. Ideally, management plans should also be developed for all areas where substantial funding is being expended on control of invasive species. The assessment of management effectiveness would be dependent on: (1) setting goals for management progress; and (2) regular monitoring of progress towards those goals.

Updating the indicator

In South Africa it is proposed to update indicators every three years.

Closely related indicators

DEPENDS UPON	LINKS WITH	REQUIRED FOR
1. Introduction pathway prominence **2.** Introduction rates **3.** Within-country pathway prominence **4.** Within-country dispersal rates **5.** Number and status of alien species **6.** Extent of alien species **7.** Abundance of alien species **8.** Impact of alien species **9.** Alien species richness **10.** Relative alien species richness **11.** Relative invasive abundance **12.** Impact of invasions **13.** Quality of regulatory framework **14.** Money spent **15.** Planning coverage **16.** Pathways treated **17.** Species treated **18.** Area treated **19.** Effectiveness of pathway treatments **20.** Effectiveness of species treatments **21.** Effectiveness of area treatments	**A.** Rate of introduction of new unregulated species **B.** Number of invasive species that have major impacts **C.** Extent of area that suffers major impacts from invasions	None

Additional information and comments

Impacts which are scored as permanent might need to be removed from the calculation at some point, as those taxa would no longer need to be managed (so wouldn't come in under pathways, species, and areas treated). Ironically, however, this could lead to a decrease in the indicator. This will need to be resolved.

APPENDIX 2

DATA USED IN THE ASSESSMENT OF THE STATUS OF PATHWAYS (CHAPTER 3)

INTRODUCTION

This Appendix provides additional detail relevant to the assessment of the status of the pathways of introduction and within-country dispersal for alien taxa, summarised in Chapter 3. Historical introduction data can be used to identify the pathways of introduction and dispersal, and determine how these pathways have changed over time (Faulkner *et al.*, 2015). However, as socio-economic factors play an important role in shaping these pathways (Essl *et al.*, 2011, 2015a), socio-economic data can also inform our understanding of the current and historical role played by the pathways, while socio-economic forecasts can give us an idea of how these pathways could change in the future. This information can be used to prioritise the pathways of introduction and dispersal, and to develop and evaluate pathway-specific policies and interventions that target priority pathways. The status of the pathways of introduction and dispersal for South Africa are discussed in Chapter 3, and here the historical introduction and socio-economic data used to evaluate the current, historical and future status of the pathways is presented.

In Table A2.1, further details are provided for the information presented in Figure 3.1 in Chapter 3. Figures A2.1 to A2.9 demonstrate the results obtained using historical introduction data: Figures A2.1 and A2.2 show the number of alien taxa introduced through the pathways; Figures A2.3 to A2.7 demonstrate recent changes to the rate at which taxa have been introduced through the pathways; and Figures A2.8 and A2.9 show the level of certainty in the pathway assignments. Figures A2.10 to A2.30 show the pathway-related socio-economic data used in the assessment.


Cylindropuntia fulgida (boxing glove cactus) – SANBI

TABLE A2.1 The rate of introduction (i.e. number of taxa introduced) for each pathway of introduction (following the scheme adopted by the Convention on Biological Diversity), how the rate of introduction has changed over time, the current prominence of the pathways in South Africa, how pathway prominence is expected to change in the future, the role of the pathways in further facilitating the dispersal of alien species within the country, the effectiveness of control measures, and examples of species introduced to South Africa'

PATHWAY	PATHWAY SUBCATEGORY	RATE OF INTRODUCTION	HISTORICAL CHANGES TO RATE OF INTRODUCTION	PATHWAY PROMINENCE	FORECAST PATHWAY PROMINENCE	WITHIN-COUNTRY DISPERSAL	CONTROL EFFECTIVENESS	EXAMPLE
RELEASE IN NATURE	Biological control	Over 100 alien taxa released as biological control agents (Figure A2.2). The number of insect releases for the biological control of insect pests has declined since the 1980s (Cock *et al.*, 2016).	The rate at which taxa were released for biological control has declined since the 1980s (Figure A2.4).	Recently there has been an increase in funding for biological control of alien plants and, therefore, research and implementation have also increased (Zachariades *et al.*, 2017). Almost 15 667 618 US dollars (USD) was invested in the biological control of alien plants between 2014 and 2017 (Zachariades *et al.*, 2017). Since 2013, 19 agents were approved for release against alien plants (Zachariades *et al.*, 2017).	39 species are being investigated for release. Targets for growth have been set for 2020, e.g. research on 12 new alien plant species should be initiated (Zachariades *et al.*, 2017).	Agents that reproduce and/ or disperse slowly are often mass reared and are manually redistributed (Moran, Hoffmann & Zimmermann, 2013; Zachariades *et al.*, 2017).	No reported non-target effects (Klein *et al.*, 2011) and thus the control measures appear to be working well (Klein, 2011).	*Cactoblastis cactorum* (cactus moth) was introduced as a biological control agent against *Opuntia ficus-indica* (mission prickly pear) (Zimmermann, Moran & Hoffmann, 2004).
	Erosion control/dune stabilisation	Over 60 alien taxa are known to have been released for this purpose (Figure A2.2).	No new taxa have recently been introduced (Figure A2.4), but data are likely insufficient.	No data	No data	No data	Control measures are in place, however, data are too insufficient to rate their effectiveness.	*Pennisetum purpureum* (elephant grass) has been planted for screening, as a windbreak and to prevent erosion (Bromilow, 2010).
	Fisheries	15 alien taxa have been released for fishing (Figure A2.2).	No new taxa have been released since the 1980s (Figure A2.4).	An estimated 900 tonnes of freshwater fish were caught in 2014 (FAO, 2016a). Fishing contributed ZAR 18.8 billion (~USD 1.4 billion) to the South African economy in 2007 (Van Rensburg *et al.*, 2011).	No data	Fish are often transported and dispersed by anglers (Picker & Griffiths, 2011).	No new alien taxa have been introduced since legislation was promulgated in 1986. Therefore, the legislation might have been effective.	*Micropterus salmoides* (large-mouth bass), was imported for angling in 1928 (Picker & Griffiths, 2011).
	Hunting	30 alien taxa are known to have been released for this purpose (Figure A2.2).	Although the rate of introduction has fluctuated since the 1980s, 11 new alien species were introduced for hunting between 2000 and 2011 (Figure A2.4).	Hunting generates a total estimated revenue of ZAR 2.61 billion (~USD 200 million) (Taylor, Lindsay & Davies-Mostert, 2015). Alien species have been introduced to many game farms to increase the attractiveness of the property to tourists and hunters by providing a greater diversity of species (Taylor et al., 2015). Trophy and biltong hunting markets in South Africa have increased over time (Taylor, Lindsay & Davies-Mostert, 2015)	The hunting industry may benefit from a decline in the opportunities available in other countries, but could be negatively affected by increasing global anti-hunting sentiment and publicity (Taylor, Lindsay & Davies-Mostert, 2015).	Hunting species are sold privately or through auctions and are subsequently moved around the country (Van Rensburg et al., 2011; Taylor, Lindsay & Davies-Mostert, 2015).	Despite the existence of control measures the rate of introduction appears to have increased in the 2000s. The interventions may, therefore, have been ineffective.	*Rusa unicolor* (sambar deer) was introduced for hunting (Picker & Griffiths, 2011; Van Rensburg *et al.*, 2011).
	Landscape/flora/fauna 'improvement'	Eight alien taxa are known to have been released for this purpose (Figure A2.2).	No new taxa have been released since 1900 (Figure A2.4).	Introductions for these purposes declined globally in the 20th century due to socio-economic changes like decreasing public and scientific support for acclimatisation societies (Seebens *et al.*, 2017).	The prominence of this pathway is unlikely to change much in the future	No data	No new taxa have been introduced through this pathway since long before the implementation of control measures. The control measures could be regarded as permanent as this pathway likely no longer requires management.	Cecil John Rhodes released *Sciurus carolinensis* (grey squirrel) in the Western Cape in the 1890s (Picker & Griffiths, 2011).

PATHWAY	PATHWAY SUBCATEGORY	RATE OF INTRODUCTION	HISTORICAL CHANGES TO RATE OF INTRODUCTION	PATHWAY PROMINENCE	FORECAST PATHWAY PROMINENCE	WITHIN-COUNTRY DISPERSAL	CONTROL EFFECTIVENESS	EXAMPLE
RELEASE IN NATURE	Conservation purposes or wildlife management	No taxa are known to have been introduced for this purpose (Figure A2.2).	No data	No data	No data	No data	Control measures are in place, however, data are too insufficient to rate their effectiveness.	None provided
	Release in nature for use other than above	Eight alien taxa are known to have been released for other purposes (Figure A2.2).	No new taxa have recently been introduced, but data are likely insufficient.	No data	No data	No data	Control measures are in place, however, data are too insufficient to rate their effectiveness.	*Equus asinus* (donkey) was introduced as a means of transport (Van Rensburg *et al.*, 2011).
	Other intentional release	No taxa are known to have been introduced for this purpose (Figure A2.2).	No data	No data	No data	No data	Control measures are in place, however, data are too insufficient to rate their effectiveness.	None provided
ESCAPE FROM CONFINEMENT	Agriculture	91 taxa are known to have been introduced for agriculture (Figure A2.2).	No new taxa have recently been introduced (Figure A2.5), but data are likely insufficient.	In 2014 crop production was over 40 million tonnes (Figure A2.10). The area harvested for crops has decreased over time, but production has increased (Figure A2.10).	There is considerable interest in new agricultural opportunities, like the introduction of grasses for biofuels (Visser *et al.*, 2017b).	No data	Control measures are in place, however, data are too insufficient to rate their effectiveness.	*Vicia benghalensis* (reddish tufted vetch) was introduced as a fodder crop (Bromilow, 2010).
	Aquaculture/ mariculture	12 taxa are known to have been introduced for this purpose (Figure A2.2).	There have been no new species introduced for this purpose since the 1980s (Figure A2.5).	Production in 2014 was estimated at over 6 000 tonnes, and production has increased over time (Figure A2.11).	The aquaculture sector is currently small, but is growing (Van Rensburg *et al.*, 2011).	No data	No new taxa have been introduced through this pathway since legislation was promulgated in 1986. Therefore, the legislation might have been effective.	The invasive *Oreochromis niloticus* (Nile tilapia) was introduced for aquaculture (Van Rensburg *et al.*, 2011).
	Botanical garden/zoo/ aquaria	Only three taxa are known to have been introduced through this pathway (Figure A2.2).	No new taxa have been introduced through this pathway since the 1930s.	Between 2006 and 2015, 2 304 organisms (25 in 2015) were imported for botanical garden/zoo purposes (UNEP World Conservation Monitoring Centre, 2017). The number of organisms imported for this purpose has fluctuated over time.	No data	No data	No new taxa have been introduced through this pathway since before the implementation of control measures. The control measures could be regarded as effective.	*Hemitragus jemlahicus* (Himalayan tahr) escaped from the Cape Town zoo (Picker & Griffiths, 2011).
	Pet/aquarium/ terrarium species	Over 20 taxa are known to have been introduced through this pathway (Figure A2.2).	The rate at which taxa have been introduced as pets has fluctuated slightly (Figure A2.5).	At least 1443 live organisms (only 10 in 2015 and 73 in 2014) were imported into South Africa for personal use between 2006 and 2015 (UNEP World Conservation Monitoring Centre, 2017). Van Wilgen *et al.* (2010) reported that both the number of reptile individuals and species imported into South Africa for the pet trade has increased since the 1970s.	No data	Once species have been sold at pet stores they are often traded (e.g. through private sales on gumtree) and moved around the country by members of the public (Martin & Coetzee, 2011; Measey *et al.*, 2017).	Despite control measures, there appears to have been minimal change to the rate of introduction. The control measures appear to have been ineffective.	*Pterygoplichthys disjunctivus* (vermiculated sailfin catfish) is common in the pet trade and likely escaped from captivity (Picker & Griffiths, 2011).

PATHWAY	PATHWAY SUBCATEGORY	RATE OF INTRODUCTION	HISTORICAL CHANGES TO RATE OF INTRODUCTION	PATHWAY PROMINENCE	FORECAST PATHWAY PROMINENCE	WITHIN-COUNTRY DISPERSAL	CONTROL EFFECTIVENESS	EXAMPLE
ESCAPE FROM CONFINEMENT	Farmed animals	Only five animals are known to have been introduced for farming and have escaped (Figure A2.2).	There have been no new taxa introduced through this pathway since the 1960s (Figure A2.5).	Over 200 million stock animals were found in South Africa in 2014 and over time the number of animals farmed has increased (Figure A2.12).	No data	No data	No new taxa have been introduced through this pathway since before the implementation of control measures. The control measures could be regarded as effective.	Most populations of *Sus scrofa* (feral pig) in the Western Cape escaped from farms (Picker & Griffiths, 2011).
	Forestry	30 taxa have been introduced for forestry and escaped (Figure A2.2).	No new taxa have recently been introduced (Figure A2.5), but data are likely insufficient.	Forestry production in 2014 was estimated at over 30 million m^3 (Figure A2.13). Forestry production increased over time until the mid-2000s but has since declined (Figure A2.13).	No data	No data	Control measures are in place, however, data are too insufficient to rate their effectiveness.	*Pinus pinaster* (cluster pine) was cultivated for timber (Bromilow, 2010).
	Fur farms	Only one taxon introduced for fur has escaped (Figure A2.2).	No new species have recently been introduced for this purpose (Figure A2.5) and the introduction of animals for fur also appears to have declined globally (Seebens *et al.*, 2017).	Currently only rabbits are farmed for fur (Fur Free, 2017).	No data	No data	No new taxa have been introduced through this pathway since before the implementation of control measures. The control measures could be regarded as effective.	*Mustela vison* (mink) was introduced to South Africa for its fur (Van Rensburg *et al.*, 2011).
	Horticulture	Over 200 taxa have been introduced for horticulture and have escaped (Figure A2.2).	No new taxa have recently been introduced (Figure A2.5), but data are likely insufficient.	Although there has been an increase in the popularity of indigenous ornamental plants, alien species dominate public and private gardens (Richardson *et al.*, 2003). Live plant imports into South Africa have generally increased over time and in 2016 were valued at over USD 12 million (Figure A2.14).	South African consumers in the ornamental plant sector show a desire for new varieties of plants (Middleton, 2015).	Ornamental plant species are often moved intentionally around the country by members of the public (Martin & Coetzee, 2011).	Control measures are in place, however, data are too insufficient to rate their effectiveness.	The invasive ornamental plant *Lantana camara* (lantana) spread rapidly once introduced and is now found throughout much of the country (Henderson, 2007; Bromilow, 2010).
	Ornamental purpose other than horticulture	Only one taxon has been introduced through this pathway (Figure A2.2).	No new taxa have recently been introduced (Figure A2.5).	No data	No data	No data	No new taxa have been introduced through this pathway since before the implementation of control measures. The control measures could be regarded as effective.	*Pavo cristatus* (common peacock) is a popular ornamental bird and many semi-feral populations exist (Picker & Griffiths, 2011).
	Research and ex-situ breeding	Only four taxa have been introduced through this pathway (Figure A2.2).	There have been no introductions through this pathway since the 1990s (Figure A2.5), but data are likely insufficient.	Between 2006 and 2015, 3 499 organisms were imported (30 in 2015 and 271 in 2014) into South Africa for scientific purposes and for breeding in captivity (UNEP World Conservation Monitoring Centre, 2017). The number of organisms imported for this purpose has fluctuated over time (UNEP World Conservation Monitoring Centre, 2017).	No data	No data	Control measures are in place, however, data are insufficient to rate their effectiveness.	The earthworm *Eisenia andrei* was studied in laboratory and field experiments (Plisko, 2010).

PATHWAY	PATHWAY SUBCATEGORY	RATE OF INTRODUCTION	HISTORICAL CHANGES TO RATE OF INTRODUCTION	PATHWAY PROMINENCE	FORECAST PATHWAY PROMINENCE	WITHIN-COUNTRY DISPERSAL	CONTROL EFFECTIVENESS	EXAMPLE
ESCAPE FROM CONFINEMENT	Live food and live baits	Only five taxa have been introduced for this purpose (Figure A2.2).	No new taxa have recently been introduced (Figure A2.5).	No data	No data	No data	No new taxa have been introduced through this pathway since before the implementation of control measures. The control measures could be regarded as effective.	The mollusc *Cornu aspersum* (common garden snail) may have been introduced as a food item (Herbert, 2010).
	Other escape from confinement	Over 70 species have been introduced for purposes other than those discussed above and then have escaped from confinement (Figure A2.2).	No new taxa have recently been introduced (Figure A2.5), but data are likely insufficient.	No data	No data	No data	Control measures are in place, however, data are too insufficient to rate their effectiveness.	One of the many reasons *Columba livia* (rock dove) was introduced was for communication (Van Rensburg *et al.*, 2011).
TRANSPORT-CONTAMINANT	Contaminant nursery material	Only three taxa are known to have been introduced through this pathway (Figure A2.2). Organisms are often intercepted on imported plants during inspections at South African ports of entry (Figure A2.15).	No new taxa have recently been introduced (Figure A2.6), but data are likely insufficient.	Live plant imports have increased over time and in 2016 were valued at over USD 12 million (Figure A2.14).	No data	No data	Control measures are in place, however, data are too insufficient to rate their effectiveness.	The terrestrial amphipod *Talitroides topitotum* (land hopper) might have been introduced with potted plants (Picker & Griffiths, 2011).
	Contaminated bait	No taxa appear to have been introduced through this pathway (Figure A2.2).	No data	No data	No data	No data	Control measures are in place, however, data are too insufficient to rate their effectiveness.	None provided
	Food contaminant	Seven alien taxa are known to have been introduced as contaminants of imported food (Figure A2.2). Many organisms have been intercepted at South African ports of entry during inspections of imported food (e.g. fruit) (Figure A2.15).	There have been no recent introductions through this pathway, but data are likely insufficient (Figure A2.6).	The amount of food imported into South Africa has increased over time and over 7 million tonnes were imported in 2013 (Figure A2.16).	No data	No data	Control measures are in place, however, data are too insufficient to rate their effectiveness.	*Cydia pomonella* (codling moth) might have been introduced to Cape Town with imported apples (Picker & Griffiths, 2011).
	Contaminant on animals	Nine alien taxa are known to have been introduced to South Africa as contaminants of imported animals (Figure A2.2).	The rate at which new taxa have been introduced as animal contaminants has increased slightly (Figure A2.6).	The number of animals imported into South Africa has fluctuated over time and over 1 000 000 live animals were imported in 2013 (Figure A2.17).	No data	No data	Despite control measures, there appears to have been minimal change to the rate of introduction. The control measures could be regarded as ineffective.	*Xantho incisus* (black fingered crab) was likely introduced with imported oyster spat from Europe (Picker & Griffiths, 2011).
	Parasites on animals	13 alien taxa are known to have been introduced to South Africa as parasites of imported animals (Figure A2.2).	The rate at which taxa have been introduced as parasites of animals has remained consistent (Figure A2.6).	The number of animals imported into South Africa has fluctuated over time and over 1 000 000 live animals were imported into South Africa in 2013 (Figure A2.17).	No data	No data	Despite control measures, the rate of introduction has not changed. The control measures could be regarded as ineffective.	*Argulus japonicus* (Japanese fishlouse) was probably introduced along with Koi fish, or other ornamental fish species (Picker & Griffiths, 2011).

PATHWAY	PATHWAY SUBCATEGORY	RATE OF INTRODUCTION	HISTORICAL CHANGES TO RATE OF INTRODUCTION	PATHWAY PROMINENCE	FORECAST PATHWAY PROMINENCE	WITHIN-COUNTRY DISPERSAL	CONTROL EFFECTIVENESS	EXAMPLE
TRANSPORT-CONTAMINANT	Contaminant on plants	20 taxa are known to have been introduced through this pathway (Figure A2.2). Organisms are often intercepted on imported plants during inspections at South African ports of entry (Figure A2.15).	The rate at which new taxa have been introduced as contaminants of plants has remained consistent (Figure A2.6).	Live plant imports have increased over time and in 2016 were valued at over USD 12 million (Figure A2.14).	No data	No data	Despite control measures, the rate of introduction has not changed. The control measures could be regarded as ineffective.	*Cosmos bipinnatus* (cosmos) might have been introduced with contaminated fodder (Bromilow, 2010).
	Parasite on plants	Only two taxa are known to have been introduced through this pathway (Figure A2.2). Organisms are often intercepted on imported plants during inspections at South African ports of entry (Figure A2.15).	The rate at which new taxa have been introduced as parasites of plants has remained consistent (Figure A2.6).	Live plant imports have increased over time and in 2016 were valued at over USD 12 million (Figure A2.14).	No data	No data	Despite control measures, the rate of introduction has not changed. The control measures could be regarded as ineffective.	*Heliothrips haemorrhoidalis* (black tea thrips) have been intercepted on imported plant material (Picker & Griffiths, 2011).
	Seed contaminant	Eight taxa have been introduced through this pathway (Figure A2.2). Organisms have been intercepted at the ports of entry during inspections of imported seed (Figure A2.15).	No new taxa have recently been introduced, but data are likely insufficient (Figure A2.6).	The formal seed industry imported seeds to a value of USD 89 million in 2012–2013 (Department of Agriculture Forestry and Fisheries, 2015). South Africa's agronomic seed imports have fluctuated over time, with increases often resulting from a decline in domestic production (Department of Agriculture, Forestry and Fisheries, 2015).	No data	No data	Control measures are in place, however, data are too insufficient to rate their effectiveness.	*Cirsium arvense* (Canada thistle) might have been introduced as an impurity of seed (Bromilow, 2010).
	Timber trade	Ten taxa are known to have been introduced to South Africa through this pathway (Figure A2.2). Organisms have been intercepted at the ports of entry during inspections of wood products (Figure A2.15).	No new taxa have recently been introduced (Figure A2.6), but data are likely insufficient.	The value of forestry products imported into South Africa has increased over time and in 2015 was worth over USD 2 billion (Figure A2.18).	No data	Contaminants are likely transported along with infested wood all over the country (Hurley *et al.*, 2012).	Control measures are in place, however, data are insufficient to rate their effectiveness.	*Sirex noctilio* (sirex woodwasp) was probably imported and transported around the country in infested timber (Picker & Griffiths, 2011; Hurley *et al.*, 2012).
	Transport of habitat material	Six taxa are known to have been introduced through this pathway (Figure A2.2). Organisms have been intercepted in habitat material (like soil) during inspections at South Africa's ports of entry (Figure A2.15).	The rate at which new taxa have been introduced has remained consistent (Figure A2.6).	No data	No data	No data	Despite control measures, the rate of introduction has not changed. The control measures could be regarded as ineffective.	The fly *Fucellia maritima* (seaweed fly) was probably introduced via the guano trade (Picker & Griffiths, 2011).

PATHWAY	PATHWAY SUBCATEGORY	RATE OF INTRODUCTION	HISTORICAL CHANGES TO RATE OF INTRODUCTION	PATHWAY PROMINENCE	FORECAST PATHWAY PROMINENCE	WITHIN-COUNTRY DISPERSAL	CONTROL EFFECTIVENESS	EXAMPLE
TRANSPORT - STOWAWAY	Angling/fishing equipment	No taxa are known to have been introduced through this pathway (Figure A2.2).	No data	An estimated 2.5 million anglers participated in sport and recreational fishing in 2007 (Leibold & Van Zyl, 2008), and the fishery sector as a whole is worth about ZAR 6 billion per annum (South African Government, 2017). More than 600 000 tonnes of fish were caught in 2014 (Figure A2.19), and there were over 1 200 fishing vessels in South African waters in 2016 (Figure A2.20). The quantity of fish caught has declined (Figure A2.19), and so too has the number of fishing vessels (Figure A2.20).	Fishing production is predicted to increase in the future (FAO, 2016b).	No data	No control measures are in place.	None provided
	Container/bulk	No taxa are known to have been introduced through this pathway (Figure A2.2).	No data	In 2016, ~49 000 000 metric tons of imported cargo was handled, and ~1 600 000 (teus) containers were landed following deep-sea transport at South Africa's major ports (Transnet National Ports Authority, 2017). The number of containers landed has increased since 2009 (Figure A2.21).	Over the next 30 years the amount of cargo handled at the major South African ports will increase on average by ~450% (ranges from a ~160% increase at Port Elizabeth to a ~1 800% increase at Ngqura) (Transnet National Ports Authority, 2014).	No data	Control measures are in place, however, data are insufficient to rate their effectiveness.	None provided
	Hitchhikers on airplane	Five taxa are known to have been introduced through this pathway (Figure A2.2).	No new taxa have recently been introduced (Figure A2.7), but data are likely insufficient.	Over 36 000 aircraft arrived from international destinations and 13 000 aircraft arrived from regional destinations during the 2015/2016 financial year (Airports Company South Africa, 2017). There has been an increase in the number of aircraft arriving from regional and international destinations (Figure A2.22).	There are plans to expand the airports (e.g. a cargo terminal is to be built at OR Tambo; see Department of Transport, 2016).	In the 2015/2016 financial year there were over 140 000 domestic flight arrivals at South African airports (Figure A2.23), with most of the flights arriving at OR Tambo (Figure A2.24). The number of domestic flight arrivals has increased since the 2012/2013 financial year (Figure A2.23).	Control measures are in place, however, data are insufficient to rate their effectiveness.	*Calliphora vicina* (common blow fly) was likely introduced as a stowaway on aircraft (Picker & Griffiths, 2011).
	Hitchhikers on ship/boat	21 taxa are known to have been introduced through this pathway (Figure A2.2).	The rate at which new taxa have been introduced has remained consistent (Figure A2.7).	The number of ocean going vessels arriving at South Africa's major ports has fluctuated slightly over time and in 2016, there were over 8 000 vessel arrivals (Figure A2.25).	All major ports, except Mossel Bay, will be upgraded and expanded (Transnet National Ports Authority, 2014).	Once introduced, alien taxa may be transported along the South African coastline as hitchhikers on ships.	No control measures are in place.	*Corvus splendens* (house crow) was likely introduced to Durban as a hitchhiker on ships from Zanzibar, with subsequent spread to Cape Town likely also aided by ships (Dean, 2000; Lever, 2005; Picker & Griffiths, 2011).

PATHWAY	PATHWAY SUBCATEGORY	RATE OF INTRODUCTION	HISTORICAL CHANGES TO RATE OF INTRODUCTION	PATHWAY PROMINENCE	FORECAST PATHWAY PROMINENCE	WITHIN-COUNTRY DISPERSAL	CONTROL EFFECTIVENESS	EXAMPLE
TRANSPORT - STOWAWAY	Machinery/ equipment	No taxa are known to have been introduced through this pathway (Figure A2.2).	No data	No data	No data	No data	No control measures are in place.	None provided
	People and their luggage/equipment	No alien taxa are known to have been introduced through this pathway (Figure A2.2).	No data	In 2016, 10.1 million overnight visitors entered South Africa, with tourism and travel contributing in total over USD 27 billion (real prices) to the country's Gross Domestic Product (GDP) (World Tourism and Travel Council, 2017). The number of people arriving in South Africa through air, sea and land transport has increased over time (Figure A2.26).	The contribution of travel and tourism to the country's GDP is predicted to increase in the future (Figure A2.27).	Over 13 million passengers arrived at South African airports on domestic flights in the 2015/2016 financial year, however, this number has fluctuated over time (Figure A2.28).	Control measures are in place, however, data are insufficient to rate their effectiveness.	None provided
	Organic packing material	One taxon is known to have been introduced through this pathway (Figure A2.2).	No new taxa have recently been introduced (Figure A2.7), but data are likely insufficient.	No data	No data	No data	Control measures are in place, however, data are insufficient to rate their effectiveness.	The plant *Chromolaena odorata* (triffid weed) may have been introduced as seed on packing materials (Bromilow, 2010).
	Ship/boat ballast water	51 taxa are believed to have been introduced through this pathway (Figure A2.2).	The rate at which taxa have been introduced through this pathway appears to have increased slightly over time (Figure A2.7).	The number of ocean going vessels arriving at South Africa's major ports has fluctuated slightly over time and in 2016, there were over 8 000 vessel arrivals (Figure A2.25).	All major ports, except Mossel Bay, will be upgraded and expanded (Transnet National Ports Authority, 2014).	No data	No control measures are currently in place, but the Ballast Water Management Bill has been developed.	The copepod *Acartia spinicauda* was probably introduced to Richards Bay through the release of ballast water by ships (Picker & Griffiths, 2011).
	Ship/boat hull fouling	68 taxa might have been introduced through this pathway (Figure A2.2).	The rate at which taxa have been introduced through this pathway appears to have increased over time (Figure A2.7).	The number of ocean going vessels arriving at South Africa's major ports has fluctuated slightly over time and in 2016, there were over 8 000 vessel arrivals (Figure A2.25).	All major ports, except Mossel Bay, will be upgraded and expanded (Transnet National Ports Authority, 2014).	No data	No control measures are in place.	*Obelia geniculata* (bell hydroid) was likely introduced attached to the hull of a visiting ship (Picker & Griffiths, 2011).
	Vehicles	Only one taxon is known to have been introduced through this pathway (Figure A2.2).	No new taxa have recently been introduced (Figure A2.7), but data are likely insufficient.	Over 16 million people entered South Africa through the road network in 2016 (Figure A2.26). Vehicle imports in 2016 were worth USD 5 billion (Figure A2.29). The number of people entering South Africa through the road network has increased over time (Figure A2.26) and, besides recent declines, there has been an increase in the value of vehicle imports (Figure A2.29).	No data	No data	No control measures are in place.	*Mus musculus* (house mouse) was likely transported around the world as a stowaway on a variety of vehicles (Picker & Griffiths, 2011).
	Other means of transport	No taxa are known to have been introduced through this pathway (Figure A2.2).	No data	No data	No data	No data	No control measures are in place.	None provided

PATHWAY	PATHWAY SUBCATEGORY	RATE OF INTRODUCTION	HISTORICAL CHANGES TO RATE OF INTRODUCTION	PATHWAY PROMINENCE	FORECAST PATHWAY PROMINENCE	WITHIN-COUNTRY DISPERSAL	CONTROL EFFECTIVENESS	EXAMPLE
CORRIDOR	Interconnected waterways/basins/seas	No taxa are known to have been introduced through this pathway (Figure A2.1).	No data	The pathway likely plays a minimal role.	We know of no major infra-structure proposals in the immediate future that would result in significantly greater connectivity (e.g. through waterways).	Human made corridors do facilitate the spread of species within the country and, for example, fish species can disperse along canals and tunnels (Richardson *et al.*, 2003; Van Rensburg *et al.*, 2011).	No control measures are in place.	None provided
	Tunnels and land bridges	No taxa are known to have been introduced through this pathway (Figure A2.1).	No data	The pathway likely plays a minimal role.	We know of no major infra-structure proposals in the immediate future that would result in significantly greater connectivity (e.g. through bridges or tunnels).	No data	No control measures are in place.	None provided
UNAIDED	Natural dispersal across borders of invasive species that have been introduced through the above pathways	Nine taxa are known to have spread from neighbouring countries into South Africa (Figure A2.1).	The rate at which new taxa have been introduced has remained consistent (Figure A2.3), and in the last year, two agriculturally important alien pest species might have entered South Africa through natural spread from African countries: *Tuta absoluta* (tomato leaf miner) (Visser *et al.*, 2017a; Department of Agriculture, Forestry and Fisheries, 2016a, 2016b), which has a natural ability to fly long distances (Guimapi *et al.*, 2016), and *Spodoptera frugiperda* (fall armyworm) (Agricultural Research Council-Plant Protection Research Institute, 2017).	As South Africa shares land borders with six other African countries, multiple opportunities exist for organisms that have been introduced to African countries to spread naturally into South Africa. Merchandise imports to Africa have increased over time and were worth over USD 400 billion in 2015 (Figure A2.30).	The volume of goods imported by African countries is predicted to increase over the next few years (Figure A2.30).	Once an alien organism has spread into South Africa, further natural spread is likely.	No control measures are in place.	*Cherax quadricarinatus* (redclaw crayfish) escaped from an abandoned aquaculture facility in Swaziland and established in the Sand River, the species then spread into South Africa (Picker & Griffiths, 2011).

FIGURES

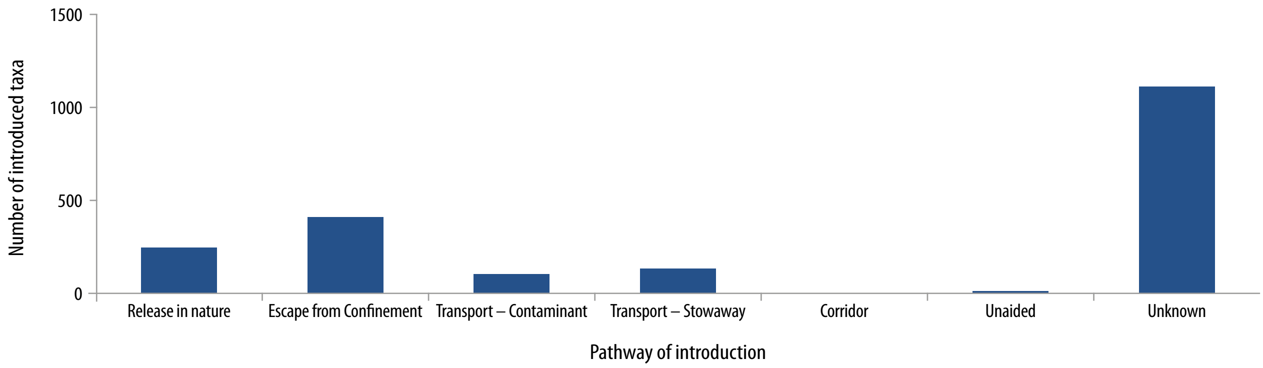


FIGURE A2.1 Number of alien taxa introduced to South Africa through the pathways of introduction (following the categorisation adopted by the Convention on Biological Diversity), and the number of taxa for which pathway of introduction was unknown.

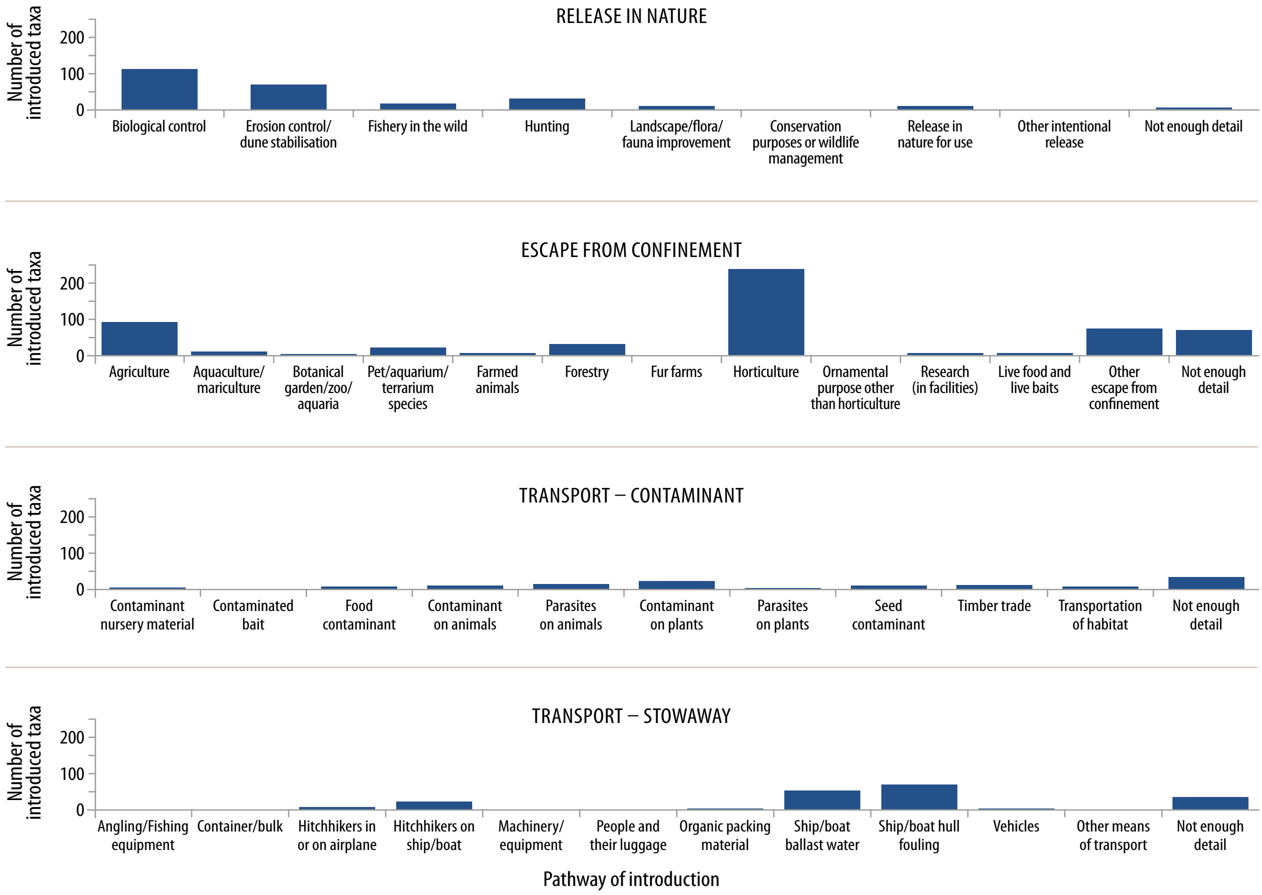


FIGURE A2.2 Number of alien taxa introduced to South Africa through the pathways of introduction (following the categories and subcategories adopted by the Convention on Biological Diversity), and the number for which designation at the pathway subcategory level was not possible due to insufficient information. Results for the unaided pathway are not shown.

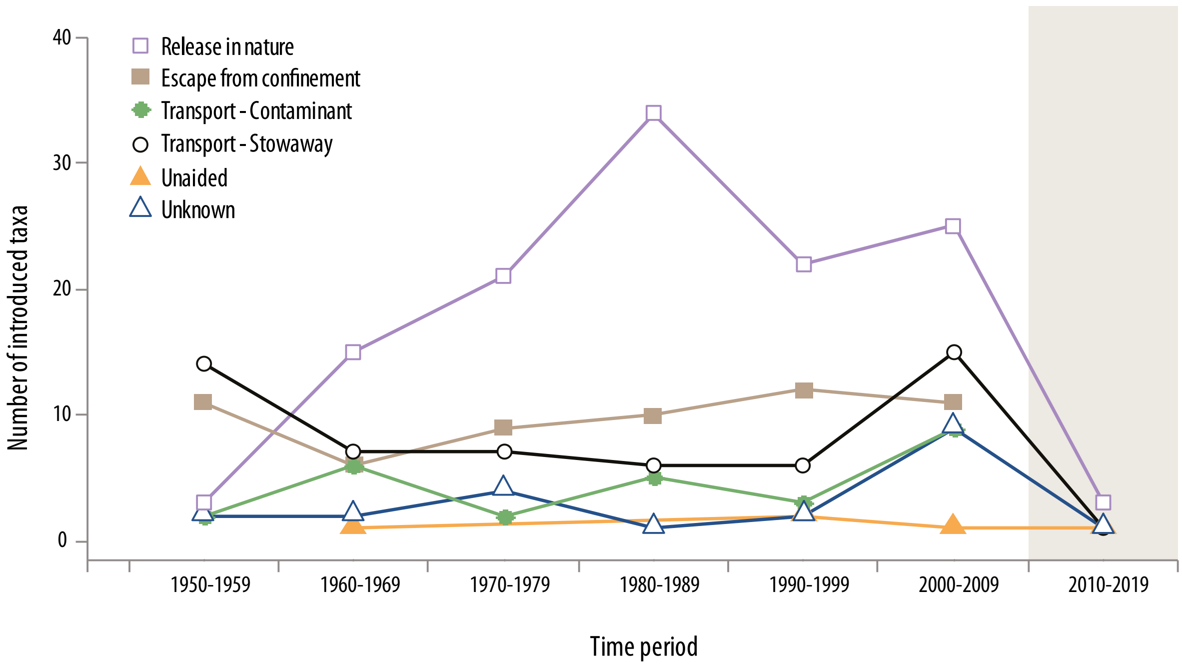


FIGURE A2.3 The number of taxa introduced to South Africa through the pathways of introduction (following the categories adopted by the Convention on Biological Diversity) during each decade since the 1950s. Data for 2010 to 2019 were incomplete and are shaded in grey.

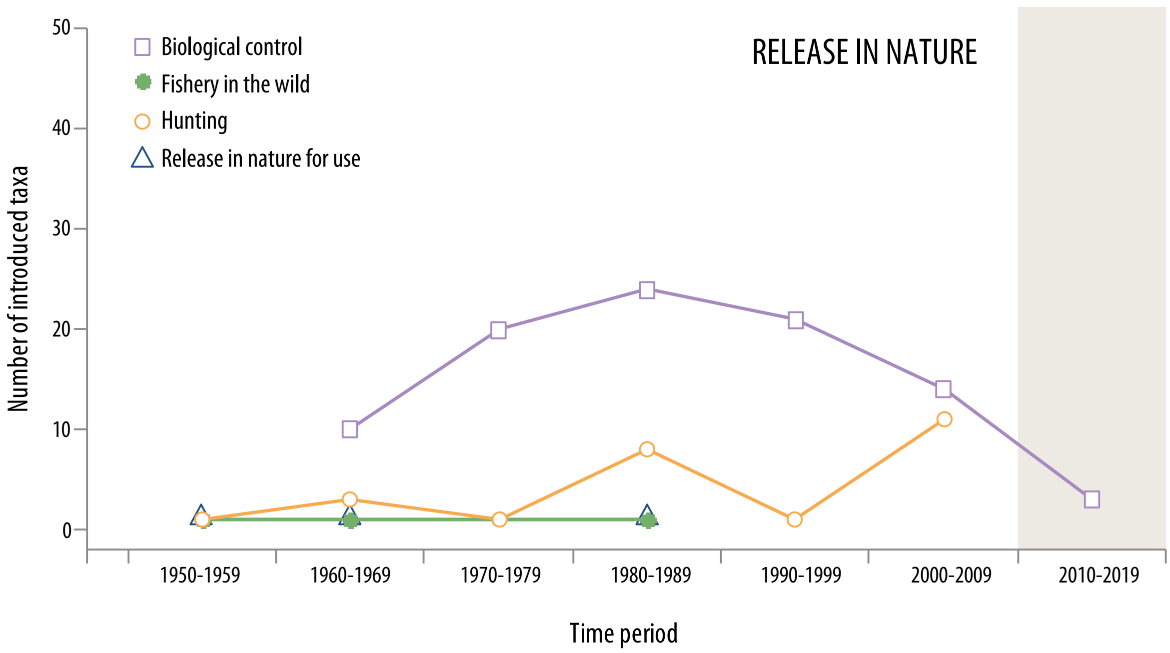


FIGURE A2.4 The number of taxa released intentionally into South Africa during each decade since the 1950s and the purpose for which they were introduced. Data for 2010 to 2019 were incomplete and are shaded in grey.

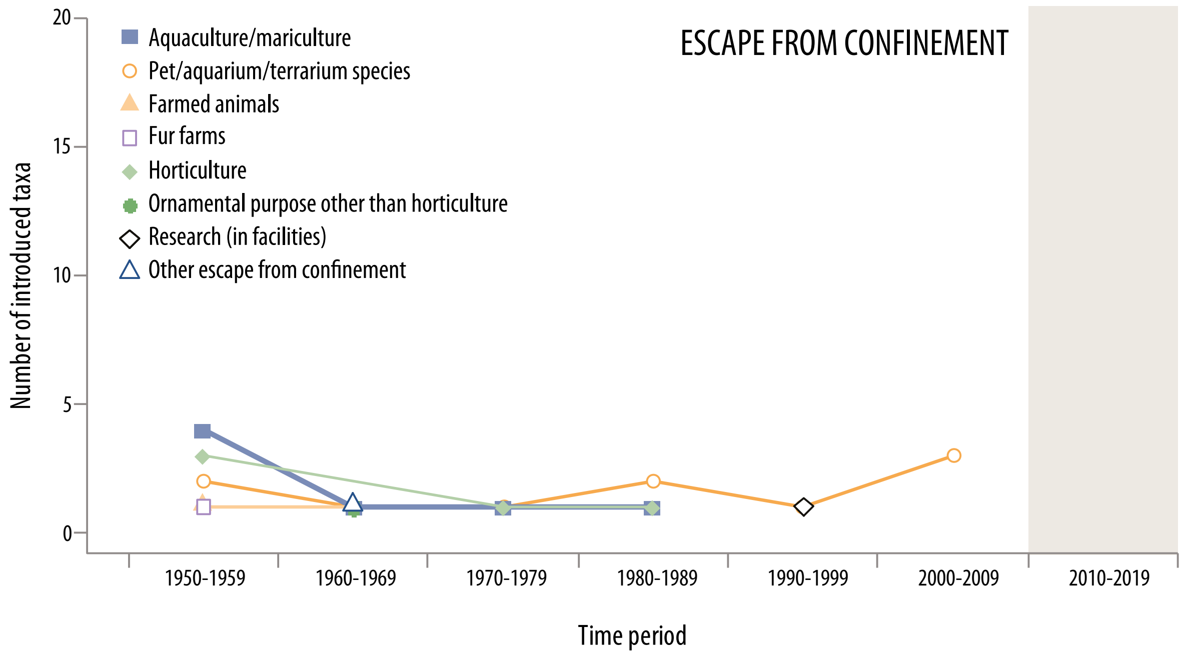


FIGURE A2.5 The number of taxa that have escaped from confinement in South Africa during each decade since the 1950s and the purpose for which they were introduced. Data for 2010 to 2019 were incomplete and are shaded in grey.

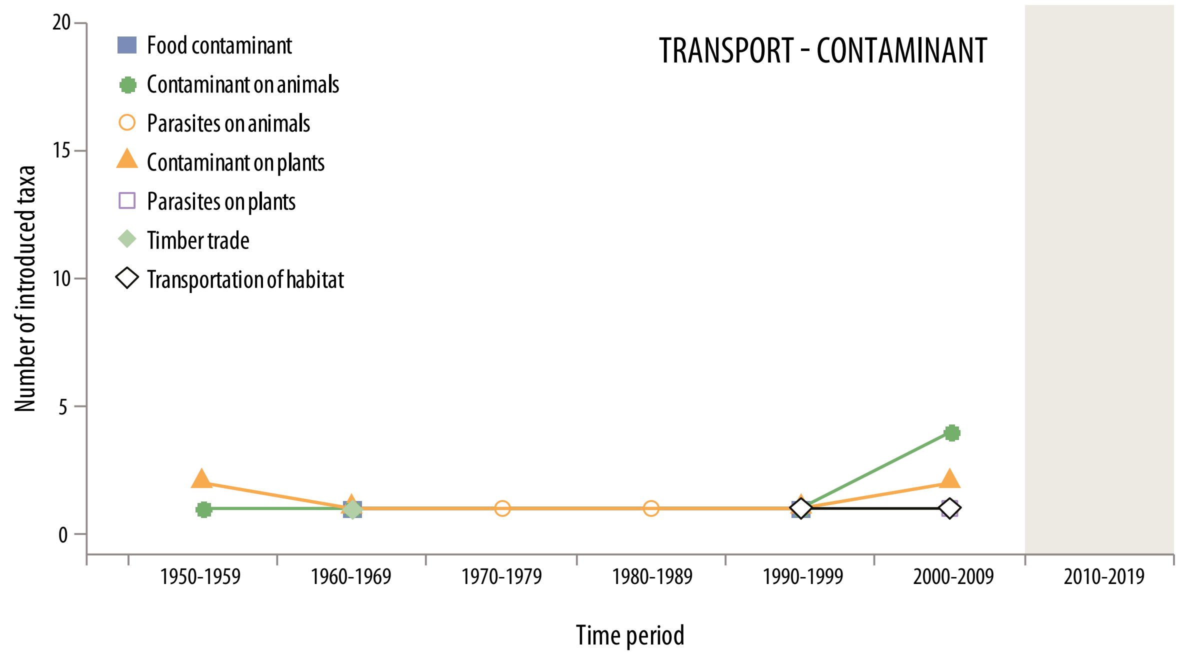


FIGURE A2.6 The number of taxa that have been introduced to South Africa as commodity contaminants during each decade since the 1950s and the contaminated commodity. Data for 2010 to 2019 were incomplete and are shaded in grey.

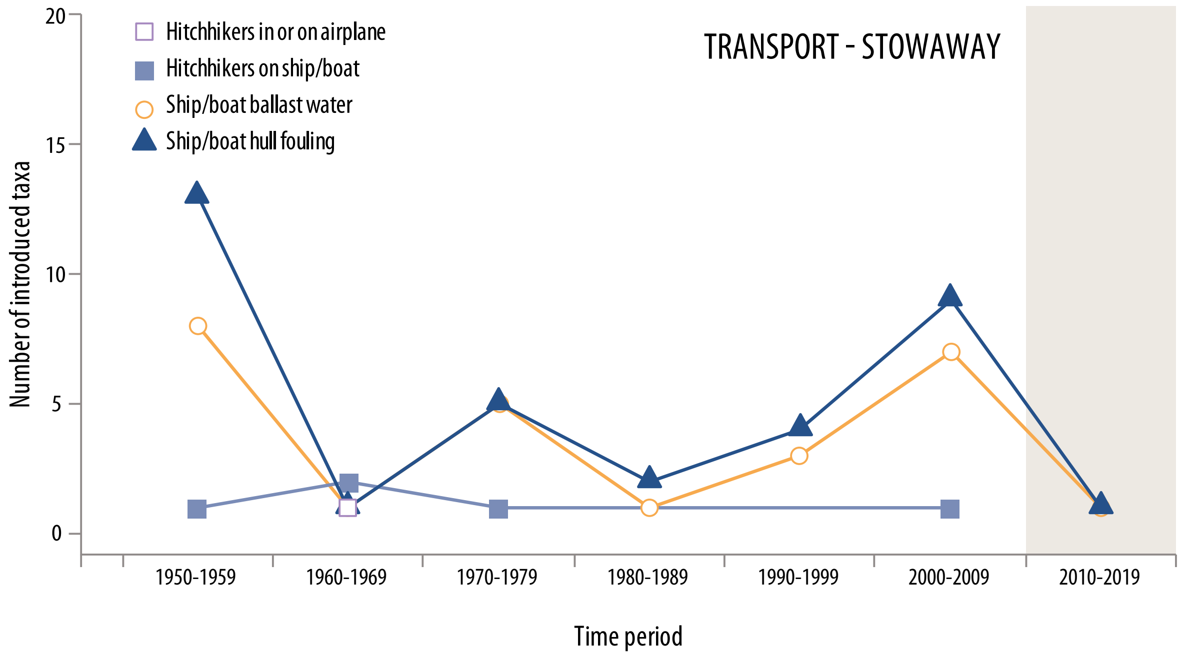


FIGURE A2.7 The number of taxa that have been introduced to South Africa as stowaways during each decade since the 1950s and the transport vector concerned. Data for 2010 to 2019 were incomplete and are shaded in grey.

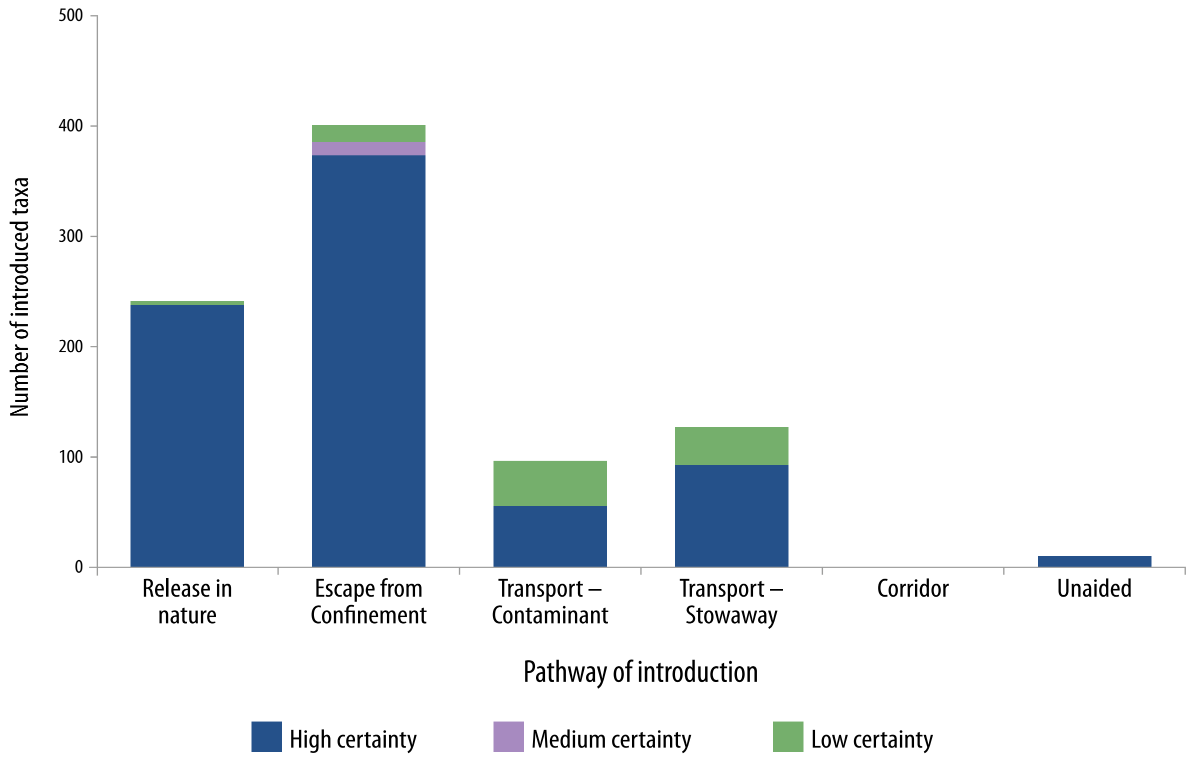


FIGURE A2.8 The number of alien taxa introduced to South Africa through the pathways of introduction (following the categories adopted by the Convention on Biological Diversity), and certainty in each categorisation.

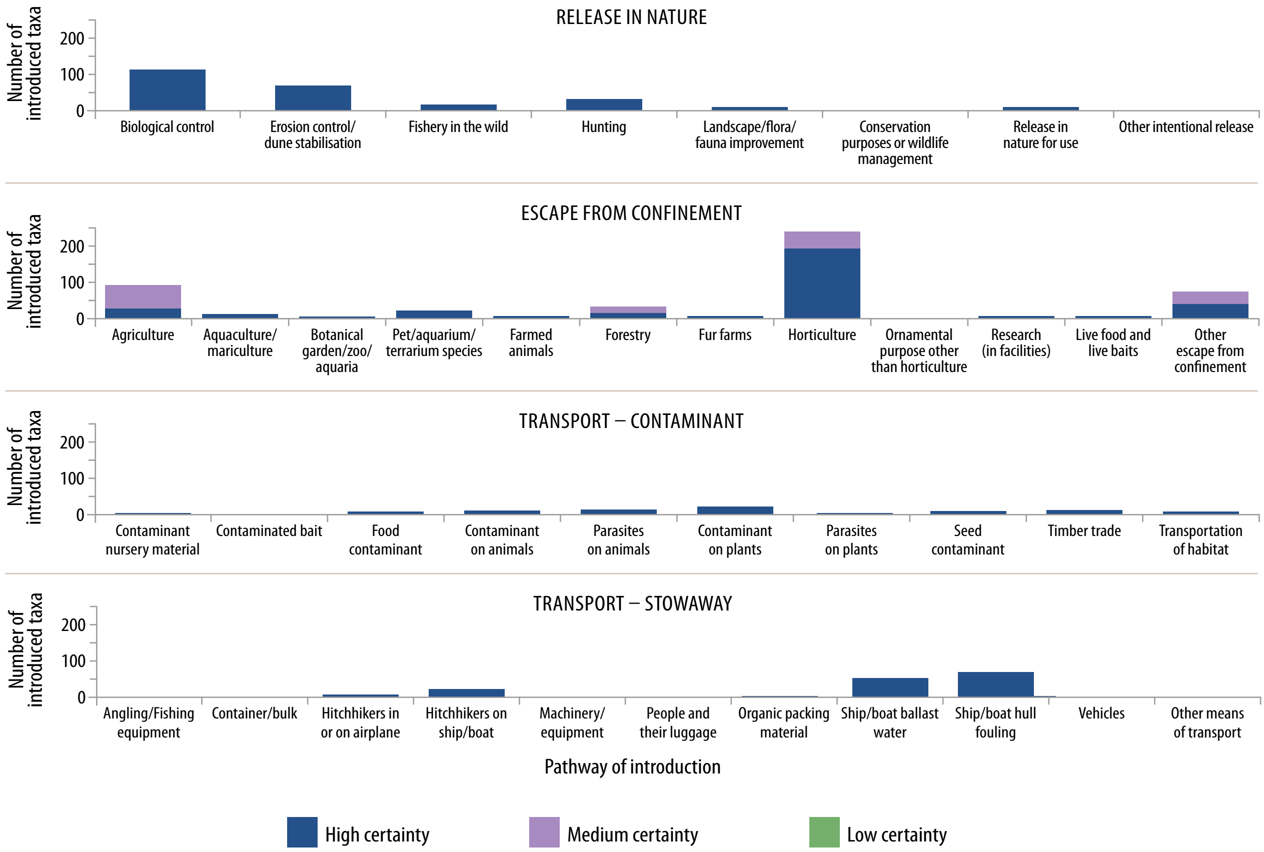


FIGURE A2.9 Number of alien taxa introduced to South Africa through the pathways of introduction (following the categories and subcategories adopted by the Convention on Biological Diversity), and our certainty in the categorisations. Results for the unaided pathway are not shown.

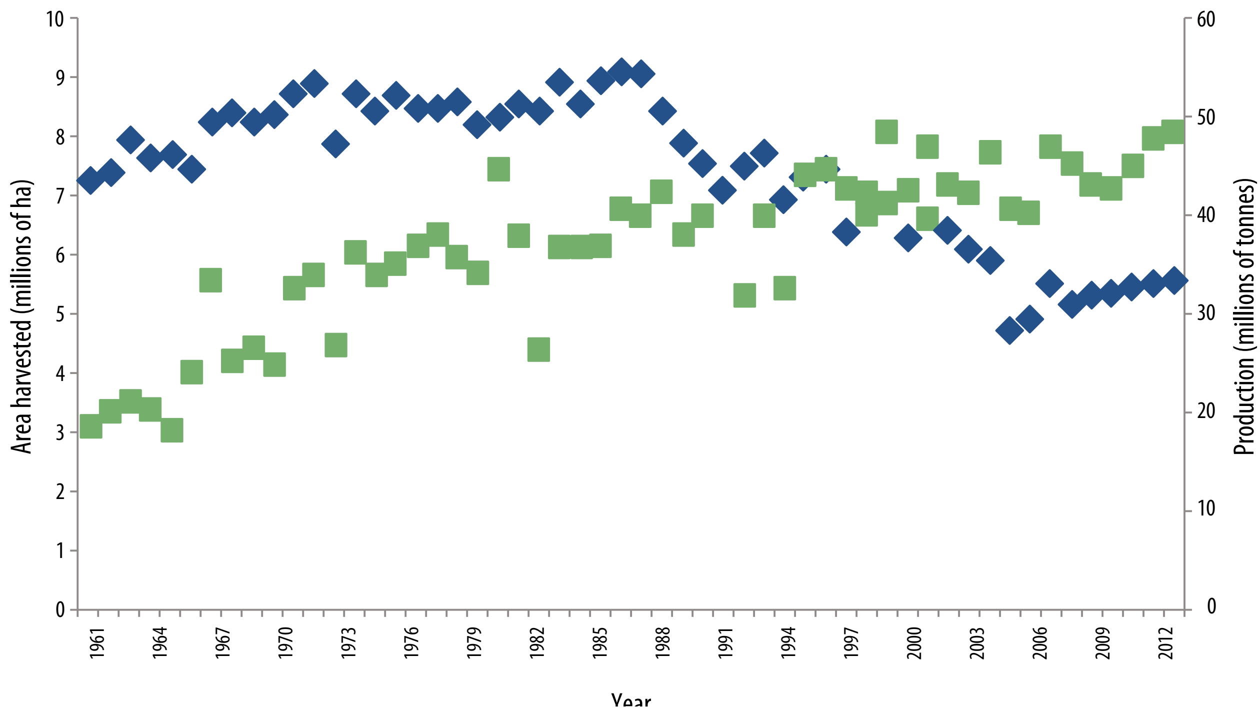


FIGURE A2.10 While the area harvested for crops (in blue) has declined since the early 1990s, crop production (in green) has increased. Data were obtained from the Food and Agricultural Organisation of the United Nations (FAO, 2017).

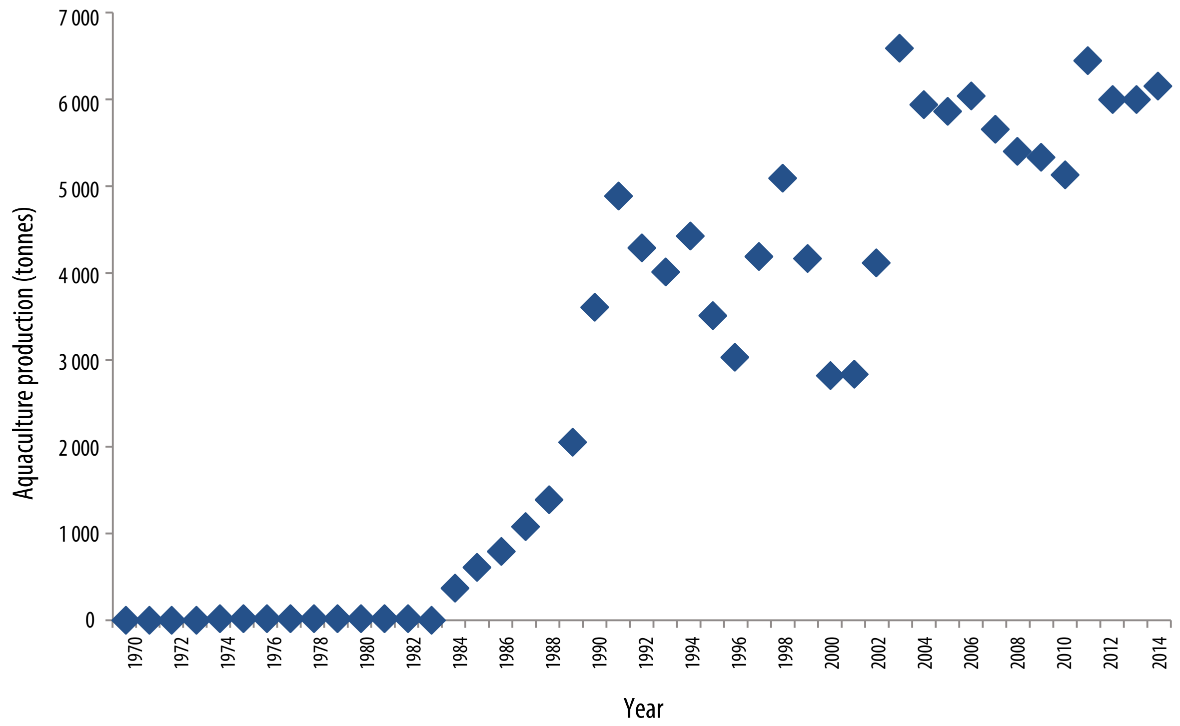


FIGURE A2.11 Aquaculture production in South Africa has increased since the 1990s. Data were obtained from the FishstatJ database of the Food and Agricultural Organisation of the United Nations (FAO, 2016a).

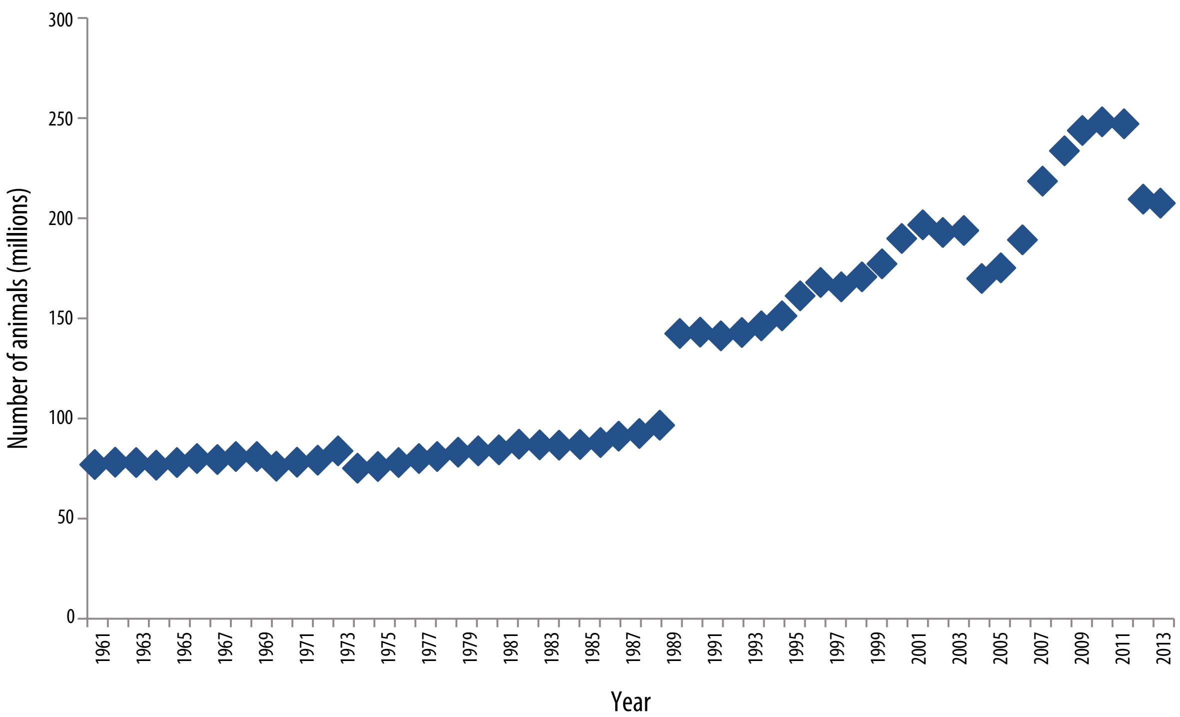


FIGURE A2.12 The number of animals farmed in South Africa has declined recently, but in general has increased over time. Data were obtained from the Food and Agricultural Organisation of the United Nations (FAO, 2017).

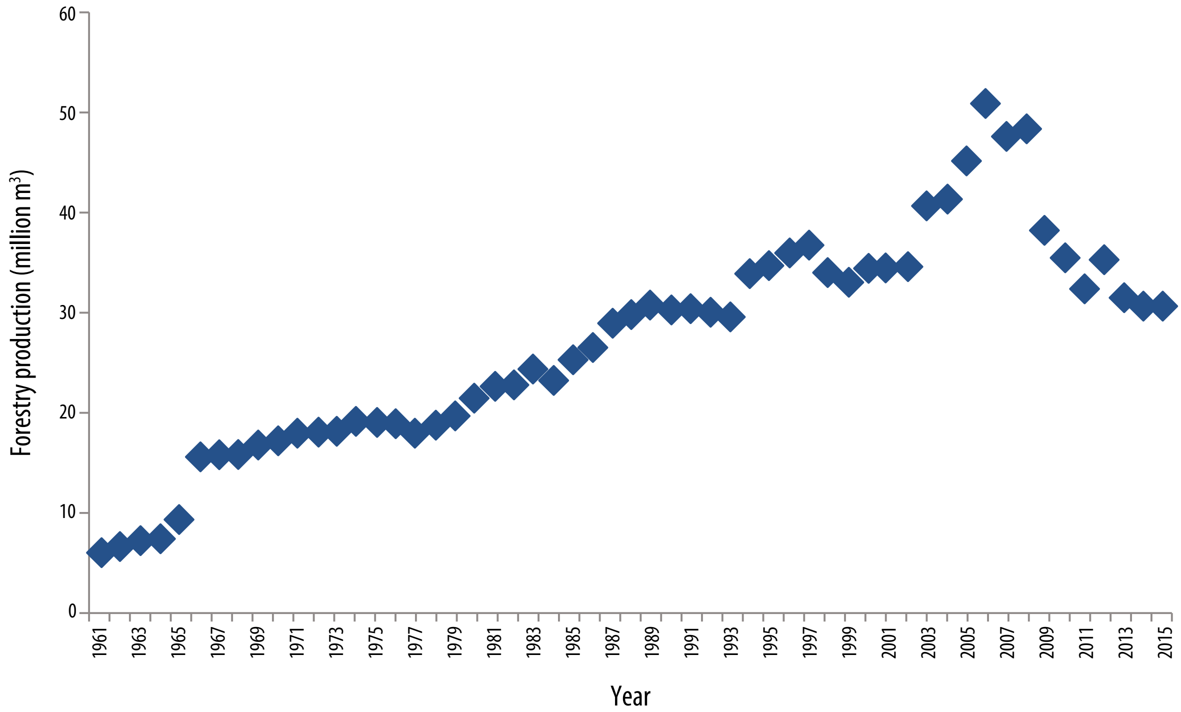


FIGURE A2.13 Forestry production in South Africa has declined since the mid-2000s. Data were obtained from the Food and Agricultural Organisation of the United Nations (FAO, 2017).

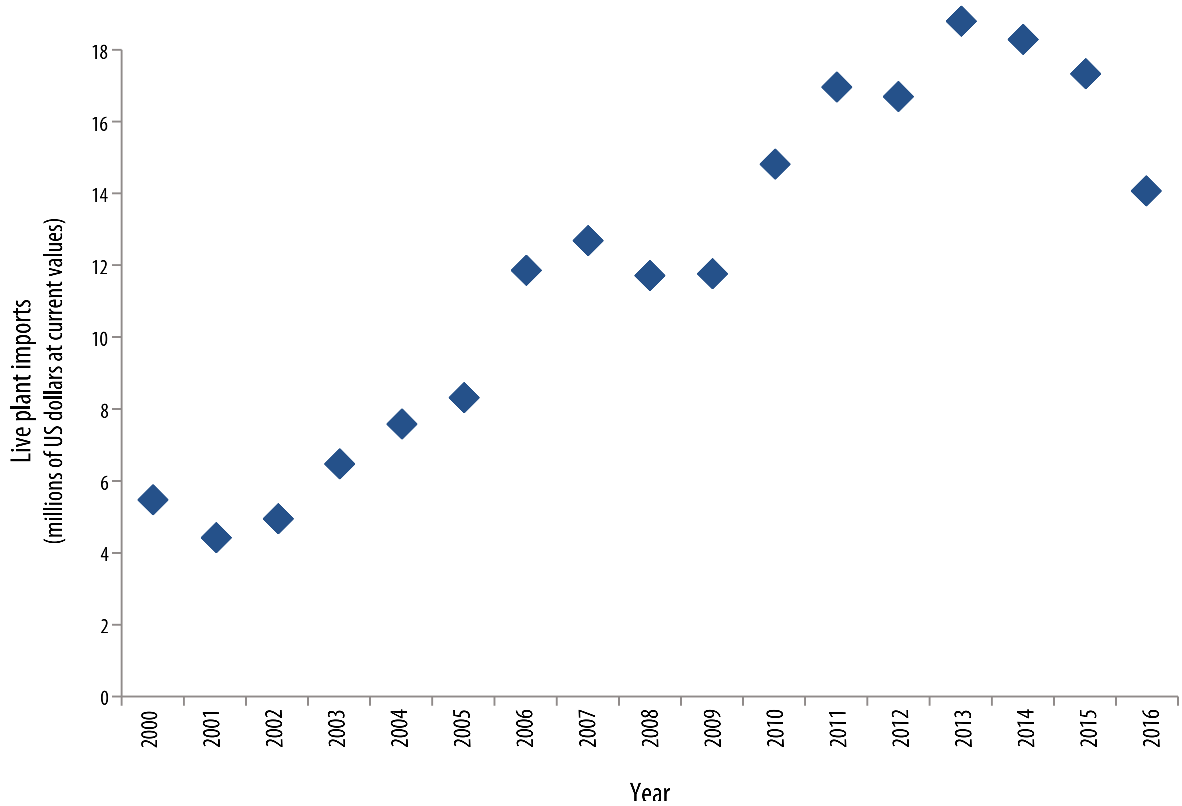


FIGURE A2.14 The value of live plant imports to South Africa has increased since 2000. Data were obtained from the United Nations Comtrade database (UN-Comtrade, 2017).

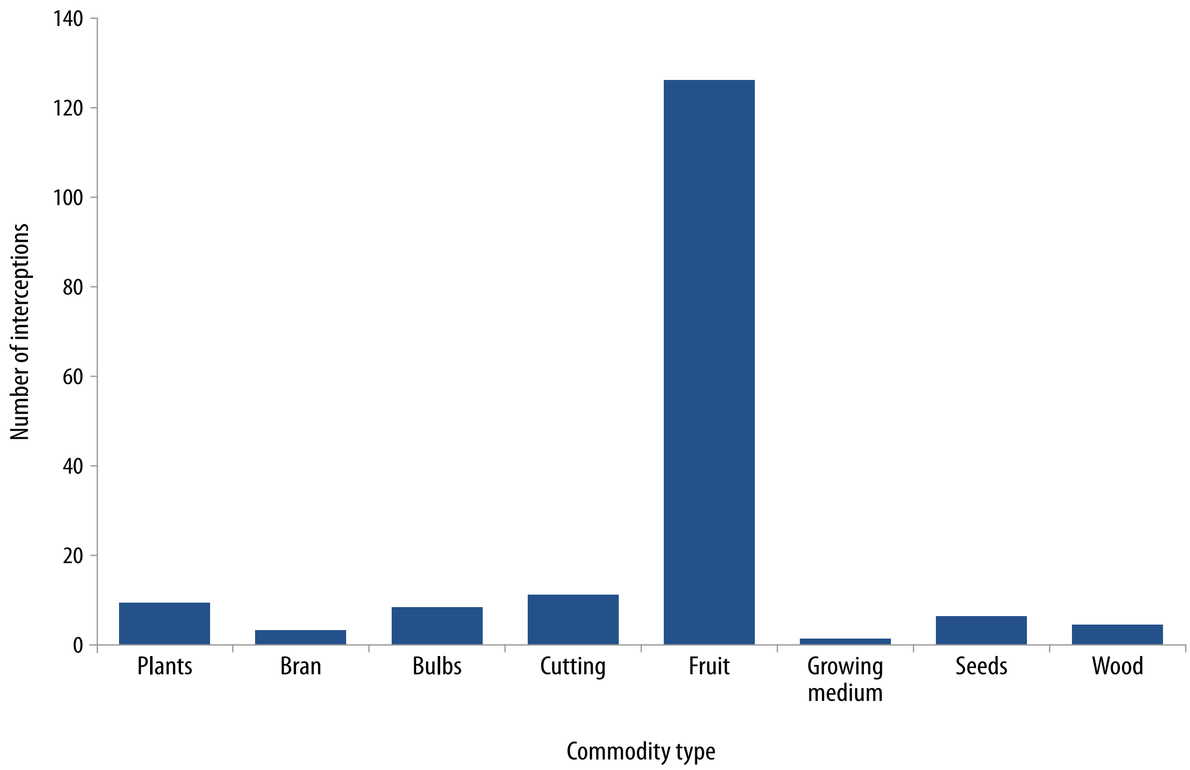


FIGURE A2.15 The number of interceptions made on various types of commodities during inspections at South African ports of entry undertaken from January 2013 to January 2014. Data were obtained from the Department of Agriculture, Forestry and Fisheries (2017).

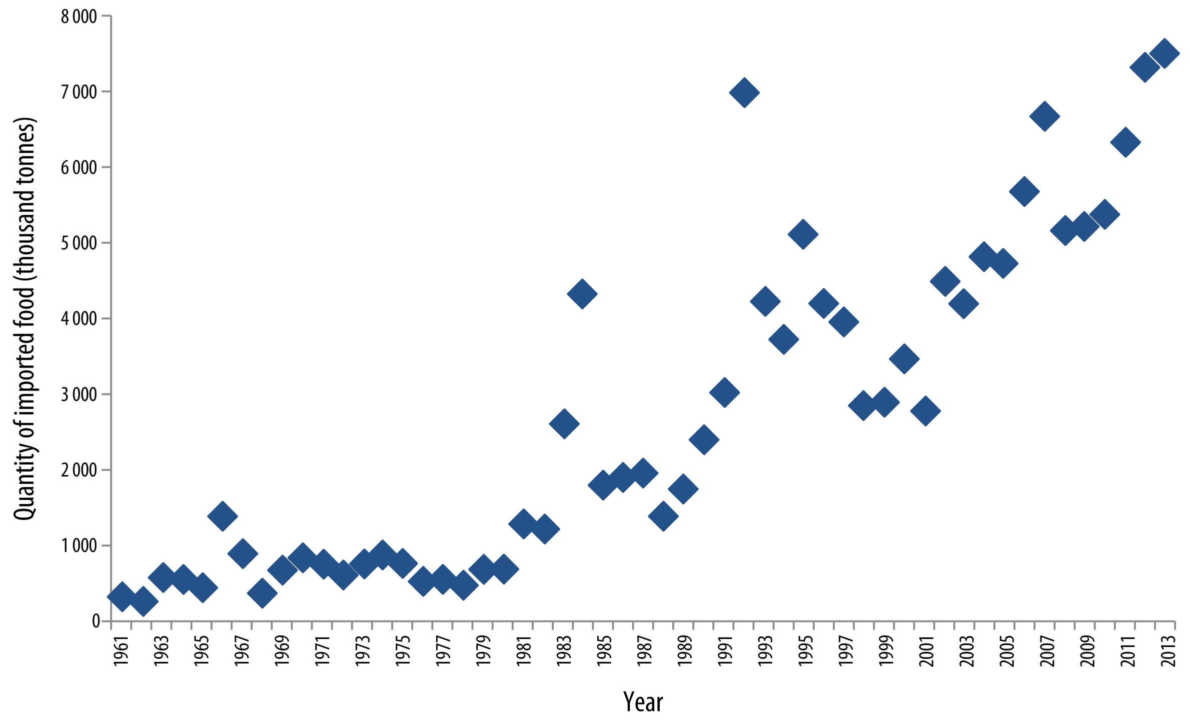


FIGURE A2.16 The quantity of food imported into South Africa has increased, particularly since 2000. Data were obtained from the Food and Agricultural Organisation of the United Nations (FAO, 2017).

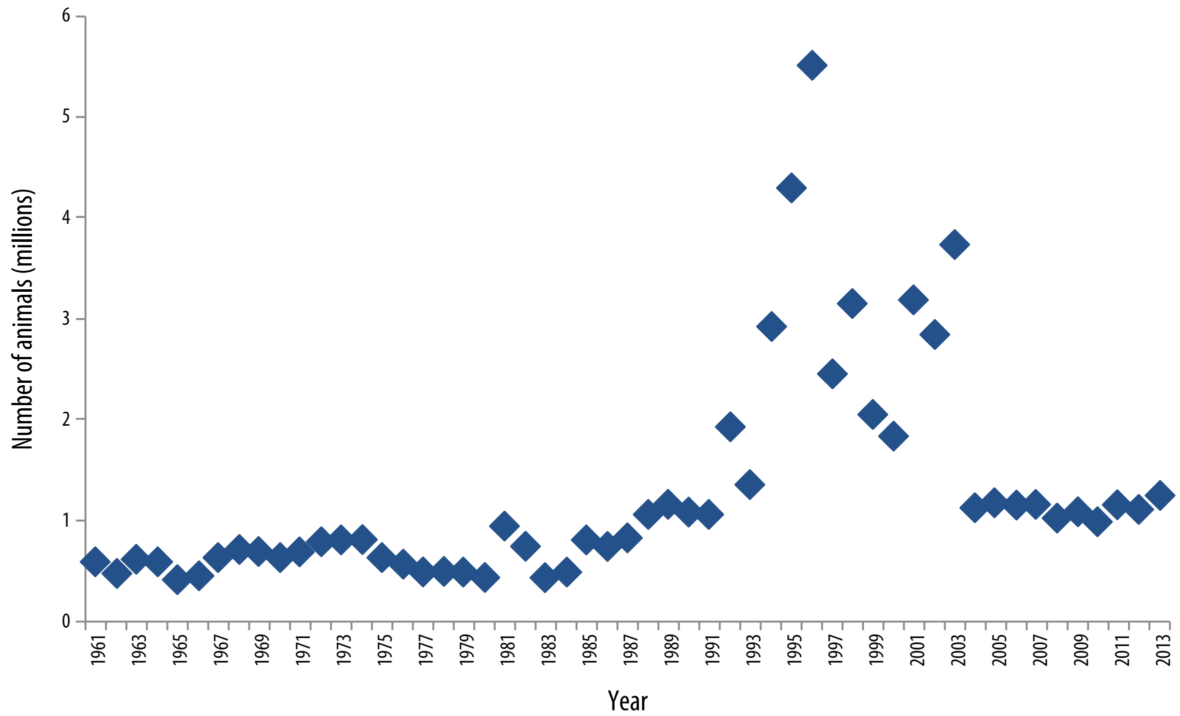


FIGURE A2.17 The number of animals imported into South Africa has fluctuated over time. Data were obtained from the Food and Agricultural Organisation of the United Nations (FAO, 2017).

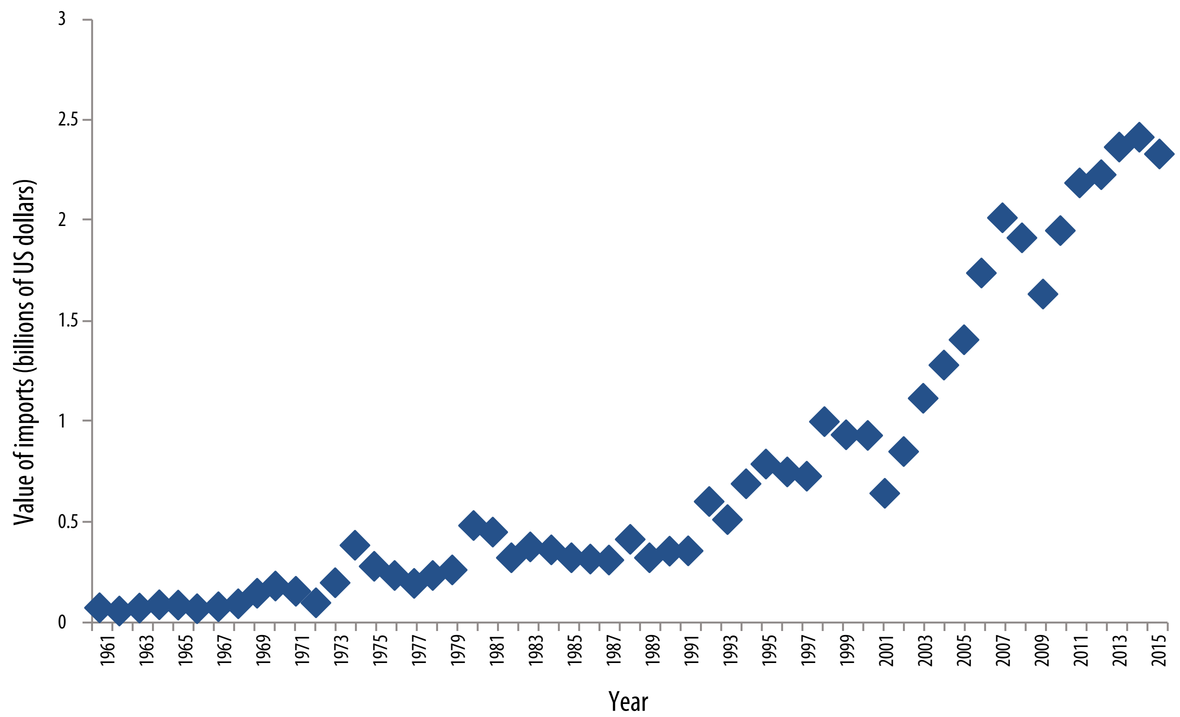


FIGURE A2.18 The value of forestry products imported into South Africa has increased since the 1990s. Data were obtained from the Food and Agricultural Organisation of the United Nations (FAO, 2017).

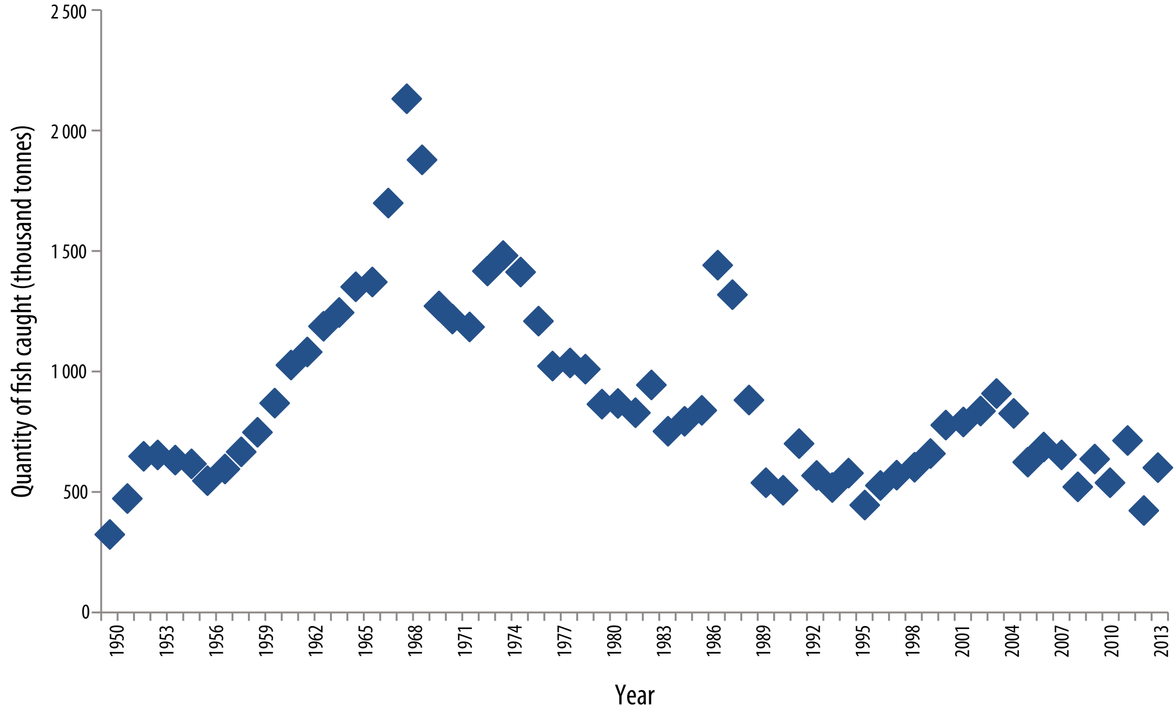


FIGURE A2.19 The quantity of fish caught in South Africa has declined over time. Data were obtained from the FishstatJ database of the Food and Agricultural Organisation of the United Nations (FAO, 2016a).

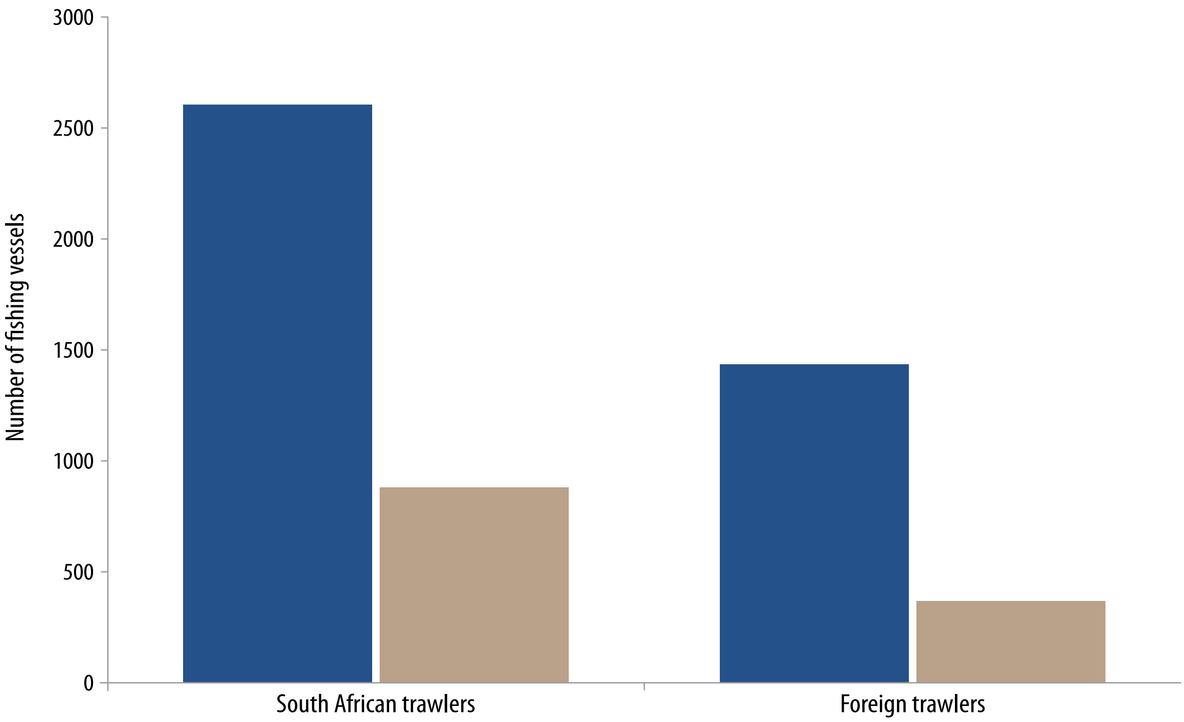


FIGURE A2.20 The number of foreign and South African fishing vessels visiting South African ports declined between 2006 (in blue) and 2016 (in grey). These data were obtained from the Transnet National Ports Authority (2017).

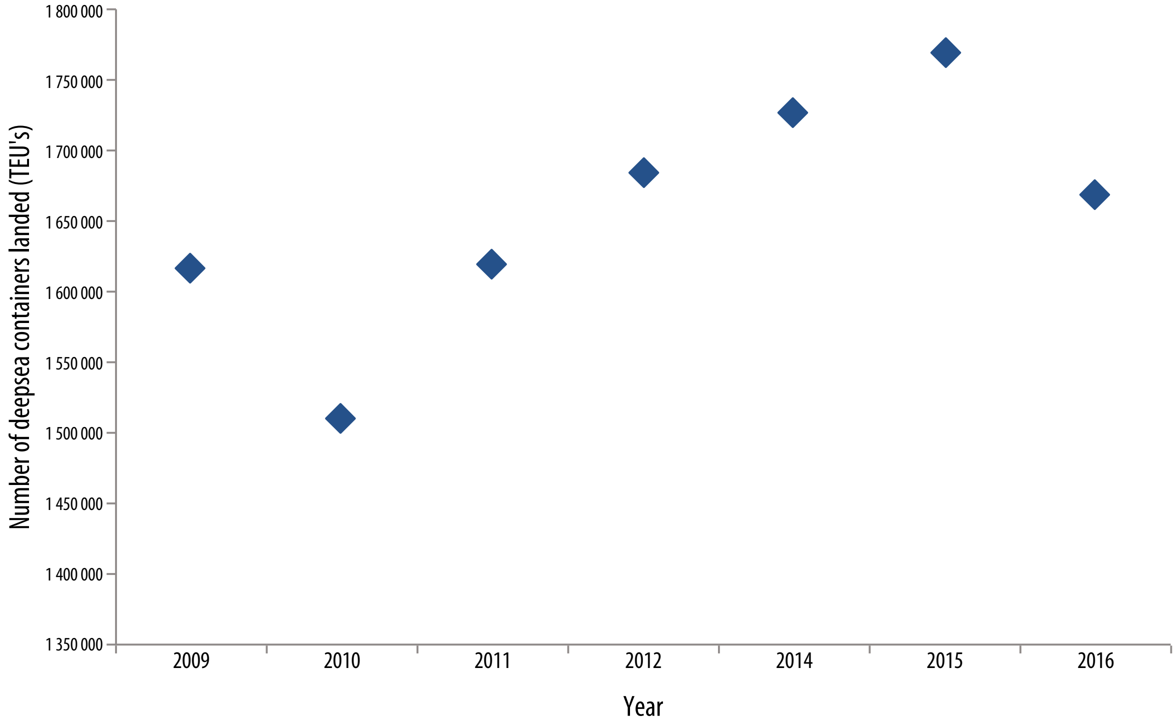


FIGURE A2.21 The number of deep sea containers landed at South African ports increased since 2009, but declined in 2016. These data were obtained from the Transnet National Ports Authority (2017).

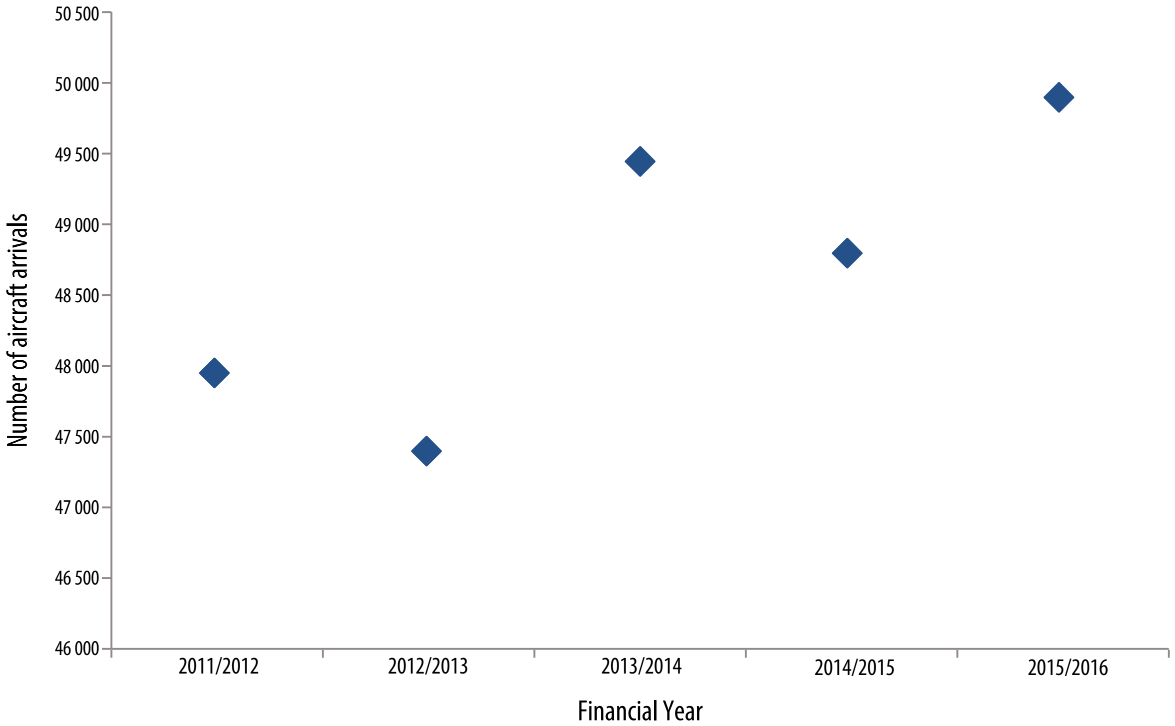


FIGURE A2.22 The number of scheduled aircraft arriving in South Africa from international and regional destinations has increased over the last few years. These data were obtained from Airports Company South Africa (2017).

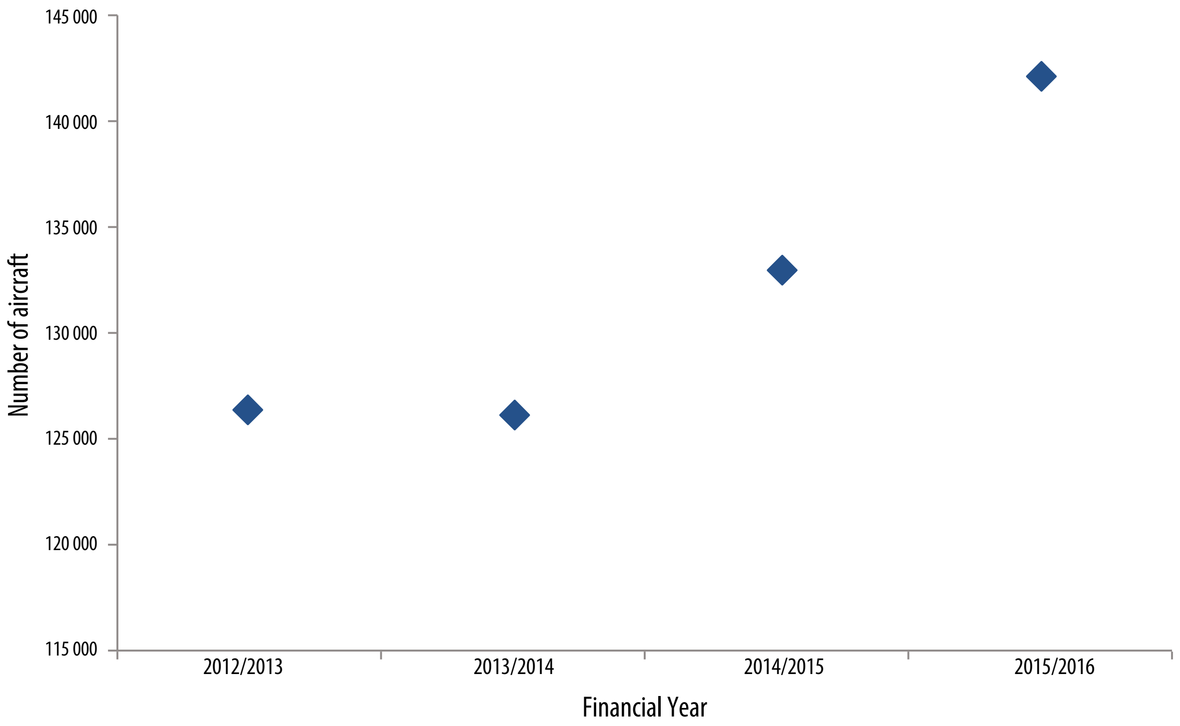


FIGURE A2.23 The total number of scheduled aircraft arriving at South African airports from domestic destinations has increased since the 2012/2013 financial year. These data were obtained from Airports Company South Africa (2017).

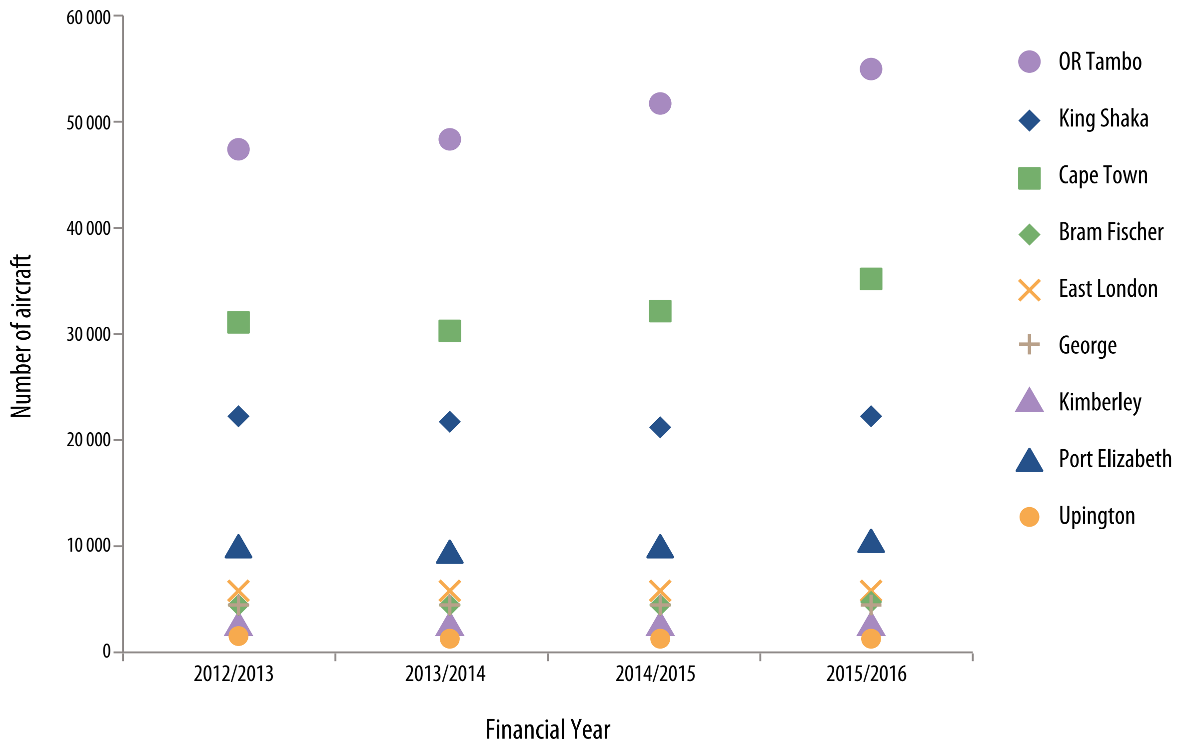


FIGURE A2.24 The number of scheduled aircraft arriving at each major South African airport from domestic destinations. These data were obtained from Airports Company South Africa (2017).

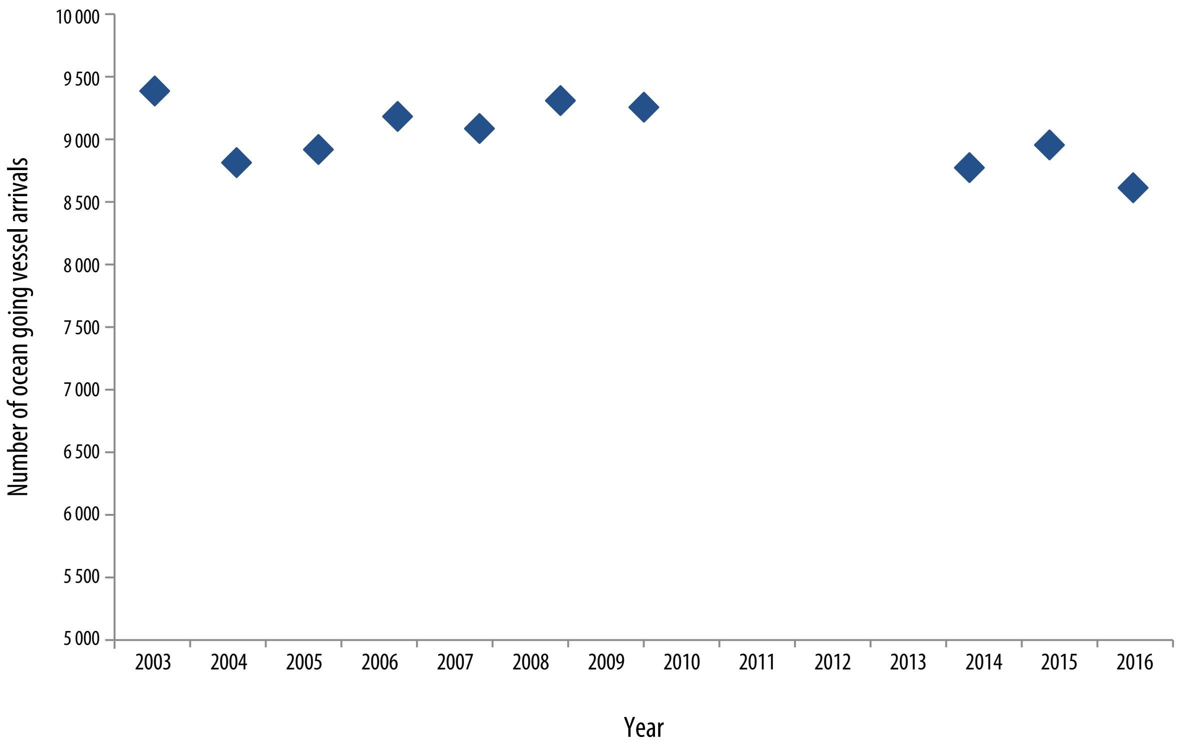


FIGURE A2.25 The number of ocean going vessels arriving at South African ports has fluctuated slightly over time. Data for 2010–2012 were not obtained. These data were obtained from Transnet National Ports Authority (2017).

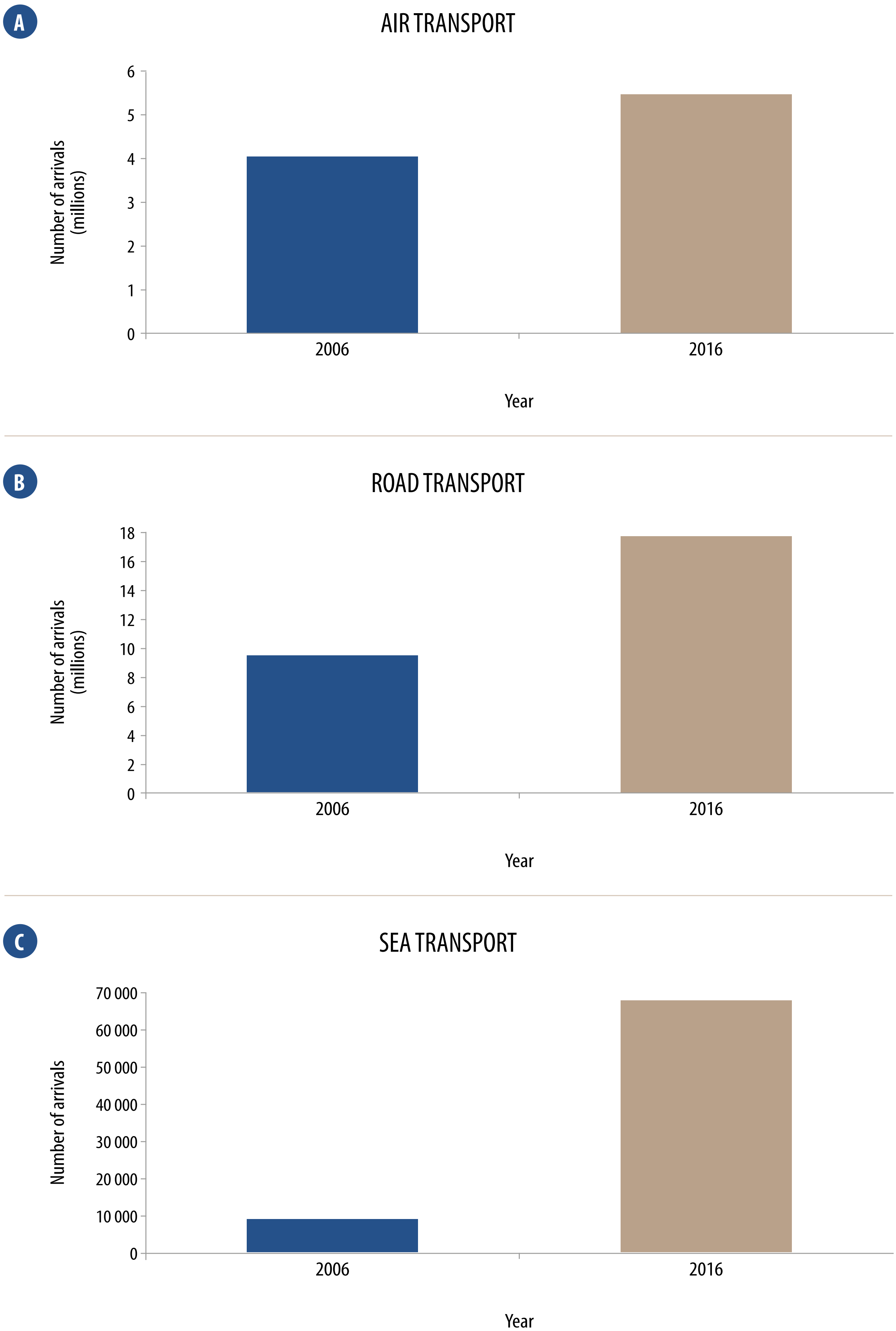


FIGURE A2.26 The number of people arriving in South Africa by (A) air, (B) road and (C) sea transport in 2006 and 2016. Data were obtained from Statistics South Africa (2017).

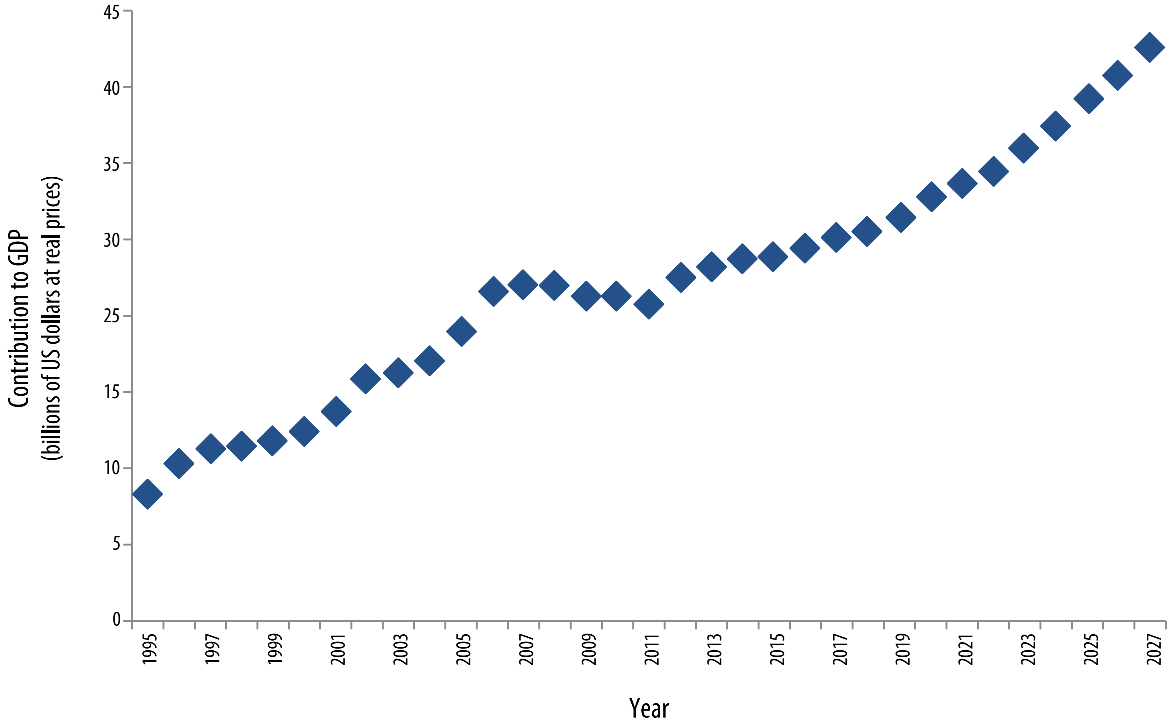


FIGURE A2.27 The contribution of travel and tourism to South Africa's Gross Domestic Product has increased over time. Data were obtained from the World Tourism and Travel Council (2017).

FIGURE A2.28 The number of passengers arriving at South African airports from domestic destinations. These data were obtained from Airports Company South Africa (2017).

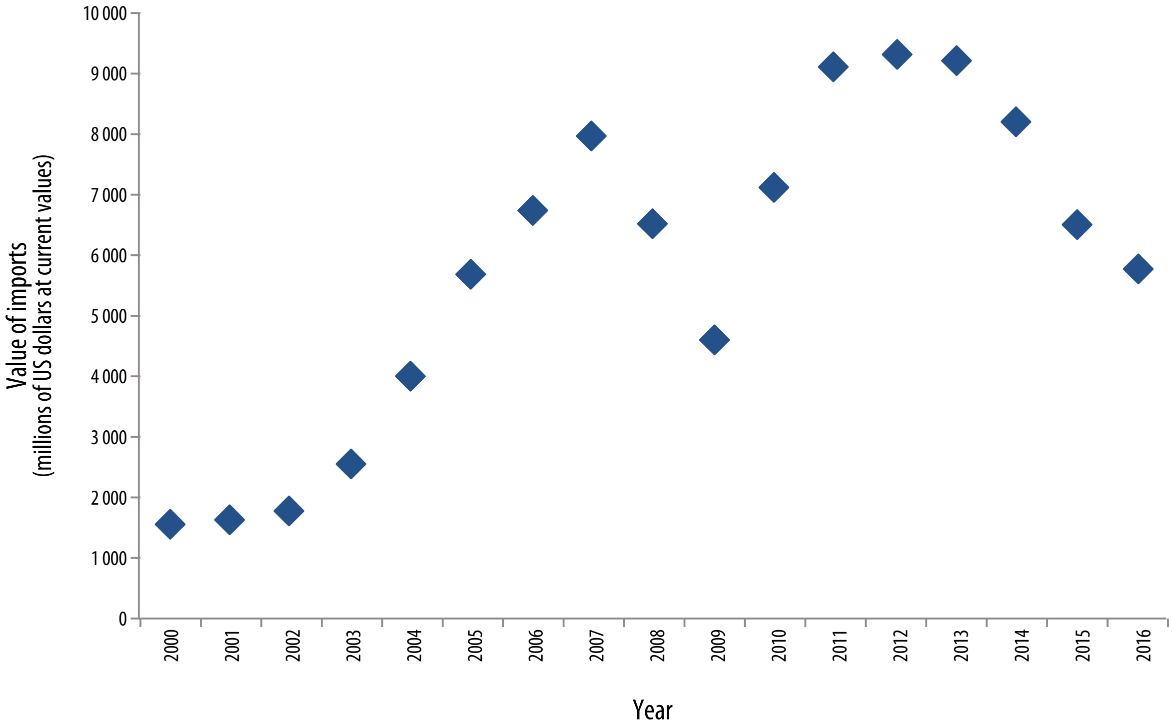
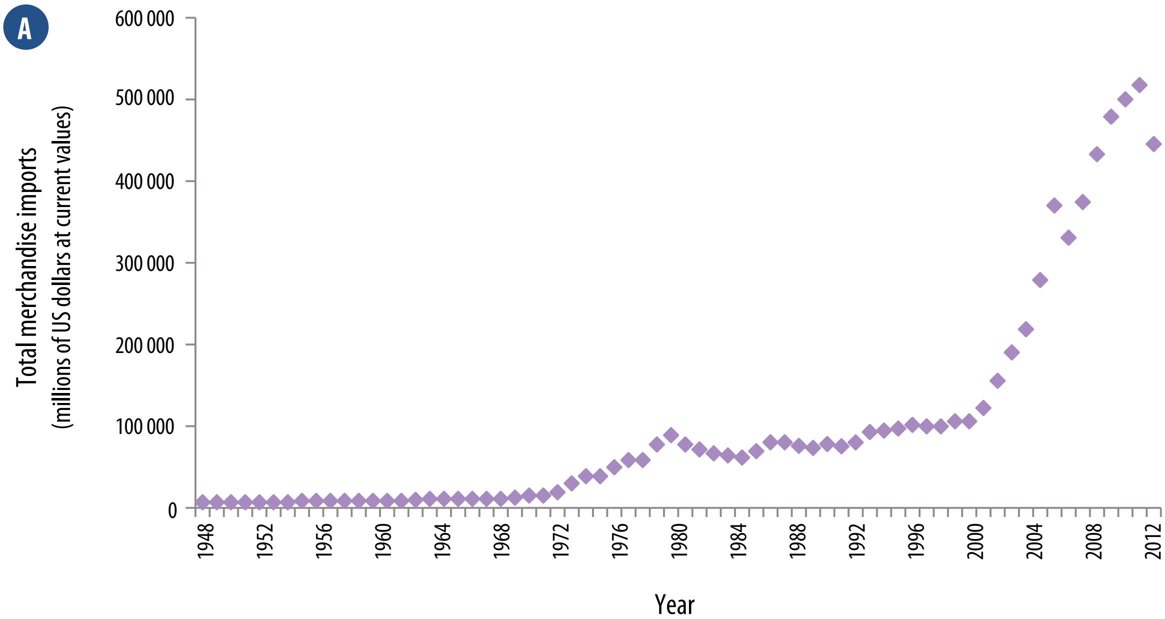


FIGURE A2.29 Besides recent declines, the value of vehicles imported into South Africa has increased over time. Data were obtained from the United Nations Comtrade database (UN-Comtrade, 2017).



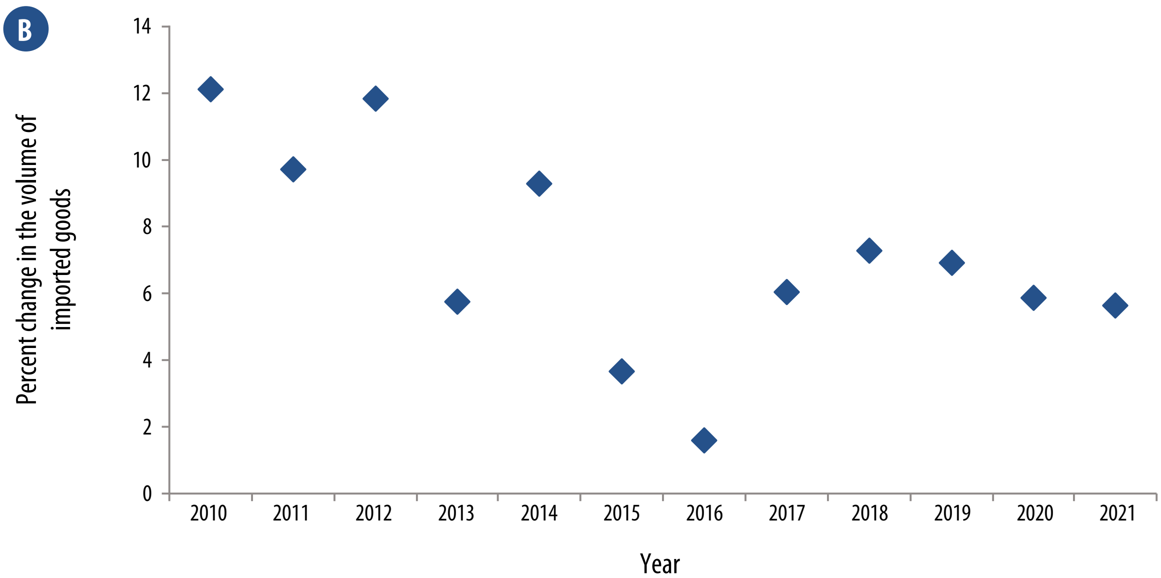


FIGURE A2.30 (A) The value of merchandise imports to mainland African countries has increased over time, and (B) the volume of goods imported into this region is expected to increase in the future. South African imports were not included. Data were obtained from the World Trade Organisation (2017) and International Monetary Fund (2016).

APPENDIX 3
ALIEN SPECIES IN SOUTH AFRICA

This appendix provides three species lists:

1. A list of alien species reported as present outside of captivity or cultivation in South Africa;
2. A list of species that are prohibited in terms of the Alien and Invasive Species (A&IS) Regulations under the National Environmental Management: Biodiversity Act (excluding species listed as prohibited, but that have established a presence in South Africa such that they are included in the first list); and
3. A list of species that are neither present, nor prohibited, but for which an assessment of risk in terms of potential invasiveness has been completed.

The first list identifies 2 034 alien species reported as present outside of captivity or cultivation in South Africa, or on offshore islands. The list includes all of the species listed as invasive in the 2014 A&IS Lists (as amended in 2016), supplemented with species reported in the literature, in databases, or supplied by contributing authors.

The species are ordered alphabetically by scientific species names, although in the regulations they are ordered by **high-level groupings**, these groupings (see below) are included in the lists for reference.

- Invert. (fw) – Freshwater invertebrates
- Invert. (marine) – Marine invertebrates
- Invert. (t) – Terrestrial invertebrates
- Microbe – Microbial species (note that all fungi are recorded as microbial species as spores are microbial)
- Plant (marine)
- Plant (t / fw) – Plants: Terrestrial and freshwater
- Vertebrates:
    - Amphibians
    - Birds
    - Fish (fw) – Freshwater fish
    - Fish (marine) – Marine fish (there are no alien marine fish recorded from South African waters, but there is one prohibited species)
    - Mammals
    - Reptiles

Authorities for scientific names are provided, and one common name is provided for each species. The common name used is in English, recognising that more than one English common name may exist, and that common names in other South African official languages also exist. Exceptions are made when a non-English common name is predominantly or exclusively used to describe a species (e.g. in the case of *Acacia cyclops*, the common name "rooikrans" is used in preference to the English "red eye").

The column on ***legal status*** refers to status in terms of the A&IS Regulations. The categories are:

- Category 1(a): Species that are targets for eradication.
- Category 1 (b): Species that must be controlled.
- Category 2: Species where cultivation, ownership and trade are allowed subject to the issuing of a permit, and that must be controlled in the absence of a permit.
- Category 3: Species that are subject to exemptions, but that cannot be further traded or propagated, and otherwise must be controlled.
- Context-specific: Species that are listed in different categories depending on the area or ecosystem in which they are found.
- Prohibited: Species that are assumed to not yet be in the country, and for which a permit may not be issued.
- Unlisted: Alien species that are not listed in the regulations, but that have been reported as present outside of captivity or cultivation in South Africa or on offshore islands.
- Species introduced as biological control agents are listed in the legal status column as "Unlisted (Biocontrol agent with permit)", as all biological control agents would have been released under a permit from the Department of Agriculture, Forestry and Fisheries.

Most entries in the column on ***introduction status*** are based on Blackburn *et al.* (2011)'s Unified Framework, with the following categories:

- **A0** – Never introduced beyond limits of indigenous range to South Africa
- **A1** – Has been introduced beyond limits of indigenous range to South Africa, but no longer present

- **B1** – Individuals transported beyond limits of indigenous range, and in captivity or quarantine (i.e. individuals provided with conditions suitable for them, but explicit measures of containment are in place)
- **B2** – Individuals transported beyond limits of indigenous range, and in cultivation (i.e. individuals provided with conditions suitable for them but explicit measures to prevent dispersal are limited at best)
- **B3** – Individuals transported beyond limits of indigenous range, and directly released into novel environment

- **C0** – Individuals released outside of captivity or cultivation in location where introduced, but incapable of surviving for a significant period
- **C1** – Individuals surviving outside of captivity or cultivation in location where introduced, no reproduction
- **C2** – Individuals surviving outside of captivity or cultivation in location where introduced, reproduction occurring, but population not self–sustaining
- **C3** – Individuals surviving outside of captivity or cultivation in location where introduced, reproduction occurring, and population self–sustaining

- **D1** – Self–sustaining population outside of captivity or cultivation, with individuals surviving a significant distance from the original point of introduction
- **D2** – Self–sustaining population outside of captivity or cultivation, with individuals surviving and reproducing a significant distance from the original point of introduction

- **E** – Fully invasive species, with individuals dispersing, surviving and reproducing at multiple sites across a greater or lesser spectrum of habitats and extent of occurrence

The introduction status categories used in the Unified Framework can be grouped into four high–level descriptors of introduction status and are shown in the table below. Chapter 4 provides a detailed description of how species were allocated to the different categories of introduction status. Species that could no be placed into a category due to a lack of information are classified as "data deficient" (DD). For species whose introduction status was not evaluated, the entry is "NE".

PRESENCE IN SOUTH AFRICA	HIGH–LEVEL INTRODUCTION STATUS	DETAILED INTRODUCTION STATUS ACCORDING TO THE UNIFIED FRAMEWORK OF BLACKBURN *ET AL.* (2011)
ABSENT	Not introduced, or eradicated	**A0** (taxa that have no record of introduction in RSA)
		A1 (expanded to include taxa which were historically present in RSA but there is moderate evidence that they are no longer present)
PRESENT	Introduced but not naturalised	**B1** (in captivity or quarantine)
		B2 (in cultivation but no measures in place to prevent escape)
		B3 (released outside of captivity or cultivation)
		C0 (some escape outside of captivity or cultivation, but survival limited)
		C1 (escape and survival outside of captivity or cultivation, but no reproduction)
		C2 (escape, survival, and reproduction outside of captivity or cultivation, not clear if population self–sustaining though)
	Naturalised but not invasive	**C3** (escape, survival, and reproduction outside of captivity or cultivation; population self–sustaining but not spreading)
	Invasive	**D1** (escape, survival, reproduction and spread outside of captivity or cultivation; though no evidence of reproduction post–dispersal)
		D2 (escape, survival, reproduction, spread, and subsequent reproduction outside of captivity or cultivation; though spread as yet limited to a few localities)
		E (escape, survival, reproduction, spread to and subsequent reproduction at multiple sites outside of captivity or cultivation)

The column on **distribution status** provides, where available, the number of quarter–degree grid-cells in which the species is found. In some cases, where distribution data were available at the scale of province, the province in which the species has been recorded is noted (WC = Western Cape; NC = Northern Cape; EC = Eastern Cape; FS = Free State; GP = Gauteng; NW = Northwest; MP = Mpumalanga; LP = Limpopo; KZN = KwaZulu–Natal). For marine species, distribution data were recorded on the basis of habitats (aquaculture facilities, harbours, estuaries, rocky intertidal, sandy intertidal, subtidal or coastal open waters), and where available localities (for example Cape Town harbour, or Knysna estuary) or regions (for example rocky shores, west coast, or sandy beaches, southern coast). For species where there is no information, the entry reads "NA" for not assessed. In addition, all species that are found only on offshore islands are listed as "Offshore islands".

The column on ***impact status*** is based loosely on Hawkins *et al*. (2015) framework and guidelines for implementing the proposed IUCN Environmental Impact Classification for Alien Taxa (EICAT). The following categories of impact are used in the EICAT scheme:

- Massive – A species is leading to the replacement and local extinction of indigenous species, and produces irreversible changes in the structure of communities and the abiotic or biotic composition of ecosystems.
- Major – The species causes the local or population extinction of at least one indigenous species, and leads to reversible changes in the structure of communities and the abiotic or biotic composition of ecosystems, and has no impacts that cause it to be classified in the "Massive" impact category.
- Moderate – The species causes declines in the population densities of indigenous species, but no changes to the structure of communities or to the abiotic or biotic composition of ecosystems, and has no impacts that would cause it to be classified in a higher impact category.
- Minor – The species causes reductions in the fitness of individuals in the indigenous biota, but no declines in indigenous population densities, and has no impacts that would cause it to be classified in a higher impact category.
- Minimal Concern – The species is unlikely to have caused deleterious impacts on the indigenous biota or abiotic environment. Species that have been evaluated but for which impacts have not been assessed in any study should rather be categorised as Data Deficient.
- Data Deficient – Species where there is either inadequate information to classify the species with respect to its impact, or insufficient time has elapsed since introduction for impacts to have become apparent.
- Not Evaluated – A species is "Not Evaluated" when it has not yet been evaluated against the criteria.

Because almost no alien species have been assessed using the EICAT scheme, this report used expert opinion to assign impact scores to listed species. See Chapter 4 for a description of the method used to assign species to impact status categories. The scheme used, and corresponding EICAT scores, are as follows:

SCHEME USED IN THIS REPORT	CORRESPONDING EICAT SCORE
Severe	Massive
Major	Major
Some	Moderate
Few	Minor
Negligible	Minimal Concern
DD	Data Deficient
NE	Not Evaluated

Whether or not a **risk assessment** for the species has been carried out is also noted.

Finally, the number of **permits granted** for possession of listed (category 2) species is provided, as well as the number of cases where a **permit** was **refused.** For organisms introduced for biological control, the entry in the column is "RP" to indicate the assumption that a release permit was obtained – this was not formally checked.

LIST 1 The status of individual alien species reported as present in natural ecosystems in South Africa. The notation t / fw indicates terrestrial and/or freshwater

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1	Plant (t / fw)	Abutilon grandifolium (Willd.) Sweet	Hairy Indian mallow	Unlisted	C2	4	NE	No	0	0
2	Plant (t / fw)	Acacia adunca A.Cunn. ex G.Don	Cascade wattle	1a	C3	1	NE	No	0	0
3	Plant (t / fw)	Acacia baileyana F.Muell.	Bailey's wattle	3	E	63	Some	No	0	0
4	Plant (t / fw)	Acacia cultriformis A.Cunn. ex G.Don	Knife-leaved wattle	Unlisted	C3	1	NE	No	0	0
5	Plant (t / fw)	Acacia cyclops A.Cunn. ex G.Don	Red eye, Rooikrans	1b	E	115	Severe	No	0	0
6	Plant (t / fw)	Acacia dealbata Link	Silver wattle	2	E	240	Severe	Yes	3	0
7	Plant (t / fw)	Acacia decurrens Willd.	Green wattle	2	E	105	Severe	No	0	0
8	Plant (t / fw)	Acacia elata A.Cunn. ex Benth.	Pepper tree wattle	1b	E	1	Some	No	0	0
9	Plant (t / fw)	Acacia fimbriata A.Cunn. ex G.Don	Fringed wattle	1a	D2	40	NE	No	0	0
10	Plant (t / fw)	Acacia implexa Benth.	Screw pod wattle	1a	E	1	NE	Yes	0	0
11	Plant (t / fw)	Acacia longifolia (Andrews) Willd.	Long-leaved wattle	1b	E	53	Severe	No	0	0
12	Plant (t / fw)	Acacia mearnsii De Wild.	Black wattle	2	E	369	Severe	Yes	6	0
13	Plant (t / fw)	Acacia melanoxylon R.Br.	Australian blackwood	2	E	124	Severe	No	5	0
14	Plant (t / fw)	Acacia paradoxa DC.	Kangaroo thorn	1a	D2	1	Some	No	0	0
15	Plant (t / fw)	Acacia podalyriifolia A.Cunn. ex G.Don	Pearl acacia	1b	E	60	Some	No	0	0
16	Plant (t / fw)	Acacia pycnantha Benth.	Golden wattle	1b	E	30	Some	No	0	0
17	Plant (t / fw)	Acacia retinodes Schltdl.	Swamp wattle	Unlisted	C3	NA	NE	No	0	0
18	Plant (t / fw)	Acacia saligna (Labill.) H.L.Wendl.	Port Jackson	1b	E	126	Severe	No	0	0
19	Plant (t / fw)	Acacia stricta (Andrews) Willd.	Hop wattle	1a	E	7	NE	Yes	0	0
20	Plant (t / fw)	Acacia viscidula Benth.	Sticky wattle	Unlisted	C3	1	NE	No	0	0
21	Reptile	Acanthophis antarcticus (Shaw & Nodder, 1802)	Common death adder	Unlisted	NA	NA	NE	No	0	0
22	Invert. (t)	Acanthoscelides macrophthalmus (Schaeffer)	Bean weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
23	Invert. (t)	Acanthoscelides obtectus (Say, 1831)	Bean weevil	Unlisted	NA	NA	NE	No	0	0
24	Plant (t / fw)	Acanthospermum australe (Loefl.) Kuntze	Eight-seeded prostrate starbur	Unlisted	C2	11	NE	No	0	0
25	Plant (t / fw)	Acanthospermum hispidum DC.	Upright starbur	Unlisted	E	10	NE	No	0	0
26	Plant (t / fw)	Acanthus mollis L.	Bear's-breeches	Unlisted	E	2	NE	No	0	0
27	Plant (t / fw)	Acanthus polystachius Delile var. pseudopubescens Cufod.	Spiny bear's breeches	Unlisted	E	3	NE	No	0	0
28	Invert. (t)	Acarapis woodi (Rennie, 1921)	Tracheal mite	1b	C3	NA	Negligible	No	0	0
29	Invert. (marine)	Acartia spinicauda Giesbrecht, 1889	No common name found	Unlisted	C2	Harbours Richards Bay, Durban	DD	No	0	0
30	Plant (t / fw)	Acer buergerianum Miq.	Chinese maple	Context specific	E	11	Negligible	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
31	Plant (t / fw)	Acer negundo L.	Ash-leaved maple	3	E	19	Negligible	No	0	0
32	Invert. (t)	Aceria aloinis Keifer	Aloe gall mite	Unlisted	NA	NA	NE	No	0	0
33	Invert. (t)	Aceria cynodoniensis Sayed, 1946	Grass rosette mite	Unlisted	NA	NA	NE	No	0	0
34	Invert. (t)	Aceria ficus (Cotte, 1920)	Fig bud mite	Unlisted	NA	NA	NE	No	0	0
35	Invert. (t)	Aceria lantanae (Cook, 1909)	Lantana gall mite	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
36	Invert. (t)	Aceria mangiferae Sayed, 1946	Mango bud mite	Unlisted	NA	NA	NE	No	0	0
37	Invert. (t)	Aceria oleae Nalepa, 1900	Olive bud mite	Unlisted	NA	NA	NE	No	0	0
38	Invert. (t)	Aceria sheldoni (Ewing, 1937)	Citrus bud mite	Unlisted	NA	NA	NE	No	0	0
39	Plant (t / fw)	Achillea millefolium L.	Milfoil	Unlisted	E	5	NE	No	0	0
40	Invert. (t)	Achroia grisella Fabricius, 1794	Lesser wax moth	Unlisted	NA	NA	NE	No	0	0
41	Plant (t / fw)	Achyranthes aspera L.	Burweed	Unlisted	E	76	NE	No	0	0
42	Plant (t / fw)	Acorus calamus L.	Calamus	Unlisted	E	4	NE	No	0	0
43	Reptile	Acrantophis dumerili Jan, 1860	Dumeril's boa	Unlisted	NA	NA	NE	No	0	0
44	Reptile	Acrantophis madagascariensis Duméril & Bibron, 1844	Madagascar ground boa	Unlisted	NA	NA	NE	No	0	0
45	Bird	Acridotheres cristatellus (Linnaeus, 1766)	Crested Mynah	2	NA	0	Negligible	Yes	0	0
46	Bird	Acridotheres fuscus Wagler, 1827	Jungle Mynah	2	NA	0	Some	Yes	2	0
47	Bird	Acridotheres tristis Linnaeus, 1766	Common Mynah	3	E	776	Some	No	0	0
48	Plant (t / fw)	Actinidia deliciosa (A.Chev.) C.F.Liang & A.R.Ferguson	Kiwifruit	Unlisted	C2	1	NE	No	0	0
49	Invert. (t)	Acyrthosiphon kondoi Shinji, 1938	Blue alfalfa aphid	Unlisted	NA	NA	NE	No	0	0
50	Invert. (t)	Acyrthosiphon pisum (Harris, M., 1776)	Pea aphid	Unlisted	NA	NA	NE	No	0	0
51	Mammal	Addax nasomaculatus (de Blainville,1816)	Addax	2	NA	NA	Negligible	Yes	1	0
52	Plant (t / fw)	Adiantum raddianum Presl	Maidenhair fern	Unlisted	C2	1	NE	No	0	0
53	Invert. (fw)	Aedes aegypti (Linnaeus, 1762)	Yellow fever mosquito	Unlisted	E	10	Negligible	No	0	0
54	Invert. (fw)	Aedes albopictus (Skuse, 1894)	Asian tiger mosquito	1b	E	10	Negligible	No	0	0
55	Invert. (t)	Aegopinella nitidula (Draparnaud, 1805)	Pea aphid	Unlisted	Introduced	1	Negligible	No	0	0
56	Mammal	Aepyceros melampus petersi Bocage, 1879	Black-faced impala	2	NA	NA	Negligible	Yes	1	0
57	Invert. (t)	Africoribates depilatus (Berlese, 1910)	No common name found	Unlisted	Introduced	WC	NE	No	0	0
58	Invert. (t)	Africoribates undulatus Balogh, 1959	Arachnids	Unlisted	Introduced	FS, EC, KZN	NE	No	0	0
59	Reptile	Agama agama (Linnaeus, 1758)	Common agama	Prohibited	B3	1	DD	No	0	0
60	Reptile	Agama planiceps Peters, 1862	Namib rock agama	Unlisted	B3	1	DD	No	0	0
61	Bird	Agapornis canus (Gmelin, 1788)	Madagascar lovebird	Unlisted	C2	5	NE	No	0	0
62	Plant (t / fw)	Agathis species (unidentified)	Kauri pine	Unlisted	C2	1	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
63	Plant (t / fw)	Agave americana L. var. americana	American agave	Unlisted	E	529	NE	No	0	0
64	Plant (t / fw)	Agave americana subsp. americana var. expansa (Jacobi) Gentry	Spreading century-plant	Context specific	E	16	Negligible	No	0	0
65	Plant (t / fw)	Agave sisalana Perrine	Sisal hemp, Sisal	2	E	101	Negligible	Yes	1	0
66	Plant (t / fw)	Agave vivipara L.	Century plant	Unlisted	E	11	NE	No	0	0
67	Plant (t / fw)	Ageratina adenophora (Spreng.) R.M.King & H.Rob.	Crofton weed	1b	E	29	Negligible	No	0	0
68	Plant (t / fw)	Ageratina riparia (Regel) R.M.King & H.Rob	Mistflower	1b	E	4	Negligible	No	0	0
69	Plant (t / fw)	Ageratum conyzoides (Mill.) M.Sharma	Invading ageratum	1b	E	42	Some	No	0	0
70	Plant (t / fw)	Ageratum houstonianum (Mill.) M.Sharma	Mexican ageratum	1b	E	57	Some	No	0	0
71	Reptile	Agkistrodon bilineatus Günther, 1863	Cantil	Unlisted	NA	NA	NE	No	0	0
72	Reptile	Agkistrodon contortrix (Linnaeus, 1766)	Copperhead	Unlisted	NA	NA	NE	No	0	0
73	Reptile	Agkistrodon piscivorus (Lacépède, 1789)	Water moccasin	Unlisted	NA	NA	NE	No	0	0
74	Plant (t / fw)	Agrimonia procera Wallr.	Scented agrimony	1b	E	32	Negligible	No	0	0
75	Plant (t / fw)	Agropyron cristatum (L.) Gaertn.	Crested wheatgrass	Unlisted	Introduced	NA	NE	No	0	0
76	Plant (t / fw)	Agropyron desertorum (Fisch. ex Link) Schult.	Desert crested wheatgrass	Unlisted	Introduced	NA	NE	No	0	0
77	Plant (t / fw)	Agropyron fragile (Roth) P. Candargy	Siberian crested wheatgrass	Unlisted	Introduced	NA	NE	No	0	0
78	Plant (t / fw)	Agropyron species (unidentified)	Wheatgrass	Unlisted	Introduced	NA	NE	No	0	0
79	Plant (t / fw)	Agrostis capillaris L.	Common bent grass	Unlisted	Introduced	NA	NE	No	0	0
80	Plant (t / fw)	Agrostis castellana Boiss. & Reut.	Bent grass	Context specific	NA	Offshore island	NE	No	0	0
81	Plant (t / fw)	Agrostis gigantea Roth	Black bent grass	Context specific	C3	Offshore island	Negligible	No	0	0
82	Plant (t / fw)	Agrostis species (unidentified)	Bent grass	Unlisted	Introduced	NA	NE	No	0	0
83	Plant (t / fw)	Agrostis stolonifera L.	Creeping bent grass	Context specific	E	Offshore island	Severe	No	0	0
84	Invert. (t)	Agrotis ipsilon Hufnagel	Black cutworm	Unlisted	D2	2	NE	No	0	0
85	Invert. (t)	Agrotis segetum Schiffermüller	Turnip Moth	Unlisted	E	4	NE	No	0	0
86	Invert. (t)	Ahasverus advena (Waltl, 1834)	Foreign grain beetle	Unlisted	NA	NA	NE	No	0	0
87	Plant (t / fw)	Ailanthus altissima (Mill.) Swingle	Tree-of-heaven	1b	E	58	Negligible	No	0	0
88	Bird	Aix galericulata (Linnaeus, 1758)	Mandarin duck	Unlisted	C2	5	NE	Yes	0	0
89	Bird	Aix sponsa (Linnaeus, 1758)	Wood Duck	Unlisted	C2	3	NE	Yes	0	0
90	Microbe	Albatrellus ovinus (Schaeff.) Kotl. & Pouzar, 1957	Forest lamb	Unlisted	Introduced	NA	NE	No	0	0
91	Plant (t / fw)	Albizia chinensis (Osbeck) Merr.	Chinese false-thorn	Unlisted	C2	1	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
92	Plant (t / fw)	Albizia lebbeck (L.) Benth.	Lebbeck tree	1b	E	7	Negligible	No	0	0
93	Plant (t / fw)	Albizia procera (Roxb.) Benth.	False lebbeck	1b	C2	1	NE	No	0	0
94	Bird	Alectoris chukar (J. E. Gray, 1830)	Chukar partridge	Context specific	C3	7	Negligible	Yes	2	0
95	Bird	Alectoris melanocephala	Arabian chukar	Unlisted	Introduced	1	NE	No	0	0
96	Invert. (t)	Aleurocanthus woglumi Ashby, 1915	Citrus blackfly	Unlisted	NA	NA	NE	No	0	0
97	Invert. (t)	Aleurothrixus floccosus (Maskell, 1896)	Woolly whitefly	Unlisted	NA	NA	NE	No	0	0
98	Plant (marine)	Alexandrium minutum Halim 1960	No common name found	Unlisted	C2	Open coast	DD	No	0	0
99	Plant (marine)	Alexandrium tamarense-complex	No common name found	Unlisted	C2	Harbour, Table Bay	DD	No	0	0
100	Invert. (t)	Algarobius prosopis (LeConte)	Prosopis seed beetle	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
101	Plant (t / fw)	Alhagi maurorum Medik.	Camel thorn bush	1b	E	2	Negligible	No	0	0
102	Plant (t / fw)	Alisma plantogo-aquatica L.	Mud plantain	1b	E	8	Some	No	0	0
103	Invert. (marine)	Alitta succinea Clark, 1875	Common Clamworm	Unlisted	E	Estuaries Mossel Bay to Durban	DD	No	0	0
104	Reptile	Alligator mississippiensis (Daudin, 1802)	American alligator	Unlisted	NA	NA	NE	No	0	0
105	Plant (t / fw)	Allium triquetrum L.	Angled onion	Unlisted	E	3	NE	No	0	0
106	Invert. (t)	Allolobophoridella eiseni (Levinsen, 1884)	No common name found	Unlisted	Introduced	WC, KZN, LP	NE	No	0	0
107	Invert. (t)	Allolobophoridella parva Eisen, 1874	No common name found	Unlisted	Introduced	EC, GP, KZN, WC	NE	No	0	0
108	Plant (t / fw)	Alnus glutinosa (L.) Gaertn.	Black elder	Unlisted	E	1	NE	No	0	0
109	Plant (t / fw)	Alocasia macrorrhizos (L.) G.Don	Giant taro	Unlisted	C2	1	NE	No	0	0
110	Plant (t / fw)	Alopecurus arundinaceus Poir.	Creeping foxtail	Unlisted	C2	1	NE	No	0	0
111	Plant (t / fw)	Alopecurus geniculatus L.	Marsh foxtail	Context specific	NA	NA	Some	No	0	0
112	Plant (t / fw)	Aloysia citrodora Palau	Lemon verbena	Unlisted	C2	1	NE	No	0	0
113	Plant (t / fw)	Aloysia gratissima (Gillies & Hook.) Tronc.	Common bee-brush	Unlisted	C2	1	NE	No	0	0
114	Invert. (t)	Alphitobius diaperinus (Panzer, 1797)	Lesser mealworm	Unlisted	NA	NA	NE	No	0	0
115	Plant (t / fw)	Alpinia zerumbet (Pers.) B.L.Burtt & R.M.Sm.	Shell ginger	3	E	10	Negligible	No	0	0
116	Plant (t / fw)	Alstroemeria pulchella L.f.	Parrot alstroemeria	Unlisted	E	2	NE	No	0	0
117	Plant (t / fw)	Alternanthera nodiflora R.Br.	Common joyweed	Unlisted	C2	4	NE	No	0	0
118	Plant (t / fw)	Alternanthera pungens Kunth	Khaki burweed	Unlisted	E	25	NE	No	0	0
119	Bird	Amandava amandava (Linnaeus, 1758)	Red Avadavat	Unlisted	C2	2	NE	No	0	0
120	Microbe	Amanita excelsa (Fr.) Bertill., 1866	No common name found	Unlisted	Introduced	NA	NE	No	0	0
121	Microbe	Amanita marmorata Cleland & E.-J. Gilbert, 1941	No common name found	Unlisted	Introduced	NA	NE	No	0	0
122	Microbe	Amanita muscaria (L.) Lam., 1783	Fly Agaric	Unlisted	Introduced	NA	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
123	Microbe	Amanita pantherina (DC.) Krombh., 1846	Panthercap	Unlisted	Introduced	NA	NE	No	0	0
124	Microbe	Amanita phalloides (Vaill. ex Fr.) Link, 1833	The Death Cap	Unlisted	Introduced	NA	NE	No	0	0
125	Microbe	Amanita rubescens Pers., 1797	The Blusher	Unlisted	Introduced	NA	NE	No	0	0
126	Microbe	Amanita spissa (Fr.) P. Kumm., 1871	Grey spotted amanita	Unlisted	Introduced	NA	NE	No	0	0
127	Plant (t / fw)	Amaranthus hybridus L.	Pigweed	Unlisted	E	24	NE	No	0	0
128	Bird	Amazona aestiva (Linnaeus, 1758)	Blue-fronted parrot	Unlisted	C2	16	NE	No	0	0
129	Invert. (t)	Ambigolimax valentianus (Férussac, 1822)	Threeband gardenslug	Unlisted	C3	20	Negligible	No	0	0
130	Plant (t / fw)	Ambrosia artemisiifolia L.	Annual ragweed	Unlisted	E	27	NE	No	0	0
131	Plant (t / fw)	Ambrosia psilostachya DC.	Perennial ragweed	Unlisted	C2	1	NE	No	0	0
132	Amphibian	Ambystoma mexicanum (Shaw & Nodder, 1798)	Mexican salamander	Unlisted	C2	1	DD	No	0	0
133	Amphibian	Amietophrynus gutturalis (Power, 1927)	Guttural toad	Context specific	E	109	Negligible	No	0	0
134	Plant (t / fw)	Ammi majus L.	Bishop's weed	Unlisted	E	24	NE	No	0	0
135	Plant (t / fw)	Ammophila arenaria (L.) Link	Marram grass	3	E	5	Major	No	0	0
136	Plant (t / fw)	Ammophila arenia (L.) Link	European beach grass	3	Naturalised	NA	Some	No	0	0
137	Invert. (marine)	Ammothella appendiculata (Dohrn, 1881)	No common name found	Unlisted	C2	Harbour, Durban	DD	No	0	0
138	Mammal	Ammotragus lervia (Pallas, 1777)	Barbary sheep	2	NA	NA	Negligible	Yes	14	0
139	Invert. (marine)	Amphibalanus venustus (Darwin, 1854)	No common name found	Unlisted	E	Rocky shores, harbours, Cape Town- KZN	DD	No	0	0
140	Plant (t / fw)	Amsinckia menziesii var. retrorsa (Lehm.) A.Nelson & J.F.Macbr.	Fiddleneck	Unlisted	E	3	NE	No	0	0
141	Invert. (t)	Amyelois transitella Walker, 1863	Navel orangeworm	Unlisted	C3	NA	NE	No	0	0
142	Invert. (t)	Amynthas aeruginosus Kinberg	Earthworm	Unlisted	Introduced	KZN, GP	NE	No	0	0
143	Invert. (t)	Amynthas corticis (Kinberg, 1867)	Earthworm	Unlisted	Introduced	MP,GP, NW, FS, KZN, EC, WC	NE	No	0	0
144	Invert. (t)	Amynthas diffringens (Baird, 1869)	Earthworm	Unlisted	Introduced	LP, GP, NW, FS, KZN, EC, WC	NE	No	0	0
145	Invert. (t)	Amynthas gracilis (Kinberg, 1867)	Earthworm	Unlisted	Introduced	MP, WC	NE	No	0	0
146	Invert. (t)	Amynthas hawayanus Rosa, 1891	Earthworm	Unlisted	NA	NA	NE	No	0	0
147	Invert. (t)	Amynthas minimus (Horst, 1893)	Earthworm	Unlisted	Introduced	LP, KZN, MP, EC	NE	No	0	0
148	Invert. (t)	Amynthas morrisi (Beddard, 1892)	Earthworm	Unlisted	Introduced	NW, MP, GP	NE	No	0	0
149	Invert. (t)	Amynthas rodericensis (Grube, 1879)	Earthworm	Unlisted	Introduced	LP, KZN, MP, EC	NE	No	0	0
150	Plant (t / fw)	Anagallis arvensis L.	Pimpernel	Unlisted	C2	1	NE	No	0	0
151	Invert. (t)	Anaphes nitens (Girault, 1928)	Fairyfly	Unlisted	B1	3	NE	No	0	0
152	Bird	Anas clypeata Linnaeus, 1758	Northern shoveler	Unlisted	C2	2	NE	No	0	0
153	Bird	Anas discors Linnaeus, 1766	Blue-winged teal	Unlisted	C2	4	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
154	Bird	Anas platyrhynchos Linnaeus, 1758	Mallard	2	E	233	Some	Yes	0	0
155	Bird	Anas querquedula Linnaeus, 1758	Garnaney	Unlisted	E	1338	NE	No	0	0
156	Bird	Anas rubripes Brewster, 1902	American black duck	Unlisted	E	1758	NE	No	0	0
157	Plant (t / fw)	Andropogon gerardii Vitman	Big bluestem grass	Unlisted	Introduced	NA	NE	No	0	0
158	Plant (t / fw)	Andropogon hallii Hack	Sand bluestem grass	Unlisted	Introduced	NA	NE	No	0	0
159	Invert. (t)	Anellozetes auriculatus (Mahunka, 1984)	No common name found	Unlisted	Introduced	WC, FS	NE	No	0	0
160	Plant (t / fw)	Anigozanthos flavidus DC.	Yellow kangaroo paw	Unlisted	C2	1	NE	No	0	0
161	Plant (t / fw)	Anigozanthos rufus Labill.	Red kangaroo paw	Unlisted	NA	NA	NE	No	0	0
162	Reptile	Anolis carolinensis Voigt, 1832	Green anole	Context specific	NA	NA	NE	No	0	0
163	Invert. (t)	Anoplolepis gracilipes (Smith, 1857)	Crazy ant	1b	NA	NA	Some	No	0	0
164	Plant (t / fw)	Anredera cordifolia (Ten.) Steenis	Madeira vine	1b	E	41	Major	No	0	0
165	Reptile	Antaresia childreni Gray, 1842	Children's python	Unlisted	NA	NA	NE	No	0	0
166	Reptile	Antaresia maculosa Peters, 1873	Eastern childrens python	Unlisted	NA	NA	NE	No	0	0
167	Reptile	Antaresia stimsoni Smith, 1985	Large-blotched python	Unlisted	NA	NA	NE	No	0	0
168	Invert. (t)	Anteaeolidiella cacaotica (Angas, 1864)	Sea slug	Unlisted	NA	NA	NE	No	0	0
169	Invert. (t)	Anteaeolidiella foulisi (Angas, 1864)	Sea slug	Unlisted	NA	NA	NE	No	0	0
170	Plant (t / fw)	Anthemis cotula L.	Stinking chamomille	Unlisted	C2	2	NE	No	0	0
171	Invert. (t)	Anthonomus santacruzi Hustache.	Bugweed flowerbud-feeding weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
172	Invert. (t)	Anthrenus verbasci (Linnaeus, 1767)	Varied carpet beetle	Unlisted	NA	NA	NE	No	0	0
173	Plant (t / fw)	Antigonon leptopus Hook. & Arn.1838	Coral creeper	1b	E	8	Some	No	0	0
174	Mammal	Antilope cervicapra (Linnaeus, 1758)	Indian blackbuck	2	NA	NA	Negligible	Yes	3	0
175	Plant (marine)	Antithamnionella spirographidis (Schiffner) E.M.Wollaston, 1968	No common name found	Unlisted	E	Estuaries	DD	No	0	0
176	Invert. (t)	Anystis wallacei Otto, 1992	Wriggling mite	Unlisted	NA	NA	NE	No	0	0
177	Invert. (t)	Aonidiella aurantii (Maskell, 1879)	Red scale	Unlisted	C3	NA	NE	No	0	0
178	Invert. (t)	Aonidiella orientalis (Newstead, 1894)	Oriental yellow scale	Unlisted	C3	NA	NE	No	0	0
179	Reptile	Apalone species (unidentified)	Soft-shell terrapins	2	NA	NA	Some	Yes	0	0
180	Invert. (t)	Apanteles subandinus Blanchard, 1947	Potato tuber moth parasitoid	Unlisted	NA	NA	NE	No	0	0
181	Invert. (t)	Aphanasium australe (Boisduval)	Stem-boring beetle	Unlisted (Biocontrol agent with permit)	Invasive	2	Negligible	Yes	RP	0

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182	Microbe	Aphanomyces invadans Willoughby, R.J. Roberts & Chinabut, 1995	No common name found	Unlisted	Naturalised	NA	NE	No	0	0
183	Invert. (t)	Aphidius matricariae Haliday	Parasitic wasp	Unlisted	E	Offshore island	Negligible	No	0	0
184	Invert. (t)	Aphis armoraciae Cowen, J.H., 1895	Western Aster root aphid	Unlisted	NA	NA	NE	No	0	0
185	Invert. (t)	Aphis craccivora Koch, C.L., 1854	Groundnut aphid	Unlisted	C3	NA	NE	No	0	0
186	Invert. (t)	Aphis fabae Scopoli, 1763	Black bean aphid	Unlisted	B3	NA	NE	No	0	0
187	Invert. (t)	Aphis gossypii Glover, 1877	Green fly	Unlisted	C3	NA	NE	No	0	0
188	Invert. (t)	Aphis nasturtii Kaltenbach, 1843	Buckthorn aphid	Unlisted	NA	NA	NE	No	0	0
189	Invert. (t)	Aphis spiraecola Patch, 1914	Spirea aphid	Unlisted	C3	NA	NE	No	0	0
190	Invert. (t)	Aphytis coheni DeBach, 1960	Chalcid wasps	Unlisted	NA	NA	NE	No	0	0
191	Invert. (t)	Aphytis holoxanthus DeBach, 1960	Chalcid wasps	Unlisted	NA	NA	NE	No	0	0
192	Invert. (t)	Aphytis lepidosaphes Compere, 1955	Chalcid wasps	Unlisted	NA	NA	NE	No	0	0
193	Invert. (t)	Aphytis lingnanensis Compere, 1955	Chalcid wasps	Unlisted	NA	NA	NE	No	0	0
194	Invert. (t)	Aphytis melinus DeBach, 1959	Chalcid wasps	Unlisted	NA	NA	NE	No	0	0
195	Plant (t / fw)	Apium graveolens L.	Wild celery	Unlisted	C2	2	NE	No	0	0
196	Invert. (fw)	Aplexa marmorata (Guilding, 1828)	Marbled tadpole snail	1b	NA	NA	Negligible	No	0	0
197	Invert. (marine)	Apocorophium acutum (Chevreux, 1908)	No common name found	Unlisted	C3	Harbour, Durban	DD	No	0	0
198	Invert. (t)	Aporrectodea caliginosa (Savigny, 1826)	Common earthworm	Unlisted	NA	NA	NE	No	0	0
199	Invert. (t)	Aporrectodea caliginosa (Savigny, 1826)	Common Earthworm	Unlisted	Introduced	GP,NW, EC, WC	NE	No	0	0
200	Invert. (t)	Aporrectodea longa (Ude, 1885)	Black-headed worm	Unlisted	Introduced	WC, GP	NE	No	0	0
201	Invert. (t)	Aporrectodea rosea (Savigny, 1826)	Rosy-tipped worm	Unlisted	Introduced	WC, EC	NE	No	0	0
202	Invert. (t)	Aporrectodea trapezoides (Duges, 1828)	Southern worm	Unlisted	Introduced	WC, EC, KZN, LP, MP, GP	NE	No	0	0
203	Invert. (t)	Apterothrips apteris (Daniel, 1904)	No common name found	Unlisted	E	Offshore island	NE	No	0	0
204	Plant (t / fw)	Arachis cf. pintoi Krapov. & W.C.Greg.	Pinto peanut	Unlisted	C2	1	NE	No	0	0
205	Plant (t / fw)	Aralia spinosa L.	Devil's walking stick	Unlisted	C2	1	NE	No	0	0
206	Bird	Aratinga jandaya (Gmelin, 1788)	Jandaya conure	Unlisted	Introduced	1	NE	No	0	0
207	Bird	Aratinga pertinax (Linnaeus, 1758)	Brown-throated conure	Unlisted	C2	20	NE	No	0	0
208	Bird	Aratinga weddellii (Deville, 1851)	Dusky-headed conure	Unlisted	E	504	NE	No	0	0
209	Plant (t / fw)	Araucaria bidwillii Hook.	Bunya-bunya	Unlisted	E	41	NE	No	0	0
210	Plant (t / fw)	Araujia sericifera Brot.	Moth catcher	1b	E	55	Negligible	No	0	0
211	Plant (t / fw)	Ardisia crenata Sims.	Coralberry tree	1b	E	6	NE	No	0	0
212	Plant (t / fw)	Ardisia elliptica Thunb.	Shoebutton ardisia	1b	E	2	Negligible	No	0	0

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213	Plant (t / fw)	Argemone albiflora Hornem. subsp. texana Ownbey	White prickly poppy	Unlisted	E	6	NE	No	0	0
214	Plant (t / fw)	Argemone mexicana L.	Yellow-flowered Mexican poppy	1b	E	48	Some	No	0	0
215	Plant (t / fw)	Argemone ochroleuca Sweet	White-flowered Mexican poppy	1b	E	477	Some	No	0	0
216	Invert. (fw)	Argulus japonicus Thiele, 1900	Japanese fishlouse	Unlisted	D2	4	Negligible	No	0	0
217	Invert. (t)	Arion flagellus Collinge, 1893	No common name found	Unlisted	C3	1	NE	No	0	0
218	Invert. (t)	Arion hortensis complex Ferussac, 1819	Garden slug	Unlisted	D2	NA	Negligible	No	0	0
219	Invert. (t)	Arion intermedius Normand, 1852	Hedgehog slug	Unlisted	D2	13	Negligible	No	0	0
220	Invert. (t)	Aristaea thalassias (Meyrick, 1880)	Moth	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
221	Plant (t / fw)	Aristolochia elegans Mast. 1885	Dutchman's pipe	1b	E	2	Negligible	No	0	0
222	Invert. (t)	Armadillidium vulgare (Latreille, 1804)	Common pill woodlouse	Unlisted	Introduced	WC	NE	No	0	0
223	Microbe	Armillaria gallica Marxm. & Romagn.,1987	Bulbous Honey Fungus	Unlisted	Naturalised	NA	NE	No	0	0
224	Microbe	Armillaria mellea (Vahl) Kumm.,1871	Honey Fungus	Unlisted	Naturalised	NA	NE	No	0	0
225	Plant (t / fw)	Arrhenatherum elatius (L.) P. Beauv. ex J.Presl & C.Presl.	False oat grass	Unlisted	Introduced	NA	NE	No	0	0
226	Invert. (fw)	Artemia franciscana Kellog, 1906	San Francisco brine shrimp	Unlisted	D2	3	Some	No	0	0
227	Plant (t / fw)	Arundo donax L. 1753	Giant reed	1b	E	290	Major	No	0	0
228	Invert. (marine)	Ascidia sydneiensis Stimpson, 1855	No common name found	Unlisted	E	Mostly harbours	DD	No	0	0
229	Invert. (marine)	Ascidiella aspersa (Müller, 1776)	Dirty Sea-squirt	Unlisted	E	Harbours	DD	No	0	0
230	Plant (t / fw)	Asclepias curassavica L.	Scarlet milkweed	Unlisted	C2	1	NE	No	0	0
231	Microbe	Aseroë rubra Labill.,1800	Anemone Stinkhorn	Unlisted	Naturalised	NA	NE	No	0	0
232	Plant (marine)	Asparagopsis armata Harvey	Harpoon weed	3	E	Shallow subtidal	DD	Yes	0	0
233	Plant (marine)	Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon	Pleasing seaweed	3	E	Shallow subtidal	DD	No	0	0
234	Plant (t / fw)	Asphodelus fistulosus L.	Onion weed	Unlisted	E	2	NE	No	0	0
235	Invert. (t)	Aspidiotus destructor Signoret, 1869	Coconut scale	Unlisted	C3	NA	NE	No	0	0
236	Reptile	Aspidites melanocephalus Krefft, 1864	Black-headed python	Unlisted	NA	NA	NE	No	0	0
237	Reptile	Aspidites ramsayi Macleay, 1882	Ramsay's python	Unlisted	NA	NA	NE	No	0	0
238	Invert. (fw)	Astacus leptodactylus Eschscholtz, 1823	Danube crayfish	1a	NA	NA	Negligible	No	0	0
239	Plant (t / fw)	Astartea fascicularis (Labill.) DC.	False baeckea	Unlisted	C2	1	NE	No	0	0
240	Microbe	Astatumen trinacriae (Arcidiacono, 1962)	Water bear	Unlisted	Introduced	WC	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
241	Plant (t / fw)	Aster squamatus (Spreng.) Hieron.	Swamp aster	Unlisted	C2	1	NE	No	0	0
242	Microbe	Astraeus hygrometricus (Pers.)Morgan, 1889	Barometer Earthstar	Unlisted	Introduced	NA	NE	No	0	0
243	Plant (t / fw)	Astrebla species (unidentified)	Mitchell grass	Unlisted	Introduced	NA	NE	No	0	0
244	Invert. (t)	Astylus atromaculatus (Blanchard, 1843)	Spotted maize beetle	Unlisted	NA	NA	NE	No	0	0
245	Invert. (t)	Atherigona soccata Rondani, 1871	Sorghum shoot fly	Unlisted	NA	NA	NE	No	0	0
246	Plant (t / fw)	Atriplex inflata F.Muell.	Sponge-fruit saltbush	1b	E	101	Some	No	0	0
247	Plant (t / fw)	Atriplex muelleri Benth.	Mueller's saltbush	Unlisted	C2	1	NE	No	0	0
248	Plant (t / fw)	Atriplex nummularia subsp. nummularia Lindl. 1848	Old man saltbush	2	E	140	Some	Yes	0	0
249	Plant (t / fw)	Atriplex semibaccata R.Br.	Australian saltbush	Unlisted	E	9	NE	No	0	0
250	Invert. (t)	Atropacarus tuberculosissimus (Mahunka, 1978)	No common name found	Unlisted	Introduced	KZN	NE	No	0	0
251	Invert. (fw)	Atyoida serrata (Bate, 1888)	Crevette bouledogue	Unlisted	C3	2	Negligible	No	0	0
252	Invert. (t)	Aulacaspis tubercularis Newstead, 1906	Cinnamomum scale	Unlisted	C3	NA	NE	No	0	0
253	Invert. (t)	Aulacorthum circumflexum (Buckton, 1876)	Mottled arum aphid	Unlisted	NA	NA	NE	No	0	0
254	Invert. (t)	Aulacorthum solani (Kaltenbach, 1843)	Greenhouse potato aphid	Unlisted	NA	NA	NE	No	0	0
255	Plant (t / fw)	Austrocylindropuntia cylindrica (Juss. ex Lam.) Backeberg.	Cane cactus	1a	E	3	Some	No	0	0
256	Plant (t / fw)	Austrocylindropuntia subulata subsp. exaltata (A. Berger) D.R.Hunt	Long spine cactus	1b	E	5	Some	No	0	0
257	Plant (t / fw)	Avena barbata Pott ex Link	Slender wild oat	Unlisted	C2	1	Some	No	0	0
258	Plant (t / fw)	Avena fatua L.	Wild oat	Unlisted	E	2	Negligible	No	0	0
259	Plant (t / fw)	Avena nuda L.	Hulless oat	Unlisted	Introduced	NA	NE	No	0	0
260	Plant (t / fw)	Avena sativa L.	Common oat	Unlisted	C0	Offshore island	NE	No	0	0
261	Mammal	Axis axis (Erxleben, 1777)	Chital	2	NA	NA	Some	Yes	7	0
262	Mammal	Axis porcinus (Zimmermann, 1780)	Hog deer	2	NA	NA	Negligible	Yes	7	0
263	Plant (t / fw)	Axonopus compressus (Sw.) P.Beauv.	Carpet grass	Unlisted	Introduced	NA	NE	No	0	0
264	Bird	Aythya ferina (Linnaeus, 1758)	Common pochard	Unlisted	E	102	NE	No	0	0
265	Bird	Aythya fuligula (Linnaeus, 1758)	Tufted duck	Unlisted	Introduced	1	NE	No	0	0
266	Bird	Aythya nyroca (Guldenstadt, 1770)	Ferruginous duck	Unlisted	C2	16	NE	No	0	0
267	Plant (t / fw)	Azolla cristata Kaulf.	Tropical red water fern	1b	E	2	Major	No	0	0
268	Plant (t / fw)	Azolla filiculoides Lam.	Azolla	1b	E	175	Major	No	0	0
269	Plant (t / fw)	Azolla pinnata R.Br. subsp. asiatica R.M.K.Saunders & K. Fowler	Mosquito fern	1b	E	6	Major	No	0	0
270	Invert. (t)	Bactrocera invadens dorsalis (Drew, Tsuruta and White, 2005)	Asian fruit-fly	1a	C3	All provinces except WC	Negligible	No	0	0
271	Plant (t / fw)	Baeckia species (unidentified)	Baeckia	Unlisted	C2	1	NE	No	0	0

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272	Invert. (marine)	Balanus glandula (Darwin, 1854)	Pacific barnacle	3	E	Rocky intertidal, West Coast to False bay	Some	No	0	0
273	Invert. (t)	Ballistura schoetti (Dalla Torre, 1895)	No common name found	Unlisted	Introduced	WC, EC	NE	No	0	0
274	Plant (t / fw)	Bambusa balcooa Roxb.	Common bamboo	Unlisted	E	17	NE	No	0	0
275	Plant (t / fw)	Banksia ericifolia L.f.	Heath banksia	Unlisted	E	2	NE	No	0	0
276	Plant (t / fw)	Banksia integrifolia L.f.	Coast banksia	Unlisted	E	2	NE	No	0	0
277	Plant (t / fw)	Banksia serrata L.f.	Saw banksia	Unlisted	E	2	NE	No	0	0
278	Plant (t / fw)	Banksia speciosa R.Br.	Showy banksia	Unlisted	C2	1	NE	No	0	0
279	Plant (t / fw)	Bartlettina sordida (Less.) R.M. King & H.Rob.	Bartlettina	1b	NA	NA	Some	No	0	0
280	Reptile	Basiliscus plumifrons Cope, 1876	Plumed basilisk	Context specific	NA	NA	Negligible	No	1	0
281	Reptile	Basiliscus vittatus Wiegmann, 1828	Brown basilisk	2	NA	NA	Negligible	Yes	0	0
282	Plant (t / fw)	Bauhinia forficata Link	Thorny orchid tree	Unlisted	E	2	NE	No	0	0
283	Plant (t / fw)	Bauhinia purpurea L.	Butterfly orchid tree	Context specific	E	1	Negligible	No	0	0
284	Plant (t / fw)	Bauhinia variegata L.	Orchid tree	Context specific	E	16	Negligible	No	0	0
285	Invert. (t)	Bdellodes lapidaria (Kramer, 1881)	Snout mite	Unlisted (Biocontrol agent with permit)	NA	NA	Negligible	Yes	RP	0
286	Invert. (t)	Bedeva paivae (Crosse, 1864)	Sea snail	Unlisted	NA	NA	NE	No	0	0
287	Plant (t / fw)	Begonia cucullata Willd.	Begonia	Unlisted	C2	2	NE	No	0	0
288	Invert. (t)	Bemisia tabaci (Gennadius, 1889)	Sweet potato whitefly	1b	NA	NA	Some	No	0	0
289	Plant (t / fw)	Berberis aristata DC.	Indian barberry	Unlisted	C2	2	NE	No	0	0
290	Plant (t / fw)	Berberis julianae C.K.Schneid.	Chinese barberry	Unlisted	E	3	NE	No	0	0
291	Plant (t / fw)	Berberis thunbergii D.C.	Japanese barberry	Context specific	Introduced	1	Negligible	No	0	0
292	Plant (t / fw)	Betula pendula Roth	Silver birch	Unlisted	C2	2	NE	No	0	0
293	Plant (t / fw)	Bidens bipinnata L.	Spanish black jack	Unlisted	E	5	NE	No	0	0
294	Plant (t / fw)	Bidens biternata (Lour.) Merr. & Sherff	Five-leaved black jack	Unlisted	C2	5	NE	No	0	0
295	Plant (t / fw)	Bidens pilosa L.	Black jack	Unlisted	E	29	NE	No	0	0
296	Plant (t / fw)	Billardiera heterophylla (Lindl.) L.W.Cayzer & Crisp	Bluebell creeper	1a	E	2	Negligible	Yes	0	0
297	Invert. (t)	Bipalium kewense Moseley, 1878	Spade-headed planarian	Unlisted	NA	NA	NE	No	0	0
298	Reptile	Bitis gabonica (A.M.C. Duméril, Bibron & A.H.A. Duméril, 1854) x Bitis species, Bibron & Duméril, 1854	Gaboon adder	1b	NA	NA	Negligible	No	0	0
299	Reptile	Bitis gabonica rhinoceros (Schlegel, 1855)	Rhinocerhos viper	Context specific	NA	NA	Negligible	Yes	4	0
300	Reptile	Bitis nasicornis (Shaw, 1802)	Rhinoceros viper	Context specific	NA	NA	Negligible	Yes	0	0
301	Reptile	Bitis peringueyi Boulenger, 1888	Peringuey's adder	Unlisted	NA	NA	NE	No	0	0

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302	Invert. (t)	Blastopsylla occidentalis Taylor, 1985	Eucalyptus psyllid	Unlisted	NA	NA	NE	No	0	0
303	Invert. (t)	Blatta orientalis Linnaeus, 1758	Oriental cockroach	Unlisted	NA	NA	NE	No	0	0
304	Invert. (t)	Blattella germanica (Linnaeus, 1767)	German Cockroach	Unlisted	Introduced	1	NE	No	0	0
305	Reptile	Boa constrictor Linnaeus, 1758	Common boa	Context specific	C1	3	Some	Yes	20	0
306	Invert. (marine)	Boccardia proboscidea Hartman, 1940	Shell worm	1b	E	Aquaculture & rocky shore	DD	No	0	0
307	Plant (t / fw)	Bocconia frutescens L.	Plume-poppy	Unlisted	C2	1	NE	No	0	0
308	Plant (t / fw)	Boerhavia diffusa L.	Boerhavia	Unlisted	E	14	NE	No	0	0
309	Plant (t / fw)	Boerhavia erecta L.	Erect boerhavia	Unlisted	C2	1	NE	No	0	0
310	Microbe	Boletus aestivalis (Paulet) Fr., 1838	No common name found	Unlisted	Introduced	NA	NE	No	0	0
311	Microbe	Boletus edulis Bull., 1782	King Bolete	Unlisted	Introduced	NA	NE	No	0	0
312	Mammal	Boselaphus tragocamelus (Pallas, 1766)	Nilgai	2	NA	NA	Negligible	Yes	0	0
313	Reptile	Bothriechis schlegelii (Berthold, 1846)	Eyelash viper	Unlisted	NA	NA	NE	No	0	0
314	Invert. (fw)	Bothriocephalus acheilognathi Yamaguti, 1934	Fish tapeworm	Unlisted	NA	NA	NE	No	0	0
315	Plant (t / fw)	Bothriochloa saccharoides (Sw.) Rydb.	Silver bluestem	Unlisted	Introduced	NA	NE	No	0	0
316	Invert. (marine)	Botryllus schlosseri (Pallas, 1766)	Star Ascidian	Unlisted	E	Harbours and subtidal	DD	No	0	0
317	Microbe	Botryotinia fuckeliana (de Bary) Whetzel	No common name found	Unlisted	NA	Offshore island	Some	No	0	0
318	Plant (t / fw)	Bougainvillea glabra Choisy	Bougainvillea	Unlisted	E	2	NE	No	0	0
319	Invert. (t)	Bourletiella arvalis (Fitch, 1863)	No common name found	Unlisted	Introduced	WC	NE	No	0	0
320	Plant (t / fw)	Bouteloua chondrosioides (Kunth) Benth. ex S.Watson	Sprucetop grama	Unlisted	Introduced	NA	NE	No	0	0
321	Plant (t / fw)	Bouteloua curtipendula (Michx.) Torr	Side-Oats grama	Unlisted	Introduced	NA	NE	No	0	0
322	Plant (t / fw)	Brachiaria mutica (Forssk.) Stapf	Para grass	Unlisted	Introduced	NA	NE	No	0	0
323	Invert. (t)	Brachycaudus amygdalinus (Schouteden, 1905)	Short-tailed almond aphid	Unlisted	NA	NA	NE	No	0	0
324	Invert. (t)	Brachycaudus helichrysi (Kaltenbach, 1843)	Leaf curling plum aphid	Unlisted	NA	NA	NE	No	0	0
325	Invert. (t)	Brachycaudus persicae (Passerini, 1860)	Black peach aphid	Unlisted	C3	NA	NE	No	0	0
326	Plant (t / fw)	Brachychiton populneus (Schott & Endl.) R.Br.	Kurrajong	Unlisted	C2	1	NE	No	0	0
327	Invert. (t)	Brachyiulus pusillus (Bosc, 1792)	No common name found	Unlisted	Introduced	WC	NE	No	0	0
328	Reptile	Brachylophus fasciatus Brongniart, 1800	Fiji banded iguana	Unlisted	NA	NA	NE	No	0	0
329	Invert. (t)	Brachystomella parvula (Schaeffer, 1896)	Springtail	Unlisted	Introduced	MP, WC, KZN, EC, FS	NE	No	0	0
330	Invert. (t)	Bradybaena similaris (Ferussac, 1822)	Asian trampsnail	Unlisted	C3	4	Negligible	No	0	0
331	Invert. (t)	Bradysia difformis (Frey, 1948)	Black fungus gnat	Unlisted	NA	NA	NE	No	0	0

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332	Plant (t / fw)	Brassica rapa L.	Field mustard	Unlisted	C2	3	NE	No	0	0
333	Plant (t / fw)	Brassica tournefortii Gouan	Mediterranean mustard	Unlisted	C2	2	NE	No	0	0
334	Invert. (t)	Brevicoryne brassicae (Linnaeus, 1758)	Cabbage aphid	Unlisted	B3	NA	NE	No	0	0
335	Invert. (t)	Brevipalpus californicus (Banks, 1904)	Citrus flat mite	Unlisted	NA	NA	NE	No	0	0
336	Invert. (t)	Brevipalpus obovatus Donnadieu, 1875	Scarlet tea mite	Unlisted	NA	NA	NE	No	0	0
337	Invert. (t)	Brevipalpus phoenicis (Geijskes, 1939)	False spider mite	Unlisted	NA	NA	NE	No	0	0
338	Plant (t / fw)	Breynia disticha J.R.Forst. & G.Forst.	Snowbush	Unlisted	E	2	NE	No	0	0
339	Plant (t / fw)	Briza maxima L.	Quaking grass	Unlisted	C2	9	NE	No	0	0
340	Plant (t / fw)	Bromus catharticus Vahl	Rescue grass	Unlisted	E	13	NE	No	0	0
341	Plant (t / fw)	Bromus diandrus Roth	Ripgut brome	Unlisted	C2	3	NE	No	0	0
342	Plant (t / fw)	Bromus inermis Leyss.	Smooth brome	Unlisted	Introduced	NA	NE	No	0	0
343	Plant (t / fw)	Bromus pectinatus Thunb.	Japanese brome	Unlisted	C2	5	NE	No	0	0
344	Plant (t / fw)	Brugmansia arborea (L.) Steud.	Angel's-trumpet	Unlisted	C2	1	NE	No	0	0
345	Plant (t / fw)	Brugmansia x candida Pers.	Moonflower bush	Unlisted	E	2	NE	No	0	0
346	Invert. (t)	Bryobia praetiosa Koch, 1836	Clover mite	Unlisted	NA	NA	NE	No	0	0
347	Plant (t / fw)	Bryophyllum delagoense (Eckl. & Zeyh.) Schinz	Chandelier plant	1b	E	38	Some	No	0	0
348	Plant (t / fw)	Bryophyllum fedtschenkoi (Raym.-Hamet & H.Perrier) Lauz.-March.	Lavendar scallops	Unlisted	C2	1	NE	No	0	0
349	Plant (t / fw)	Bryophyllum pinnatum Lam.	Cathedral bells	1b	E	7	Some	No	0	0
350	Plant (t / fw)	Bryophyllum proliferum Bowie ex Hook.	Green mother of millions	1b	C2	3	Some	Yes	0	0
351	Plant (t / fw)	Buchloe dactyloides (Nutt.) Engelm.	Buffalo grass	Unlisted	Introduced	NA	NE	No	0	0
352	Microbe	Buchwaldoboletus hemichrysus (Berk. & M.A. Curtis) Pilát, 1969	No common name found	Unlisted	Introduced	NA	NE	No	0	0
353	Plant (t / fw)	Buddleja davidii Franch.	Chinese sagewood	3	C2	1	Negligible	No	0	0
354	Plant (t / fw)	Buddleja madagascariensis Lam.	Madagascar sagewood	3	E	2	Negligible	No	0	0
355	Invert. (marine)	Bugulina dentata (Lamouroux, 1816)	No common name found	Unlisted	E	Harbours, rocky shores, subtidal	DD	No	0	0
356	Invert. (marine)	Bugulina flabellata (Thompson in Gray, 1848)	No common name found	Unlisted	E	Harbours, rocky shores, subtidal	DD	No	0	0
357	Invert. (marine)	Bugulina neritina (Linnaeus, 1758)	Spiral-tufted Bushy Bryozoan	Unlisted	E	Harbours, widespread	DD	No	0	0
358	Invert. (t)	Bulimulus sporadicus (d'Orbigny, 1835)	No common name found	Unlisted	C3	1	Negligible	No	0	0
359	Plant (t / fw)	Cabomba caroliniana A.Gray	Cabomba	1a	C2	2	Major	No	0	0
360	Invert. (t)	Cactoblastis cactorum Berg, 1885	Cactus moth	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
361	Bird	Cacutua sulphurea (Gmelin, 1788)	Yellow-crested cockatoo	Unlisted	C2	2	NE	No	0	0

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362	Plant (t / fw)	Caesalpinia decapetala (Roth) Alston	Mauritius thorn	1b	E	125	Major	No	0	0
363	Plant (t / fw)	Caesalpinia gilliesii Wall. ex. Hook.	Bird-of-paradise flower	1b	E	48	Major	No	0	0
364	Plant (t / fw)	Caesalpinia pulcherrima (L.) Sw.	Pride of Barbados	Unlisted	C2	5	NE	No	0	0
365	Invert. (marine)	Cafius xantholoma (Gravenhorst, 1806)	No common name found	Unlisted	E	Beaches, SW Cape	DD	No	0	0
366	Bird	Cairina moschata (Linnaeus, 1758)	Muscovy duck	Unlisted	C2	2	NE	No	0	0
367	Invert. (t)	Caliroa cerasi (Linnaeus, 1758)	Pear slug	Unlisted	C3	NA	NE	No	0	0
368	Invert. (t)	Calliphora vicina Robineau-Desvoidy	Common blow fly	Unlisted	C3	3	NE	No	0	0
369	Plant (t / fw)	Callisia fragrans (Lindl.) Woodson	Basket plant	Unlisted	C2	1	NE	No	0	0
370	Plant (t / fw)	Callisia repens (Jacq.) L., 1760	Creeping inch plant	1b	E	4	Negligible	No	0	0
371	Plant (t / fw)	Callistemon citrinus (Curtis) Skeels	Lemon bottlebrush	3	C2	3	Negligible	No	0	0
372	Plant (t / fw)	Callistemon glaucus (DC.) Sweet	Albany bottlebrush	Unlisted	C2	1	NE	No	0	0
373	Plant (t / fw)	Callistemon rigidus R.Br.	Stiff-leaved bottlebrush	Context specific	NA	NA	Negligible	No	0	0
374	Plant (t / fw)	Callistemon rugulosus (Schltdl. ex Link) DC.	Scarlet bottlebrush	Unlisted	E	2	NE	No	0	0
375	Plant (t / fw)	Callistemon viminalis Sol. ex Gaertner) G.Don ex Loudon	Weeping bottlebrush	Context specific	E	11	Negligible	No	0	0
376	Bird	Callonetta leucophrys (Vieillot, 1816)	Ringed teal	Unlisted	Introduced	1	NE	Yes	0	0
377	Plant (t / fw)	Calluna vulgaris (L.) Hull	Common heather	Unlisted	Introduced	1	NE	No	0	0
378	Invert. (t)	Calophya schini (Tuthill, 1959)	Peppertree psyllid	Unlisted	NA	NA	NE	No	0	0
379	Reptile	Calotes versicolor Daudin, 1802	Changeable lizard	1b	Naturalised	3	Negligible	No	0	0
380	Plant (t / fw)	Calothamnus sanguineus Labill.	One-sided bottlebrush	Unlisted	C2	1	NE	No	0	0
381	Plant (t / fw)	Calotropis procera (Aiton) W.T Aiton	Calotropis	1b	E	16	Some	No	0	0
382	Invert. (t)	Calycomyza eupatorivora (Spencer, 1973)	Leafmining fly	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
383	Invert. (t)	Calycomyza lantanae Frick, 1956	Leafmining fly	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
384	Plant (t / fw)	Campuloclinium macrocephalum (Less.) DC.	Pompom weed	1b	E	108	Major	No	0	0
385	Plant (t / fw)	Canna flaccida Salisb.	Golden canna	Unlisted	E	4	NE	No	0	0
386	Plant (t / fw)	Canna glauca L.	Yellow-flowered glaucous canna	Unlisted	C2	1	NE	No	0	0
387	Plant (t / fw)	Canna indica L.	Indian shot	1b	E	73	Some	No	0	0
388	Plant (t / fw)	Canna x generalis L.H.Bailey	Garden canna	Unlisted	E	61	NE	No	0	0
389	Plant (t / fw)	Cantinoa mutabilis (Rich.) Harley & J.F.B.Pastore	Tropical bushmint	Unlisted	C2	1	NE	No	0	0

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390	Invert. (t)	Capitophorus elaeagni (Del Guercio, 1894)	Artichoke aphid	Unlisted	NA	NA	NE	No	0	0
391	Mammal	Capra hircus Linnaeus, 1758	Goat	1a	NA	Offshore island	Major	No	0	0
392	Invert. (marine)	Caprella mutica Schurin, 1935	Japanese Skeleton Shrimp	Unlisted	C2	Yachts	DD	No	0	0
393	Plant (t / fw)	Capsella bursa-pastoris (L.) Medik.	Shepherd's purse	Unlisted	C2	7	NE	No	0	0
394	Fish (fw)	Carassius auratus (Linnaeus, 1758)	Goldfish	Unlisted	Introduced	1	Some	No	0	0
395	Invert. (t)	Carausius morosus (Sinéty, 1901)	Indian Stick Insect	Unlisted	NA	NA	NE	No	0	0
396	Invert. (marine)	Carcinus maenas (Linnaeus, 1758)	European shore crab/ Green crab	1b	E	Harbours, Table Bay and Hout Bay and intertidal on the Cape Peninsula	Negligible	No	12	4
397	Plant (t / fw)	Cardiospermum grandiflorum Swartz	Balloon vine	1b	E	50	Some	No	0	0
398	Plant (t / fw)	Cardiospermum halicacabum L.	Lesser balloon vine	3	E	30	Some	No	0	0
399	Bird	Carduelis carduelis Linnaeus, 1758	European goldfinch	2	C2	4	NE	Yes	0	0
400	Bird	Carduelis chloris Linnaeus, 1758	European greenfinch	2	Introduced	1	NE	No	0	0
401	Bird	Carduelis flammea (Linnaeus, 1758)	Common redpoll	2	E	1338	Negligible	No	0	0
402	Plant (t / fw)	Carduus nutans L.	Nodding thistle	1b	E	10	Some	No	0	0
403	Plant (t / fw)	Carica papaya L.	Papaw	Unlisted	E	6	Negligible	No	0	0
404	Invert. (t)	Carpophilus dimidiatus (Fabricius, 1792)	Corn-sap beetle	Unlisted	NA	NA	NE	No	0	0
405	Invert. (t)	Carposina autologa Meyrick	Hakea seed-moth	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
406	Invert. (t)	Carvalhotingis hollandi Drake	Cotton lace bug	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
407	Invert. (t)	Carvalhotingis visenda Drake & Hambleton	Leafsucking lace bug	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
408	Plant (t / fw)	Castanea dentata (Marshall) Borkh.	American chestnut	Unlisted	C2	1	NE	No	0	0
409	Plant (t / fw)	Castanea sativa Mill.	Sweet chestnut	Unlisted	C2	1	NE	No	0	0
410	Plant (t / fw)	Castanospermum australe A.Cunn. & C.Fraser	Australian chestnut	Unlisted	C2	1	NE	No	0	0
411	Plant (t / fw)	Casuarina cunninghamiana Miq.	Beefwood	Context specific	E	42	Some	Yes	10	0
412	Plant (t / fw)	Casuarina equisetifolia L.	Horsetail tree	2	E	21	Some	Yes	0	0
413	Plant (t / fw)	Catharanthus roseus (L.) G.Don	Madagascar periwinkle	1b	E	82	Negligible	No	0	0
414	Invert. (t)	Catorhintha schaffneri Brailovsky & Garcia, 1987	Pereskia stem-wilter	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0

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415	Invert. (marine)	Catriona columbiana (O'Donoghue, 1922)	Red-tentacle Cuthona	Unlisted	C2	Harbour, Table Bay only, NA	DD	No	0	0
416	Invert. (t)	Cecilioides acicula (Muller, 1774)	Blind Awlsnail	Unlisted	Naturalised	7	DD	No	0	0
417	Invert. (t)	Cedrobium laportei Remaudière, G. , 1954	Deodar aphid	Unlisted	NA	NA	NE	No	0	0
418	Plant (t / fw)	Cedronella canariensis (L.) Webb & Berthel.	Canary Islands balm	Unlisted	C2	1	NE	No	0	0
419	Plant (t / fw)	Cedrus deodara (Roxb.) G.Don	Deodar cedar	Unlisted	E	5	NE	No	0	0
420	Invert. (t)	Ceiracanthium furculatum Karsch, 1879	No common name found	Unlisted	NA	Offshore island	NE	No	0	0
421	Plant (t / fw)	Celtis australis L.	Nettle tree	3	C2	1	Negligible	No	0	0
422	Plant (t / fw)	Celtis occidentalis L.	Common hackberry	3	NA	NA	Negligible	No	0	0
423	Plant (t / fw)	Celtis sinensis Pers.	Chinese nettle tree	Unlisted	E	4	NE	No	0	0
424	Plant (t / fw)	Cenchrus brownii Roem. & Schult.	Fine burgrass	Unlisted	E	6	NE	No	0	0
425	Plant (t / fw)	Centaurea melitensis L.	Cockspur thistle	Unlisted	C2	3	NE	No	0	0
426	Plant (t / fw)	Centaurea solstitialis L.	Barnaby's thistle	Unlisted	C2	2	NE	No	0	0
427	Plant (t / fw)	Centranthus ruber (L.) DC.	Red valerian	Context specific	E	7	Negligible	No	0	0
428	Reptile	Centrochelys sulcata Miller, 1779	Spur-thighed tortoise	2	NA	NA	Negligible	Yes	5	0
429	Invert. (marine)	Cerapus tubularis Say, 1817	No common name found	Unlisted	E	Harbour/ subtidal Saldanha to KZN	DD	No	0	0
430	Reptile	Cerastes cerastes Linnaeus, 1758	Desert horned viper	Unlisted	NA	NA	NE	No	0	0
431	Reptile	Cerastes gasperetti Leviton and Anderson, 1967	Arabian horned viper	Unlisted	NA	NA	NE	No	0	0
432	Reptile	Cerastes vipera (Linnaeus, 1758)	Sahara sand viper	Unlisted	NA	NA	NE	No	0	0
433	Plant (t / fw)	Cerastium fontanum Baumg.	Common mouse-ear chickweed	1b	E	1	Negligible	No	0	0
434	Invert. (t)	Cerataphis brasiliensis (Hempel, 1901)	Palm aphid	Unlisted	NA	NA	NE	No	0	0
435	Invert. (t)	Cerataphis orchidearum (Westwood, 1879)	Orchid aphid	Unlisted	NA	NA	NE	No	0	0
436	Invert. (t)	Ceratitis capitata (Wiedemann, 1824)	Mediterranean fruit fly	Unlisted	NA	NA	NE	No	0	0
437	Microbe	Ceratocystis pirilliformis I. Barnes & M.J. Wingf., 2003	No common name found	Unlisted	Naturalised	NA	NE	No	0	0
438	Amphibian	Ceratophrys ornata (Bell, 1843)	Argentine horned frog	Unlisted	B2	1	DD	No	0	0
439	Invert. (t)	Ceratophysella denticulata (Bagnall)	Mushroom springtail	Unlisted	E	Offshore island	NE	No	0	0
440	Microbe	Cercospora pistiae Nag Raj, Govindu & Thirum., 1971	No common name found	Unlisted	Introduced	NA	NE	No	0	0
441	Microbe	Cercospora rodmanii Conway	No common name found	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
442	Plant (t / fw)	Cereus hexagonus (L.) Mill.	Queen of the night	1b	NA	NA	Negligible	No	0	0
443	Plant (t / fw)	Cereus hildmannianus K. Schum.	Queen of the night	1b	Introduced	1	Negligible	No	0	0

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444	Plant (t / fw)	Cereus jamacaru DC.	Queen of the night	1b	E	156	Some	No	0	0
445	Microbe	Cerospora echii G. Winter, 1884	White Saddle	Unlisted	Introduced	NA	NE	No	0	0
446	Mammal	Cervus elaphus Linnaeus, 1758	Red deer	2	NA	NA	Some	Yes	3	0
447	Mammal	Cervus nippon Temminck, 1838	Sika deer	2	NA	NA	Some	Yes	0	0
448	Plant (t / fw)	Cestrum aurantiacum Lindl.	Orange cestrum	1b	E	5	Some	No	0	0
449	Plant (t / fw)	Cestrum elegans (Brongn.) Schltdl.	Crimson cestrum	1b	E	2	Some	No	0	0
450	Plant (t / fw)	Cestrum laevigatum Schltdl.	Inkberry	1b	E	70	Major	No	0	0
451	Plant (t / fw)	Cestrum parqui L'Her.	Chilean cestrum	1b	E	21	Some	No	0	0
452	Plant (t / fw)	Cestrum species (unidentified)	Cestrum species	3	NA	NA	NE	No	0	0
453	Invert. (t)	Ceutorhynchus pallidactylus Schoenherr, 1837	Cabbage stem weevil	Unlisted	C3	NA	NE	No	0	0
454	Invert. (t)	Chaetophiloscia elongata (Dollfus, 1884)	Isopods	Unlisted	Introduced	WC	NE	No	0	0
455	Invert. (t)	Chaetosiphon fragaefolii (Cockerell, T.D.A. , 1901)	Strawberry aphid	Unlisted	NA	NA	NE	No	0	0
456	Invert. (t)	Chaitophorus leucomelas Koch, C.L 1854	Poplar aphid	Unlisted	NA	NA	NE	No	0	0
457	Invert. (t)	Chaitophorus populialba (Boyer de Fonscolombe, 1841)	No common name found	Unlisted	NA	NA	NE	No	0	0
458	Microbe	Chalciporus piperatus (Bull.) Bataille, 1908	Peppery Bolete	Unlisted	Introduced	NA	NE	No	0	0
459	Reptile	Chamaeleo calyptratus Duméril and Bibron, 1851	Cone-headed chameleon	Unlisted	NA	NA	NE	No	0	0
460	Plant (t / fw)	Chamaesyce prostrata (Aiton) Small	Hairy creeping milkweed	Unlisted	E	2	NE	No	0	0
461	Plant (t / fw)	Chamaesyce serpens (Kunth) Small	Milkweed	Unlisted	C2	1	NE	No	0	0
462	Invert. (t)	Charidotis auroguttata Boheman	Golden spotted tortoise beetle	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
463	Invert. (marine)	Chelura terebrans Philippi, 1839	No common name found	Unlisted	E	Harbours, Saldanha to Port Elizabeth	DD	No	0	0
464	Reptile	Chelydra serpentina (Linnaeus, 1758)	Common snapping turtle	2	C1	2	DD	Yes	2	0
465	Plant (t / fw)	Chenopodium album L.	White goosefoot	Unlisted	E	23	NE	No	0	0
466	Invert. (fw)	Cherax cainii Austin & Ryan, 2002	Smooth marron	2	NA	NA	NE	No	5	0
467	Invert. (fw)	Cherax destructor Clark, 1936	Yabby	1a	B1	1	Negligible	No	0	0
468	Invert. (fw)	Cherax quadricarinatus Von Martins, 1868	Red claw crayfish	1b	D2	3	Severe	No	0	0
469	Invert. (fw)	Cherax tenuimanus Smith, 1912	Hairy marron	2	B1	2	Negligible	No	8	0
470	Invert. (t)	Chilo partellus (Swinhoe, 1885)	Spotted stem borer	Unlisted	C3	NA	NE	No	0	0
471	Invert. (t)	Chilo sacchariphagus Bojer, 1856	Spotted borer	Unlisted	C3	NA	NE	No	0	0
472	Amphibian	Chiromantis xerampelina Peters, 1854	Grey foam-nest tree frog	Unlisted	B3	44	DD	No	0	0
473	Reptile	Chlamydosaurus kingii Gray, 1827	Frilled lizard	Unlisted	NA	NA	NE	No	0	0

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474	Invert. (t)	Chlorophorus annularis (Fabricius, 1787)	Bamboo Borer	Unlisted	NA	NA	NE	No	0	0
475	Microbe	Chlorophyllum rhacodes (Vittad.) Vellinga 2002	Shaggy Parasol	Unlisted	Naturalised	NA	NE	No	0	0
476	Plant (t / fw)	Chondrilla juncea L.	Skeleton weed	1a	C2	1	Negligible	Yes	0	0
477	Plant (t / fw)	Chondrosum eriopodum Torr.	Black grama	Unlisted	Introduced	NA	NE	No	0	0
478	Plant (t / fw)	Chondrosum gracile Kunth	Blue grama	Unlisted	Introduced	NA	NE	No	0	0
479	Plant (t / fw)	Chondrosum hirsutum (Lag.) Sweet	Hairy grama	Unlisted	Introduced	NA	NE	No	0	0
480	Plant (t / fw)	Chorizema cordatum Lindl.	White goosefoot	Unlisted	C2	1	NE	No	0	0
481	Invert. (t)	Chromatomyia horticola Goureau, 1851	Pea leafminer	Unlisted	NA	NA	NE	No	0	0
482	Plant (t / fw)	Chromolaena odorata (L.) R.M.King & H.Rob.	Triffid weed, Chromolaena	1b	E	110	Severe	No	0	0
483	Invert. (t)	Chrysolina quadrigemina Suffrian	Greater St. John's wort beetle	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
484	Bird	Chrysolophus pictus (Linnaeus, 1758)	Golden pheasant	Unlisted	E	1758	NE	No	0	0
485	Invert. (t)	Chrysomphalus aonidum (Linnaeus, 1758)	Egyptian black scale	Unlisted	C3	NA	NE	No	0	0
486	Invert. (t)	Chrysomya megacephala (Fabricius, 1794)	Oriental latrine fly	Unlisted	NA	NA	NE	No	0	0
487	Plant (t / fw)	Chukrasia tabularis A.Juss.	Indian mahogany	Unlisted	C2	1	NE	No	0	0
488	Plant (t / fw)	Cichorium intybus L.	Chicory	Unlisted	E	32	NE	No	0	0
489	Invert. (t)	Cinara cronartii Tissot & Pepper, 1967	Black pine aphid	Unlisted	C3	NA	NE	No	0	0
490	Invert. (t)	Cinara cupressi (Buckton, 1881)	Cypress aphid	1b	NA	NA	Some	No	0	0
491	Plant (t / fw)	Cinnamomum camphora (L.) J.Presl	Camphor tree	Context specific	E	17	Negligible	No	0	0
492	Invert. (marine)	Ciona intestinalis (Linnaeus, 1767)	Sea vase, Ascidian	3	E	Harbours only	Negligible	No	0	0
493	Invert. (t)	Circulifer tenellus (Baker, 1896)	Beet leafhopper	Unlisted	Naturalised	2	NE	No	0	0
494	Plant (t / fw)	Cirsium arvense (L.) Scop.	Canada thistle	Unlisted	E	3	NE	No	0	0
495	Plant (t / fw)	Cirsium vulgare (Savi) Ten.	Spear thistle	1b	E	336	Some	No	0	0
496	Invert. (t)	Cissoanthonomus tuberculipennis Hustache, 1939	Seed-feeding weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
497	Plant (t / fw)	Cissus antarctica Vent.	Kangaroo vine	Unlisted	C2	1	NE	No	0	0
498	Plant (t / fw)	Cistus ladanifer L.	Common gum cistus	Unlisted	C2	1	NE	No	0	0
499	Plant (t / fw)	Citrus limon (L.) Burm.f.	Lemon	Unlisted	E	8	NE	No	0	0
500	Plant (marine)	Cladophora prolifera (Roth) Kützing, 1843	No common name found	Unlisted	E	Rocky shores KZN	DD	No	0	0
501	Microbe	Clathrus archeri (Berk.)Dring, 1980	Devil's Fingers	Unlisted	Naturalised	NA	NE	No	0	0
502	Invert. (marine)	Clavelina lepadiformis (Müller, 1776)	Light-bulb sea squirt	Unlisted	E	Harbours, widespread	DD	No	0	0
503	Microbe	Clavulina cristata (L.: Fr.) Schröt.	Kamfingersopp	Unlisted	Introduced	NA	NE	No	0	0

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504	Plant (t / fw)	Cleome houtteana Schltdl.	Pink-queen	Unlisted	C2	1	NE	No	0	0
505	Plant (t / fw)	Clerodendrum bungei Steud.	Glory-flower	Unlisted	E	5	NE	No	0	0
506	Microbe	Clitopilus prunulus (Scop.) P. Kumm. , 1871	Sweetbread Mushroom	Unlisted	Introduced	NA	NE	No	0	0
507	Invert. (t)	Clogmia albipunctata (Williston, 1893)	Drain fly	Unlisted	NA	NA	NE	No	0	0
508	Plant (t / fw)	Clusia rosea Jacq.	Balsam fig	Unlisted	E	2	NE	No	0	0
509	Invert. (marine)	Cnemidocarpa humilis (Heller, 1878)	No common name found	Unlisted	E	Harbours and subtidal, west coast	DD	No	0	0
510	Invert. (t)	Coccus hesperidum Linnaeus, 1758	Brown soft scale	Unlisted	NA	NA	NE	No	0	0
511	Invert. (t)	Cochlicella barbara (Linnaeus, 1758)	Small pointed snail	Unlisted	D2	46	Negligible	No	0	0
512	Invert. (t)	Cochlicella ventricosa Draparnaud, 1801	No common name found	Unlisted	NA	NA	NE	No	0	0
513	Invert. (t)	Cochlicopa cf. lubrica (Muller, 1774)	Slippery moss snail	Unlisted	C3	12	Negligible	No	0	0
514	Invert. (t)	Cochlicopa cf. lubricella (Porro, 1838)	Dwarf awlsnail	Unlisted	C3	12	Negligible	No	0	0
515	Plant (marine)	Codium fragile (Suringar) Hariot, 1889	Green sea fingers	Unlisted	E	Rocky shores West coast	DD	No	0	0
516	Invert. (t)	Coelocephalapion camarae Kissinger	Lantana petiole weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
517	Plant (t / fw)	Coix lacryma-jobi L.	Job's tears	Unlisted	E	11	NE	No	0	0
518	Invert. (t)	Coleosoma blandum (Cambridge, 1882)	No common name found	Unlisted	NA	NA	NE	No	0	0
519	Bird	Colinus virginianus (Linnaeus, 1758)	Northern bobwhite quail	2	Introduced	1	NE	Yes	0	0
520	Plant (t / fw)	Colocasia esculenta (L.) Schott	Elephant's ear	Unlisted	E	19	NE	No	0	0
521	Bird	Coloeus monedula (Linnaeus, 1758)	Eurasian jackdaw	Unlisted	C3	20	NE	Yes	0	0
522	Bird	Columba livia (Gmelin, 1789)	Rock dove	Context specific	E	504	Some	Yes	0	0
523	Bird	Columba palumbus Linnaeus, 1758	Common wood-pigeon	2	E	102	Some	Yes	0	0
524	Bird	Columbina inca (Lesson, 1847)	Inva dove	Unlisted	Introduced	1	NE	No	0	0
525	Plant (t / fw)	Combretum indicum (L.) DeFilipps	Rangoon-creeper	Unlisted	C2	1	NE	No	0	0
526	Invert. (t)	Comperiella bifasciata Howard, 1906	Red scale parasite	Unlisted	NA	NA	NE	No	0	0
527	Invert. (marine)	Conopeum seurati (Canu, 1928)	No common name found	Unlisted	E	Estuaries/bays, Saldanha and Zandvlei only	DD	No	0	0
528	Invert. (t)	Contarinia sorghicola (Coquillett, 1899)	Sorghum midge	Unlisted	NA	NA	NE	No	0	0
529	Plant (t / fw)	Convolvulus arvensis L.	Field bindweed	1b	E	2	Some	No	0	0
530	Invert. (t)	Copidosoma koehleri Blanchard, 1940	No common name found	Unlisted (Biocontrol agent with permit)	NA	NA	Negligible	Yes	RP	0

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531	Microbe	Coprinopsis picacea (Bull.) Redhead, Vilgalys & Moncalvo, 2001	Magpie Inkcap	Unlisted	Naturalised	NA	NE	No	0	0
532	Plant (t / fw)	Coprosma repens A.Rich.	Mirrorplant	Unlisted	E	2	NE	No	0	0
533	Invert. (t)	Coptotermes amanii (Sjostedt 1911)	No common name found	Unlisted	Introduced	KZN	NE	No	0	0
534	Invert. (t)	Coptotermes curvignathus Holmgren	Rubber termite	Unlisted	Introduced	KZN	NE	No	0	0
535	Invert. (t)	Coptotermes formosanus (Shiraki, 1909)	Formosan subterranean termite	1b	Introduced	WC	Some	No	0	0
536	Bird	Coracias cyanogaster Cuvier, 1816	Blue-bellied roller	Unlisted	NA	NA	NE	No	0	0
537	Reptile	Corallus hortulanus Linnaeus, 1758	Amazon tree boa	Unlisted	NA	NA	NE	No	0	0
538	Plant (t / fw)	Corchorus trilocularis L.	Threelocule corchorus	Unlisted	C2	15	NE	No	0	0
539	Reptile	Cordylus warreni mossambicus Fitzsimons, 1958	No common name found	Unlisted	Introduced	21	NE	No	0	0
540	Plant (t / fw)	Coreopsis lanceolata L.	Tickseed	1a	E	38	Negligible	No	0	0
541	Invert. (t)	Cornu aspersum (Muller, 1774)	Common garden snail	Unlisted	E	115	Severe	No	0	0
542	Invert. (t)	Cornuaspis beckii Borchsenius, 1963	Citrus mussel scale	Unlisted	NA	NA	NE	No	0	0
543	Plant (t / fw)	Cornus cf. florida L.	Flowering dogwood	Unlisted	C2	1	NE	No	0	0
544	Plant (t / fw)	Cortaderia jubata (Lemoine) Stapf.	Pampas grass	1b	E	35	Negligible	No	0	0
545	Plant (t / fw)	Cortaderia selloana (Schult.) Asch. & Graebn.	Pampas grass	1b	E	41	Some	No	0	0
546	Bird	Corvus splendens Vieillot, 1817	House crow	1a	C3	16	Negligible	No	0	0
547	Plant (t / fw)	Corymbia ficifolia (F.Muell.) K.D.Hill & L.A.S.Johnson	Red flowering gum	Unlisted	E	1	NE	No	0	0
548	Invert. (marine)	Coryne eximia Allman, 1859	No common name found	Unlisted	E	Harbour/Lagoon Table Bay –Langebaan	DD	No	0	0
549	Invert. (t)	Cosmophila sabulifera (Guénée, 1852)	Angled gem moth	Unlisted	C2	Offshore island	NE	No	0	0
550	Invert. (t)	Cosmopolites sordidus (Germar, 1824)	Banana root borer	1b	C3	NA	NE	No	0	0
551	Plant (t / fw)	Cosmos bipinnatus Cav.	Cosmos	Unlisted	E	144	NE	No	0	0
552	Invert. (t)	Cotesia vestalis (Haliday, 1834)	Parasitoid wasp	Unlisted	NA	NA	NE	No	0	0
553	Plant (t / fw)	Cotoneaster coriaceus Franch.	Milkflower cotoneaster	Unlisted	C2	1	NE	No	0	0
554	Plant (t / fw)	Cotoneaster franchetii Bois	Cotoneaster	1b	E	15	Some	No	0	0
555	Plant (t / fw)	Cotoneaster glaucophyllus Franch.	Late cotoneaster	1b	E	1	Some	No	0	0
556	Plant (t / fw)	Cotoneaster pannosus Franch.	Silver leaf cotoneaster	1b	E	41	Some	No	0	0
557	Plant (t / fw)	Cotoneaster salicifolius Franch.	Willow-leaved showberry	1b	NA	NA	Some	No	0	0
558	Plant (t / fw)	Cotoneaster simonsii hort. ex Baker	Himalayan cotoneaster	1b	NA	NA	Some	No	0	0
559	Bird	Coturnix chinensis (Linnaeus, 1766)	Asian blue quail	Unlisted	NA	NA	NE	No	0	0

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560	Invert. (fw)	Craspedacusta sowerbii Lankester, 1880	Freshwater Jellyfish	Unlisted	D2	3	Some	No	0	0
561	Invert. (marine)	Crassostrea gigas (Thunberg, 1793)	Japanese oyster	2	E	Estuaries, S coast	Negligible	Yes	0	0
562	Plant (t / fw)	Crataegus cf. mexicana DC.	Mexican hawthorn	Unlisted	C2	1	NE	No	0	0
563	Plant (t / fw)	Crataegus monogyna Jacq.	English hawthorn	Unlisted	E	2	NE	No	0	0
564	Plant (t / fw)	Crataegus x lavalleei Herincq ex Lavallee	Lavallee thorn	Unlisted	E	4	NE	No	0	0
565	Invert. (t)	Cremastobombycia lantanella Busck, 1910	Lantana leaf miner	Unlisted	NA	NA	NE	No	0	0
566	Bird	Crinifer piscator (Boddaert, 1783)	Western gray plaintain-eater	Unlisted	NA	NA	NE	No	0	0
567	Bird	Criniferoides leucogaster Roberts, 1926	White-bellied-goaway-bird	Unlisted	NA	NA	NE	No	0	0
568	Invert. (t)	Crocidosema lantana Busck	Lantana flower-cluster moth	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
569	Invert. (t)	Crossopriza lyoni (Blackwall, 1867)	Tailed cellar spiders	Unlisted	NA	NA	NE	No	0	0
570	Plant (t / fw)	Crotalaria agatiflora Schweinf.	Canarybird bush	1b	E	33	Negligible	No	0	0
571	Reptile	Crotalus adamanteus Palisot de Beauvois, 1799	Eastern diamond-backed rattlesnake	Unlisted	NA	NA	Negligible	No	0	1
572	Reptile	Crotalus atrox Baird & Girard, 1853	Western diamond-backed rattlesnake	Unlisted	NA	NA	Negligible	No	0	1
573	Reptile	Crotalus durissus Linnaeus, 1758	Cascabel rattlesnake	Unlisted	NA	NA	Negligible	No	0	1
574	Reptile	Crotalus enyo (Cope, 1861)	Baja California rattlesnake	Unlisted	NA	NA	NE	No	0	0
575	Reptile	Crotalus lepidus Kennicott, 1861	Rock rattlesnake	Unlisted	NA	NA	NE	No	0	0
576	Reptile	Crotalus simus Latreille In Sonnini & Latreille, 1801	Central American rattlesnake	Unlisted	NA	NA	Negligible	No	0	1
577	Reptile	Crotalus vegrandis Klauber, 1941	Uracoan rattlesnake	Unlisted	NA	NA	Negligible	No	0	1
578	Reptile	Cryptelytrops purpureomaculatus (Gray, 1832)	Mangrove pit viper	Unlisted	NA	NA	NE	No	0	0
579	Plant (t / fw)	Cryptomeria japonica (L.f.) D.Don	Japanese cedar	Unlisted	E	2	NE	No	0	0
580	Invert. (t)	Cryptophlebia illepida (Butler, 1882)	Koa seedwormcidae	Prohibited	Introduced	1	NE	No	0	0
581	Plant (t / fw)	Cryptostegia grandiflora Roxb.	Rubber vine	1b	E	21	Major	Yes	1	0
582	Plant (t / fw)	Cryptostegia madagascariensis Bojer ex Decne	Madagascar rubber vine	1b	E	2	Major	No	0	0
583	Invert. (marine)	Cryptosula pallasiana (Moll, 1803)	No common name found	Unlisted	E	Harbours, estuaries, widespread	DD	No	0	0
584	Invert. (t)	Cryptotermes brevis (Walker, 1853)	Powderpost termite	Unlisted	Introduced	WC,KZN,EC	NE	No	0	0
585	Invert. (t)	Ctenarytaina eucalypti (Maskell, 1890)	Blue gum psyllid	Unlisted	C3	NA	NE	No	0	0

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586	Invert. (t)	Ctenocephalides felis (Bouche, 1835)	Cat flea	Unlisted	NA	NA	NE	No	0	0
587	Invert. (t)	Ctenolepisma longicaudata Escherich, 1905	Gray silverfish	Unlisted	NA	NA	NE	No	0	0
588	Fish (fw)	Ctenopharyngodon idella (Valenciennes in Cuvier & Valenciennes, 1844)	Grass carp	Context specific	Introduced	4	Some	No	27	0
589	Fish (fw)	Ctenopharyngodon idella Valenciennes,1844	Triploid grass carp	Context specific	NA	NA	DD	Yes	22	0
590	Reptile	Ctenosaura acanthura Shaw, 1802	Northeastern spinytail iguana	Unlisted	NA	NA	NE	No	0	0
591	Invert. (fw)	Culex pipiens (Linnaeus, 1758)	Northern House Mosquito	Unlisted	E	10	Negligible	No	0	0
592	Reptile	Cuora species (unidentified)	Chinese or Asian box terrapins	1b	NA	NA	Negligible	No	0	0
593	Plant (t / fw)	Cuphea ignea A.DC.	Cigarette bush	Unlisted	C2	1	NE	No	0	0
594	Plant (t / fw)	Cuphea micropetala Kunth	Tartan bush	Unlisted	C2	1	NE	No	0	0
595	Plant (t / fw)	Cupressus arizonica Greene	Arizona cypress	Unlisted	E	17	NE	No	0	0
596	Plant (t / fw)	Cupressus lusitanica Mill.	Mexican cypress	Unlisted	E	2	NE	No	0	0
597	Plant (t / fw)	Cuscuta campestris Yunck.	Common dodder	1b	E	30	Some	No	0	0
598	Plant (t / fw)	Cuscuta suaveolens Ser.	Lucerne dodder	1b	E	2	Some	No	0	0
599	Invert. (t)	Cuthona columbiana (O'Donoghue, 1922)	Sea slug	Unlisted	NA	NA	NE	No	0	0
600	Bird	Cyanoliseus patagonus (Vieillot, 1818)	Patagonian conure	Unlisted	NA	NA	NE	No	0	0
601	Invert. (t)	Cydia pomonella Linnaeus, 1758	Codling moth	Unlisted	NA	NA	NE	No	0	0
602	Invert. (t)	Cydmaea binotata Lea, 1899	hakea leaf weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
603	Plant (t / fw)	Cydonia oblonga Mill.	Quince	Unlisted	E	7	NE	No	0	0
604	Bird	Cygnus atratus (Latham, 1790)	Black swan	Unlisted	Naturalised	2	NE	No	0	0
605	Bird	Cygnus olor (Gmelin, 1789)	Mute swan	Unlisted	NA	NA	NE	No	0	0
606	Invert. (t)	Cylas formicarius (Fabricius, 1798)	Sweet potato weevil	Unlisted	NA	NA	NE	No	0	0
607	Invert. (t)	Cylindroiulus britannicus (Verhoeff, 1891)	Millipede	Unlisted	Introduced	WC	NE	No	0	0
608	Invert. (t)	Cylindroiulus truncorum (Silvestri, 1896)	Millipede	Unlisted	Introduced	WC	NE	No	0	0
609	Plant (t / fw)	Cylindropuntia fulgida (Engelm.) F.M.Knuth var. fulgida	Chain-fruit cholla (previously known as rosea cactus)	1b	E	91	NE	No	0	0
610	Plant (t / fw)	Cylindropuntia fulgida var. mamillata (Schott ex Engelm.) Backeb.	Boxing-glove cactus	1b	E	83	Major	No	0	0
611	Plant (t / fw)	Cylindropuntia imbricata (Haw.) F.M.Knuth	Imbricate cactus	1b	E	137	Major	No	0	0
612	Plant (t / fw)	Cylindropuntia leptocaulis (DC.) F.M.Knuth	Pencil cactus	1b	E	2	Major	No	0	0
613	Plant (t / fw)	Cylindropuntia pallida (DC.) F.M.Knuth	Pink-flowered sheathed cholla	1a	E	10	Major	No	0	0

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614	Plant (t / fw)	Cylindropuntia spinosior (Engelm.) F.M.Knuth	Cane cholla	1a	E	3	Major	No	0	0
615	Amphibian	Cynops pyrrhogaster (Boie, 1826)	Japanese fire belly newt	Unlisted	B2	2	DD	No	0	0
616	Plant (t / fw)	Cynosurus cristatus L.	Crested dog's-tail	Unlisted	Introduced	NA	NE	No	0	0
617	Fish (fw)	Cyprinus carpio (Linnaeus, 1758)	Common carp	Context specific	Invasive	98	Some	Yes	3	0
618	Invert. (t)	Cyrtobagous salviniae Calder & Sands	Salvinia weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
619	Invert. (t)	Cyrtobagous singularis (Hustache, 1929)	Weevil	Unlisted	NA	NA	NE	No	0	0
620	Plant (t / fw)	Cyrtomium falcatum (L.f.) C. Presl	Japanese holly fern	Unlisted	C2	1	NE	No	0	0
621	Invert. (t)	Cyrtophora citricola (Forsskål, 1775)	Tropical tent-web spider	Unlisted	NA	NA	NE	No	0	0
622	Plant (t / fw)	Cytisus scoparius (L.) Link	Scotch broom	1a	E	14	Some	Yes	0	0
623	Plant (t / fw)	Dactylis glomerata L.	Cock's-foot	Unlisted	Introduced	NA	NE	No	0	0
624	Invert. (t)	Dactylopius austrinus De Lotto, 1974	Cladode Sucker (Cochineal)	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
625	Invert. (t)	Dactylopius ceylonicus (Green)	Cladode sucker	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
626	Invert. (t)	Dactylopius opuntiae (Cockerell, 1896)	Cladode Sucker (Cochineal)	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
627	Invert. (t)	Dactylopius tomentosus (Lamark),	Cladode Sucker (Cochineal)	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
628	Invert. (t)	Daktulosphaira vitifoliae (Fitch,1855)	Grape phylloxera	Unlisted	NA	NA	NE	No	0	0
629	Mammal	Dama dama (Linnaeus, 1758)	Fallow deer	2	NA	NA	Negligible	Yes	71	0
630	Invert. (t)	Dasineura dielsi (Rübsaamen, 1916)	Flower galler	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
631	Invert. (t)	Dasineura rubiformis Kolesik	Common flower galler	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
632	Invert. (t)	Dasineura strobila Dorchin	Bud galler	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
633	Plant (t / fw)	Datura ferox L.	Large thorn apple	1b	E	86	Some	No	0	0
634	Plant (t / fw)	Datura innoxia Mill.	Downy thorn apple	1b	E	24	Some	No	0	0
635	Plant (t / fw)	Datura metel L.	Purple thorn apple	Unlisted	E	5	NE	No	0	0
636	Plant (t / fw)	Datura stramonium L.	Common thorn apple	1b	E	138	Some	No	0	0
637	Invert. (t)	Deladenus siricidicola Bedding, 1968	Nematode	Unlisted	NA	NA	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
638	Invert. (t)	Delia platura (Meigen, 1826)	Bean seed maggot	Unlisted	NA	NA	NE	No	0	0
639	Plant (t / fw)	Delonix regia (Hook.) Raf.	Flamboyant	Unlisted	E	5	NE	No	0	0
640	Invert. (t)	Dendrobaena cognettii (Michaelsen, 1903)	No common name found	Unlisted	Introduced	WC	NE	No	0	0
641	Invert. (t)	Dendrobaena hortensis (Michaelsen, 1890)	European nightcrawler	Unlisted	Introduced	WC, EC	NE	No	0	0
642	Invert. (t)	Dendrobaena octaedra (Savigny, 1826)	Earthworm	Unlisted	Introduced	LP, KZN, EC, WC	NE	No	0	0
643	Invert. (t)	Dendrobaena veneta (Rosa, 1886)	European nightcrawler	Unlisted	Introduced	Introduced for experimental study	NE	No	0	0
644	Amphibian	Dendrobates auratus (Girard, 1855)	Poison arrow frog	2	B2	4	Negligible	No	0	0
645	Amphibian	Dendrobates leucomelas Steindachner, 1864	Poison arrow frog	2	B1	2	DD	No	0	0
646	Amphibian	Dendrobates tinctorius (Schneider, 1799)	Poison arrow frog	2	B1	1	DD	No	0	0
647	Bird	Dendrocitta vagabunda (Latham, 1790)	Rufous treepie	Unlisted	NA	NA	NE	No	0	0
648	Bird	Dendrocygna autumnalis (Linnaeus, 1758)	Black-bellied whistling duck	Unlisted	NA	NA	NE	No	0	0
649	Bird	Dendrocygna eytoni Eyton, 1838	Plumed whistling duck	1b	NA	NA	NE	No	0	0
650	Invert. (t)	Dendrodrilus rubidus (Savigny, 1826)	Bark-eating worm	Unlisted	NA	NA	NE	No	0	0
651	Invert. (t)	Dendrodrilus rubidus subsp. rubidus (Savigny, 1826)	Bark-eating worm	Unlisted	Introduced	LP, KZN, FS, GP, EC, WC	NE	No	0	0
652	Invert. (t)	Dendrodrilus rubidus subsp. subrubicundus Eisen, 1873	European barkworm	Unlisted	Introduced	FS, WC, KZN, GP	NE	No	0	0
653	Invert. (t)	Dendrolaelaps species (unidentified species)	Mite	Unlisted	NA	Offshore island	NE	No	0	0
654	Invert. (t)	Dendrosoter caenopachoides Ruschka, 1925	No common name found	Unlisted	NA	NA	NE	No	0	0
655	Plant (t / fw)	Deparia japonica (Thunb.) M.Kato	Petersen's-spleenwort	Unlisted	C2	2	NE	No	0	0
656	Invert. (t)	Dermestes maculatus De Geer, 1774	Hide beetle	Unlisted	NA	NA	NE	No	0	0
657	Invert. (t)	Deroceras invadens Reise et al, 2011	Tramp slug	Unlisted	D2	10	Severe	No	0	0
658	Invert. (t)	Deroceras laeve (Muller, 1774)	Meadow slug	Unlisted	D2	28	Some	No	0	0
659	Invert. (t)	Deroceras panormitanum (Lessona & Pollonera)	Long-neck field slug	Unlisted	E	Offshore island	Some	No	0	0
660	Invert. (t)	Deroceras reticulatum (Muller, 1774)	Gray fieldslug	Unlisted	D2	15	Negligible	No	0	0
661	Plant (t / fw)	Desmanthus virgatus (L.) Willd.	Ground tamarind	Unlisted	C2	1	NE	No	0	0
662	Plant (t / fw)	Desmodium uncinatum (Jacq.) DC.	Silverleaf desmodium	Unlisted	E	4	NE	No	0	0
663	Plant (t / fw)	Dianella tasmanica Hook.	Blue flax-lily	Unlisted	C2	1	NE	No	0	0
664	Invert. (t)	Diaspidiotus perniciosus (Comstock, 1881)	San Jose scale	Unlisted	NA	NA	NE	No	0	0
665	Invert. (t)	Diaspis bromeliae (Kerner, 1778)	Pineapple Scale	Unlisted	NA	NA	NE	No	0	0

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666	Mammal	Diceros bicornis michaeli Zukowsky, 1965	Black rhinoceros (Kenya)	2	Naturalised	16	NE	Yes	0	0
667	Invert. (t)	Dichogaster affinis (Michaelsen, 1890)	Earthworm	Unlisted	Introduced	LP, KZN	NE	No	0	0
668	Invert. (t)	Dichogaster annae Horst, 1893	Earthworm	Unlisted	Introduced	KZN	NE	No	0	0
669	Invert. (t)	Dichogaster bolaui (Michaelsen, 1891)	Earthworm	Unlisted	NA	NA	NE	No	0	0
670	Invert. (t)	Dichogaster bolavi (Michaelsen, 1891)	Earthworm	Unlisted	Introduced	LP	NE	No	0	0
671	Invert. (t)	Dichogaster krugeri (Reinecke & Ackerman, 1997)	Earthworm	Unlisted	Introduced	LP	NE	No	0	0
672	Invert. (t)	Dichogaster modiglianii (Rosa, 1896)	Earthworm	Unlisted	Introduced	KZN	NE	No	0	0
673	Invert. (t)	Dichogaster saliens (Beddard, 1893)	Earthworm	Unlisted	Introduced	LP, KZN, EC	NE	No	0	0
674	Invert. (t)	Dicomada rufa Blackburn, 1890	Bud-feeding weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
675	Invert. (t)	Dicyrtomina minuta (O. Fabricius, 1783)	No common name found	Unlisted	Introduced	WC	NE	No	0	0
676	Invert. (t)	Dimidiogalumna villiersensis Engelbrecht, 1972	Mites	Unlisted	Introduced	KZN, FS	NE	No	0	0
677	Invert. (marine)	Dinophysis acuminata Claparède & Lachmann, 1859	No common name found	Unlisted	C2	Open coast	DD	No	0	0
678	Plant (t / fw)	Diplazium esculentum (Retz.) Sw.	Vegetable fern	Unlisted	C2	2	NE	No	0	0
679	Plant (t / fw)	Diplocyclos palmatus L.	Lollipop-climber	1a	E	4	Major	No	0	0
680	Invert. (marine)	Diplosoma listerianum (Milne-Edwards, 1841)	No common name found	Unlisted	E	Harbours, rocky intertidal	DD	No	0	0
681	Invert. (t)	Dirofilaria immitis Leidy, 1856	Heartworm nematode	1b	NA	NA	Negligible	No	0	0
682	Invert. (marine)	Discinisca tenuisa (Sowerby)	Disc lamp shell	1b	E	Saldanha Bay and St Helena Bay	DD	No	0	0
683	Invert. (t)	Discus rotundatus (Muller, 1774)	Rotund disc	Unlisted	D2	4	Negligible	No	0	0
684	Invert. (t)	Disparipes antarcticus Richters	No common name found	Unlisted	NA	Offshore island	NE	No	0	0
685	Plant (t / fw)	Dittrichia graveolens (L.) Greuter	Cape khakiweed	Unlisted	C2	2	NE	No	0	0
686	Invert. (t)	Ditylenchus destructor Thorne 1945	Potato rot nematode	1b	NA	NA	Negligible	No	0	0
687	Invert. (t)	Ditylenchus dipsaci (Kuhn, 1857) Filip'ev, 1936	Stem and bulb nematode	1b	NA	NA	NE	No	0	0
688	Invert. (t)	Diuraphis noxia Kurdjumov, 1913	Russian wheat aphid	Unlisted	NA	NA	NE	No	0	0
689	Invert. (t)	Dixoncis pictus Oke, 1931	Old-fruit borer	Unlisted	NA	NA	NE	No	0	0
690	Invert. (marine)	Dodecaceria fewkesi Berkeley and Berkeley, 1954	Black coral worm	1b	C3	Harbour Table bay only	DD	No	0	0
691	Plant (t / fw)	Dolichandra unguis-cati L. (A.Gentry)	Cat's claw creeper	1b	E	44	Severe	No	0	0
692	Plant (t / fw)	Droguetia species (unidentified)	No common name found	Unlisted	C2	1	NE	No	0	0

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693	Invert. (t)	Drosophila flavohirta Malloch, 1924	Fruit fly	Unlisted	C3	NA	NE	No	0	0
694	Plant (t / fw)	Dryandra formosa R.Br.	Showy dryandra	Unlisted	C2	1	NE	No	0	0
695	Reptile	Drymarchon couperi Holbrook, 1842	Eastern indigo snake	Unlisted	NA	NA	NE	No	0	0
696	Plant (t / fw)	Duchesnea indica (Jacks.) Focke	Wild strawberry	1b	E	19	Negligible	No	0	0
697	Plant (t / fw)	Duranta erecta L.	Forget-me-not-tree	Context specific	E	13	Negligible	Yes	0	0
698	Amphibian	Duttaphrynus melanostictus (Schneider, 1799)	Asian common toad	Unlisted	C1	2	Major	No	0	0
699	Invert. (marine)	Dynamene bidentata (Adams, 1800)	No common name found	Unlisted	E	Harbour Port Elizabeth only	DD	No	0	0
700	Invert. (t)	Dysaphis apiifolia (Theobald, 1923)	Hawthorn parsley aphid	Unlisted	NA	NA	NE	No	0	0
701	Invert. (t)	Dysaphis foeniculus (Theobald, 1923)	Carrot aphid	Unlisted	NA	NA	NE	No	0	0
702	Invert. (t)	Dysaphis tulipae (Boyer de Fonscolombe, 1841)	Tulip bulb aphid	Unlisted	NA	NA	NE	No	0	0
703	Amphibian	Dyscophus antongilii Grandidier, 1877	Madagascar tomato frog	Unlisted	B1	1	DD	No	0	0
704	Invert. (t)	Dysdera crocata Koch, 1838	Woodlouse spider	Unlisted	NA	NA	NE	No	0	0
705	Invert. (t)	Dysmicoccus brevipes (Cockerell, 1893)	Pineapple mealybug	Unlisted	NA	NA	NE	No	0	0
706	Plant (t / fw)	Dysphania ambrosioides (L.) Mosyakin & Clemants	American goosefoot	Unlisted	E	25	NE	No	0	0
707	Invert. (t)	Eccritotarsus catarinensis (Carvalho, 1948)	Sap-feeding mirid	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	No	RP	0
708	Invert. (t)	Echidnophaga gallinacea (Westwood, 1875)	Hen flea	Unlisted	NA	NA	NE	No	0	0
709	Plant (t / fw)	Echinochloa esculenta (A. Braun) H.Scholz	Japanese millet	Unlisted	Introduced	NA	NE	No	0	0
710	Plant (t / fw)	Echinodorus cordifolius (L.) Griseb.	Creeping burhead	1b	NA	NA	Major	No	0	0
711	Plant (t / fw)	Echinodorus tenellus (Mart. ex Schult.) Buchenau	Amazon sword plant	1b	NA	NA	Major	No	0	0
712	Plant (t / fw)	Echinopsis chamaecereus F. Friedrich & W.Glaetzle	Peanut cactus	Unlisted	E	2	NE	No	0	0
713	Plant (t / fw)	Echinopsis huascha (Web.) Friedrich & G.D.Rowley	Red torch cactus	Unlisted	C2	1	NE	No	0	0
714	Plant (t / fw)	Echinopsis oxygona (Link & Otto) Zucc. ex Pfeiff.	Pink Easter-lily cactus	Unlisted	C2	1	NE	No	0	0
715	Plant (t / fw)	Echinopsis schickendantzii F.A.C.Weber	Torch cactus	1b	NA	NA	Major	No	0	0
716	Plant (t / fw)	Echium candicans L.f.	Pride-of-Madeira	Unlisted	E	4	NE	No	0	0
717	Plant (t / fw)	Echium plantagineum L.	Patterson's curse	1b	E	104	Severe	No	0	0
718	Plant (t / fw)	Echium vulgare L.	Blue echium	1b	E	14	Major	No	0	0
719	Invert. (t)	Ectomyelois ceratoniae (Zeller)	Locust bean moth	Unlisted	C3	NA	NE	No	0	0
720	Plant (t / fw)	Egeria densa Planch.	Dense water weed	1b	E	14	Major	No	0	0
721	Plant (t / fw)	Eichhornia crassipes (Mart.) Solms	Water hyacinth	1b	E	105	Major	No	0	0

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722	Invert. (t)	Eisenia andrei (Bouche 1972)	No common name found	Unlisted	Introduced	NA	NE	No	0	0
723	Invert. (t)	Eisenia fetida (Savigny, 1826)	Redworm	Unlisted	Introduced	LP, GP, WC, KZN, EC, WC	NE	No	0	0
724	Invert. (t)	Eiseniella tetraedra (Savigny, 1826)	Square-tailed worm	Unlisted	Introduced	GP, EC, NW, KZN, WC	NE	No	0	0
725	Plant (t / fw)	Elaeocarpus sphaericus (Gaertn.) K.Schum.	Blueberry-ash	Unlisted	C2	1	NE	No	0	0
726	Reptile	Elaphe schrenckii Strauch, 1873	Amur ratsnakes	Unlisted	NA	NA	NE	No	0	0
727	Reptile	Elaphe spiloides (Duméril, Bibron and Duméril, 1854)	Gray rat snake	Unlisted	NA	NA	NE	No	0	0
728	Mammal	Elaphurus davidianus Milne-Edwards, 1866	Père David's deer	2	NA	NA	Negligible	Yes	0	0
729	Invert. (marine)	Elimidius modestus Darwin, 1854	New Zealand Barnacle	Unlisted	C2	Table Bay harbour only	DD	No	0	0
730	Plant (t / fw)	Elodea canadensis Michx.	Canadian water weed	1b	C2	1	Major	No	0	0
731	Plant (t / fw)	Elymus caninus (L.) L.	Bearded couch grass	Unlisted	Introduced	NA	NE	No	0	0
732	Plant (t / fw)	Elymus elongatus (Host) Runemark	Tall wheatgrass	Unlisted	Introduced	NA	NE	No	0	0
733	Plant (t / fw)	Elymus repens (L.) Gould	Couch grass	Context specific	C3	Offshore island	Major	No	0	0
734	Plant (t / fw)	Elymus smithii (Rydb.) Gould	Western wheatgrass	Unlisted	Introduced	NA	NE	No	0	0
735	Plant (t / fw)	Elymus trachycaulus (Link) Gould ex Shinners	Slender wheatgrass	Unlisted	Introduced	NA	NE	No	0	0
736	Reptile	Emys orbicularis Linnaeus, 1758	European pond turtle	1b	NA	NA	Negligible	No	0	0
737	Invert. (t)	Enoggera reticulata Naumann, 1991	No common name found	Unlisted	NA	NA	NE	No	0	0
738	Plant (t / fw)	Enterolobium contortisiliquum (Vell.) Morong	Black ear	Unlisted	C2	1	NE	No	0	0
739	Invert. (t)	Entomobrya multifasciata (Tullberg, 1871)	No common name found	Unlisted	Introduced	WC, NC, G	NE	No	0	0
740	Invert. (t)	Entomobrya nivalis (Linnaeus, 1758)	Cosmopolitan springtail	Unlisted	Introduced	WC, EC, FS, KZN	NE	No	0	0
741	Microbe	Entyloma ageratinae R.W. Barreto & H.C. Evans	No common name found	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
742	Invert. (t)	Eobania vermiculata (Muller, 1774)	Chocolate-Band Snail	Unlisted	C3	11	Some	No	0	0
743	Invert. (t)	Ephestia elutella Hübner, 1796	Tobacco moth	Unlisted	NA	NA	NE	No	0	0
744	Invert. (t)	Ephestia kuehniella Zeller, 1879	Mediterranean flour moth	Unlisted	NA	NA	NE	No	0	0
745	Reptile	Epicrates cenchria Linnaeus, 1758	Rainbow boa	Unlisted	NA	NA	NE	No	0	0
746	Reptile	Epicrates maurus Gray, 1849	Brown rainbow boa	Unlisted	NA	NA	NE	No	0	0
747	Invert. (t)	Epilohmannia minuta Berlese, 1920	No common name found	Unlisted	Introduced	FS, KZN, WC	NE	No	0	0
748	Invert. (t)	Epinotia lantana Busck, 1910	Lantana flower-cluster moth	Unlisted	NA	NA	NE	No	0	0

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749	Plant (t / fw)	Epipremnum aureum (Linden & André) G.S.Bunting	Devil's ivy	Unlisted	E	4	NE	Yes	0	0
750	Plant (t / fw)	Equisetum hyemale L.	Rough horsetail	1a	NA	NA	Some	Yes	0	0
751	Mammal	Equus asinus Linnaeus, 1758	Donkey	Unlisted	NA	NA	NE	No	0	0
752	Mammal	Equus ferus caballus Linnaeus, 1758	Horse	Unlisted	NA	NA	NE	No	0	0
753	Plant (t / fw)	Eragrostis tef (Zucc.) Trotter	Teff	Unlisted	Introduced	NA	NE	No	0	0
754	Invert. (t)	Eremaeozetes machadoi Mahunka, 1989	No common name found	Unlisted	Introduced	NW	NE	No	0	0
755	Invert. (marine)	Erichthonius brasiliensis (Dana, 1853)	No common name found	Unlisted	E	Harbours, rocky shores, subtidal	DD	No	0	0
756	Invert. (marine)	Ericthonius difformis Edwards, 1830	No common name found	Unlisted	C2	Kalk Bay harbour only	DD	No	0	0
757	Plant (t / fw)	Erigeron bonariensis L.	Flax-leaf fleabane	Unlisted	E	1	NE	No	0	0
758	Plant (t / fw)	Erigeron canadensis L.	Horseweed fleabane	Unlisted	E	4	NE	No	0	0
759	Plant (t / fw)	Erigeron karvinskianus DC.	Mexican fleabane	Unlisted	E	2	NE	No	0	0
760	Plant (t / fw)	Erigeron primulifolius (Lam.) Greuter	Chilean fleabane	Unlisted	C2	1	NE	No	0	0
761	Plant (t / fw)	Erigeron sumatrensis Retz.	Tall fleabane	Unlisted	E	102	NE	No	0	0
762	Plant (t / fw)	Eriobotrya japonica (Thunb.) Lindl.	Loquat	Context specific	E	7	Negligible	No	0	0
763	Invert. (t)	Eriosoma lanigerum (Hausmann, 1802)	Woolly apple aphid	Unlisted	C3	NA	NE	No	0	0
764	Invert. (t)	Eriosoma pyricola Baker, A.C. & Davidson, 1916	Woolly pear aphid	Unlisted	C3	NA	NE	No	0	0
765	Invert. (t)	Eristalis tenax (Linnaeus, 1758)	Drone fly	Unlisted	C2	23	NE	No	0	0
766	Microbe	Erysiphe pisi DC., 1805	No common name found	Unlisted	Introduced	NA	NE	No	0	0
767	Invert. (t)	Erytenna consputa Pascoe, 1870	hakea fruit weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
768	Microbe	Erythricium salmonicolor (Berk. & Broome) Burds., 1985	No common name found	Unlisted	Naturalised	NA	NE	No	0	0
769	Mammal	Erythrocebus patas (Schreber, 1774)	Patas monkey	Context specific	NA	NA	Negligible	Yes	1	0
770	Plant (t / fw)	Eschscholzia californica Cham.	Californian poppy	Unlisted	C2	2	NE	No	0	0
771	Invert. (t)	Ethiovertex sculperens (Kok, 1968)	No common name found	Unlisted	Introduced	All provinces	NE	No	0	0
772	Reptile	Eublepharis macularius (Blyth 1854)	Leopard gecko	Unlisted	NA	NA	NE	No	0	0
773	Invert. (t)	Euborellia annulipes (Lucas, 1847)	Ringlegged earwig	Unlisted	NA	NA	NE	No	0	0
774	Plant (t / fw)	Eucalyptus botryoides Sm.	Bangalay	Unlisted	C2	1	NE	No	0	0
775	Plant (t / fw)	Eucalyptus camaldulensis Dehnh.	River red gum	Context specific	E	136	Severe	Yes	3	0
776	Plant (t / fw)	Eucalyptus cinerea F.Muell. ex Benth.	Florist's gum	Unlisted	E	17	NE	No	0	0
777	Plant (t / fw)	Eucalyptus cladocalyx F. Muell.	Sugar gum	Context specific	E	39	Negligible	Yes	0	0

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778	Plant (t / fw)	Eucalyptus cloeziana F.Muell.	Iron gum	Unlisted	C2	1	NE	No	0	0
779	Plant (t / fw)	Eucalyptus conferruminata D.J.Carr & S.G.M.Carr	Spider gum	Context specific	E	18	Negligible	Yes	0	0
780	Plant (t / fw)	Eucalyptus diversicolor F. Muell.	Karri	Context specific	E	8	Negligible	Yes	0	0
781	Plant (t / fw)	Eucalyptus exserta F.Muell.	Queensland peppermint	Unlisted	C2	1	NE	No	0	0
782	Plant (t / fw)	Eucalyptus fastigata Deane & Maiden	Cut-tail gum	Unlisted	C2	1	NE	No	0	0
783	Plant (t / fw)	Eucalyptus globulus Labill.	Blue gum	Unlisted	E	3	NE	No	0	0
784	Plant (t / fw)	Eucalyptus gomphocephala A.DC.	Tuart	Unlisted	E	2	NE	No	0	0
785	Plant (t / fw)	Eucalyptus grandis W.Hill ex Maiden	Saligna gum	Context specific	E	64	Negligible	Yes	0	0
786	Plant (t / fw)	Eucalyptus leucoxylon F. Muell.	White ironbark	Unlisted	E	2	NE	No	0	0
787	Plant (t / fw)	Eucalyptus melliodora A. Cunn. ex Schauer	Yellow box gum	Unlisted	C2	1	NE	No	0	0
788	Plant (t / fw)	Eucalyptus microcorys F. Muell.	Tallow gum	Unlisted	C2	1	NE	No	0	0
789	Plant (t / fw)	Eucalyptus microtheca F. Muell.	Coolabah	Unlisted	C2	1	NE	No	0	0
790	Plant (t / fw)	Eucalyptus paniculata Sm.	Grey ironbark	Unlisted	C2	1	NE	No	0	0
791	Plant (t / fw)	Eucalyptus regnans F.Muell.	Mountain ash	Unlisted	E	6	NE	No	0	0
792	Plant (t / fw)	Eucalyptus robusta Sm.	Mahogany gum	Unlisted	C2	1	NE	No	0	0
793	Plant (t / fw)	Eucalyptus sideroxylon A.Cunn ex Woolls	Swamp mahogany gum	Unlisted	E	11	NE	No	0	0
794	Plant (t / fw)	Eucalyptus species (unidentified)	Gum tree	Unlisted	E	579	NE	No	0	0
795	Plant (t / fw)	Eucalyptus tereticornis Sm.	Forest red gum	Context specific	C2	1	Negligible	Yes	0	0
796	Bird	Eudocimus ruber (Linnaeus, 1758)	Scarlet ibis	Unlisted	NA	NA	NE	No	0	0
797	Invert. (t)	Eudriloides durbanensis (Beddard,1893)	Earthworm	Unlisted	Introduced	KZN	NE	No	0	0
798	Invert. (t)	Eudrilus eugeniae (Kinberg, 1867)	African nightcrawler	Unlisted	Introduced	KZN, NW	NE	No	0	0
799	Plant (t / fw)	Eugenia uniflora L.	Pitanga, Surinam cherry	1b	E	3	Negligible	No	0	0
800	Invert. (fw)	Eukerria saltensis (Beddard, 1895)	A subtropical earthworm	Unlisted	Introduced	GP, KZN, FS, NW, MP, EC, WC, MP	NE	No	0	0
801	Invert. (t)	Eulachnus rileyi (Williams, T.A., 1911)	Pine needle aphid	Unlisted	C3	NA	NE	No	0	0
802	Reptile	Eunectes notaeus Cope, 1862	Yellow anaconda	Unlisted	NA	NA	NE	No	0	0
803	Bird	Euodice cantans (Gmelin, 1789)	African silverback	Unlisted	NA	NA	NE	No	0	0
804	Plant (t / fw)	Euphorbia esula L.	Leafy spurge	1a	C2	1	Some	No	0	0
805	Plant (t / fw)	Euphorbia heterophylla L.	Annual poinsettia	Unlisted	E	24	NE	No	0	0
806	Plant (t / fw)	Euphorbia indica Lam.	No common name found	Unlisted	E	7	NE	No	0	0
807	Plant (t / fw)	Euphorbia lathyris L.	Moleplant	Unlisted	E	2	NE	No	0	0
808	Plant (t / fw)	Euphorbia leucocephala Lotsy	White poinsettia	1b	C2	2	Negligible	No	0	0

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809	Plant (t / fw)	Euphorbia milii Des Moul.	Christ's-thorn	Unlisted	C2	2	NE	No	0	0
810	Plant (t / fw)	Euphorbia peplus L.	Stinging milkweed	Unlisted	C2	3	NE	No	0	0
811	Plant (t / fw)	Euphorbia pulcherrima Willd. ex Klotzsch	Poinsettia	Unlisted	E	7	NE	No	0	0
812	Plant (t / fw)	Euphorbia terracina L.	Geraldton carnation	Unlisted	E	5	NE	No	0	0
813	Invert. (t)	Evania appendigaster (Linnaeus, 1758)	No common name found	Unlisted	B3	2	NE	No	0	0
814	Bird	Falco columbarius Linnaeus, 1758	Merlin	Unlisted	NA	NA	NE	No	0	0
815	Invert. (t)	Falconia intermedia (Distant, 1893)	Lantana Sap Sucker	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
816	Plant (t / fw)	Fallopia convolvulus (L.) A. Love	Climbing knotweed	Unlisted	C2	2	NE	No	0	0
817	Plant (t / fw)	Fallopia sachalinensis (F. Schmidt) Ronse Decr.	Giant knotweed	1a	Introduced	1	Negligible	No	0	0
818	Invert. (t)	Fannia albitarsis Stein, 1911	No common name found	Unlisted	B3	4	NE	No	0	0
819	Invert. (t)	Fannia canicularis (L.)	Little House Fly	Unlisted	E	3	NE	No	0	0
820	Mammal	Felis catus Linnaeus, 1758	Domestic cat	1a	Introduced	Offshore island	Major	No	0	0
821	Invert. (t)	Fenusa dohrnii (Tischbein)	Alder leafminer	Unlisted	NA	NA	NE	No	0	0
822	Invert. (t)	Ferrisia malvastra (McDaniel,1962)	White-tailed mealy bug	Unlisted	NA	NA	NE	No	0	0
823	Plant (t / fw)	Festuca arundinacea Schreb	Tall fescue	Unlisted	Introduced	NA	NE	No	0	0
824	Plant (t / fw)	Festuca ovina L.	Sheep's fescue	Unlisted	Introduced	NA	NE	No	0	0
825	Plant (t / fw)	Festuca pratensis Huds.	Meadow fescue	Unlisted	Introduced	NA	NE	No	0	0
826	Plant (t / fw)	Festuca rubra L.	Creeping red fescue	Context specific	C3	Offshore island	Major	No	0	0
827	Invert. (marine)	Ficopomatus enigmaticus (Fauvel, 1923)	Estuarine tube-worm	1b	E	Estuaries, Berg River to KZN	Some	No	0	0
828	Plant (t / fw)	Ficus carica L.	Edible fig	Unlisted	E	25	NE	No	0	0
829	Plant (t / fw)	Ficus elastica Roxb. ex Hornem.	Rubber fig	Unlisted	C2	1	NE	No	0	0
830	Plant (t / fw)	Ficus macrophylla Pers.	Australian banyan	Unlisted	C2	1	NE	No	0	0
831	Plant (t / fw)	Flaveria bidentis (L) Kuntze	Smelter's-bush	1b	E	56	Some	No	0	0
832	Plant (t / fw)	Foeniculum vulgare A.W.Hill	Fennel	Unlisted	E	47	NE	No	0	0
833	Bird	Forpus passerinus (Linnaeus, 1758)	Blue-winged parrotlet	Unlisted	NA	NA	NE	No	0	0
834	Bird	Foudia madagascariensis Linnaeus, 1766	Madagascar red fody	3	NA	NA	Some	No	0	0
835	Invert. (t)	Frankliniella occidentalis (Pergande, 1895)	Western flower thrips	Unlisted	NA	NA	NE	No	0	0
836	Invert. (t)	Frankliniella schultzei (Trybom, 1910)	Common blossom thrips	Unlisted	NA	NA	NE	No	0	0
837	Plant (t / fw)	Fraxinus americana L.	American ash	Context specific	E	12	Negligible	No	0	0
838	Plant (t / fw)	Fraxinus angustifolia Vahl	Algerian ash	3	E	4	Some	No	0	0
839	Plant (t / fw)	Fraxinus species (unidentified)	Ash tree	Unlisted	E	31	NE	No	0	0
840	Plant (t / fw)	Fraxinus?pennsylvanica/?velutina (identification uncertain)	Green ash	Unlisted	E	8	NE	No	0	0

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841	Invert. (t)	Friesea claviseta Axelson, 1900	No common name found	Unlisted	Introduced	KZN, WC	NE	No	0	0
842	Bird	Fringilla coelebs Linnaeus, 1758	Chaffinch	2	C3	4	Negligible	Yes	0	0
843	Invert. (t)	Fucellia tergina (Zetterstedt, 1845)	No common name found	Unlisted	B3	2	NE	No	0	0
844	Plant (t / fw)	Fuchsia species (unidentified)	fuchsia	Unlisted	E	8	NE	No	0	0
845	Bird	Fulica americana Gmelin, 1789	American coot	Unlisted	NA	NA	NE	No	0	0
846	Invert. (t)	Fulmekiola serrata Kobus, 1893	Sugarcane thrips	Unlisted	NA	NA	NE	No	0	0
847	Plant (t / fw)	Fumaria muralis Sond. ex Koch	Wall fumitory	Unlisted	C2	7	NE	No	0	0
848	Plant (t / fw)	Fumaria officinalis L.	Common fumitory	Unlisted	C2	1	NE	No	0	0
849	Reptile	Furcifer oustaleti (Mocquard, 1894)	Oustalet's chameleon	2	NA	NA	Negligible	Yes	0	0
850	Reptile	Furcifer pardalis (Cuvier, 1829)	Panther chameleon	2	NA	NA	Negligible	Yes	0	0
851	Plant (t / fw)	Furcraea foetida L.	Mauritian hemp	1a	E	20	Some	No	0	0
852	Plant (t / fw)	Furcraea selloa K.Koch	Maguey	Unlisted	E	2	NE	No	0	0
853	Microbe	Fusarium circinatum Nirenberg & O'Donnell, 1998	No common name found	1b	NA	NA	NE	No	0	0
854	Plant (t / fw)	Galinsoga parviflora Cav.	Gallant soldier	Unlisted	E	8	NE	No	0	0
855	Invert. (t)	Galleria mellonella Linnaeus, 1758	Greater wax moth	Unlisted	NA	NA	NE	No	0	0
856	Bird	Gallinula comeri (Allen, JA, 1892)	Gough moorhen	Unlisted	NA	NA	NE	No	0	0
857	Bird	Gallinula nesiotis P. L. Sclater, 1861	Tristan moorhen	Unlisted	NA	NA	NE	No	0	0
858	Bird	Gallus gallus (Linnaeus, 1758)	Red jungle fowl	Unlisted	NA	NA	NE	No	0	0
859	Invert. (t)	Galumna barnardi (Jacot, 1940)	No common name found	Unlisted	Introduced	WC	NE	No	0	0
860	Invert. (t)	Galumna discifera Balogh, 1960	No common name found	Unlisted	Introduced	LP, KZN, NW, FS, MP, WC, EC	NE	No	0	0
861	Fish (fw)	Gambusia affinis (Baird & Girard, 1853)	Mosquito-fish	Context specific	Invasive	33	Some	No	1	0
862	Plant (t / fw)	Gamochaeta pensylvanica (Willd.) Cabrera	Pennsylvania cudweed	Unlisted	E	5	NE	No	0	0
863	Invert. (t)	Gargaphia decoris Drake, 1931	Woolly nightshade lace bug	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
864	Reptile	Gehyra mutilata (Wiegmann, 1834)	Stump-tailed gecko	3	NA	NA	Negligible	No	0	0
865	Reptile	Gekko gecko (Linnaeus, 1758)	Tokay gecko	2	NA	NA	Negligible	Yes	1	0
866	Reptile	Gekko monarchus Schlegel, 1836	Spotted house gecko	Unlisted	B3	1	DD	No	0	0
867	Invert. (t)	Geminozetes lamellatus Balogh, 1966	No common name found	Unlisted	Introduced	MP	NE	No	0	0
868	Plant (t / fw)	Genista monspessulana (L.) L.A.S.Johnson	Montpellier broom	1a	E	5	Some	Yes	0	0

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869	Bird	Geopelia cuneata (Latham, 1802)	Diamond dove	Unlisted	NA	NA	NE	No	0	0
870	Plant (t / fw)	Glandularia aristigera (S. Moore) Tronc.	Fine-leaved verbena	Unlisted	E	87	NE	No	0	0
871	Plant (t / fw)	Glandularia hybrida (hort. ex Groenl. & Rümpler) G.L.Nesom & Pruski	Garden verbena	Unlisted	C2	1	NE	No	0	0
872	Plant (t / fw)	Glebionis coronaria (L.) Cass. ex Spach	Chrysanthemum greens	Unlisted	E	2	NE	No	0	0
873	Plant (t / fw)	Gleditsia triacanthos L.	Honey locust	1b	E	158	Negligible	No	0	0
874	Invert. (t)	Globodera rostochiensis (Wollenweber, 1923) Behrens, 1975	Golden cyst nematode	1b	NA	NA	Some	No	0	0
875	Invert. (t)	Glycaspis brimblecombei Moore, 1964	Red gum lerp psyllid	Unlisted	C3	NA	NE	No	0	0
876	Plant (t / fw)	Glyceria maxima (Hartm.) Holmb.	Reed meadow grass	Context specific	E	9	Major	No	0	0
877	Invert. (t)	Glycyphagus domesticus (de Geer)	House itch mite	Unlisted	NA	Offshore island	NE	No	0	0
878	Plant (t / fw)	Gnaphalium luteoalbum L.	Jersey cudweed	Unlisted	C2	1	NE	No	0	0
879	Invert. (t)	Gnathocerus cornutus (Fabricius, 1798)	Broad-horned flour beetle	Unlisted	NA	NA	NE	No	0	0
880	Plant (t / fw)	Gomphrena celosioides Mart.	Prostrate globe amaranth	Unlisted	E	30	NE	No	0	0
881	Reptile	Gongylophis colubrinus Linnaeus, 1758	Spotted house gecko	Unlisted	NA	NA	NE	No	0	0
882	Reptile	Gongylophis conicus Schneider, 1801	Russell's boa	Unlisted	NA	NA	NE	No	0	0
883	Invert. (t)	Goniocotes gallinae (De Geer, 1778)	Poultry fluff louse	Unlisted	NA	NA	NE	No	0	0
884	Invert. (t)	Gonipterus scutellatus Gyllenhal, 1833	Eucalyptus snout beetle	Unlisted	NA	NA	NE	No	0	0
885	Invert. (marine)	Gonothyraea loveni (Allman, 1859)	No common name found	Unlisted	C2	Harbour, Table Bay only	DD	No	0	0
886	Invert. (t)	Grapholita molesta (Busck, 1916)	Oriental fruit moth	Unlisted	C3	NA	NE	No	0	0
887	Invert. (t)	Gratiana spadicea (Klug, 1829)	Leaf feeder	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
888	Plant (t / fw)	Grevillea banksii R.Br.	Australian crimson oak	1b	E	6	Negligible	No	0	0
889	Plant (t / fw)	Grevillea robusta A.Cunn. ex R.Br	Australian silky oak	3	E	52	Negligible	No	0	0
890	Plant (t / fw)	Grevillea rosmarinifolia A. Cunn.	Rosemary grevillea	3	C2	1	Negligible	No	0	0
891	Plant (t / fw)	Grevillea sericea (Sm.) R.Br.	Pink spider flower	Unlisted	C2	1	NE	No	0	0
892	Plant (t / fw)	Guilleminea densa (Willd.) Moq.	Carrot weed	Unlisted	E	11	NE	No	0	0
893	Plant (t / fw)	Gunnera species (unidentified)	Giant gunnera	Unlisted	C2	1	NE	No	0	0
894	Invert. (t)	Gyraulus chinensis Dunker, 1848	No common name found	Unlisted	NA	NA	NE	No	0	0
895	Invert. (fw)	Gyrodactylus kherulensis Ergens, 1974	Fish skin fluke	Unlisted	D2	2	Negligible	No	0	0

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896	Invert. (fw)	Gyrodactylus kobayashii Hukuda, 1940	Fish gillworm	Unlisted	D2	2	Negligible	No	0	0
897	Microbe	Gyroporus castaneus (Bull.) Quél., 1886	No common name found	Unlisted	Introduced	NA	NE	No	0	0
898	Invert. (t)	Habrocerus capillaricornis (Gravenhorst, 1806)	No common name found	Unlisted	NA	NA	NE	No	0	0
899	Invert. (t)	Haematopinus eurysternus (Nitzsch, 1818)	Short-nosed cattle louse	Unlisted	NA	NA	NE	No	0	0
900	Invert. (t)	Haematopinus suis (Linnaeus, 1758)	Pig-louse	Unlisted	NA	NA	NE	No	0	0
901	Plant (t / fw)	Hakea drupacea (C.F.Gaertn.) Roem. & Schult.	Sweet hakea	1b	E	7	Some	No	0	0
902	Plant (t / fw)	Hakea gibbosa Cav.	Rock hakea	1b	E	7	Major	No	0	0
903	Plant (t / fw)	Hakea salicifolia (Vent.) B.L.Burtt	Willow hakea	Context specific	E	12	Negligible	Yes	0	0
904	Plant (t / fw)	Hakea sericea Schrad. & J.C.Wendl.	Silky hakea	1b	E	39	Severe	No	0	0
905	Plant (t / fw)	Hakea victoria J.Drumm.	Royal hakea	Unlisted	C2	1	NE	No	0	0
906	Invert. (t)	Halotydeus destructor (Tucker, 1925)	Redlegged earth mite	Unlisted	NA	NA	NE	No	0	0
907	Plant (t / fw)	Handroanthus chrysotrichus (Mart. ex DC.) Mattos	Yellow trumpet tree	Unlisted	E	1	NE	No	0	0
908	Invert. (t)	Harmonia axyridis (Pallas 1773)	Asian ladybeetle	1b	C3	6	Some	No	0	0
909	Plant (t / fw)	Harrisia balansae (K.Schum.) N.P.Taylor & Zappi	Strangler prickly apple	1a	E	3	Major	No	0	0
910	Plant (t / fw)	Harrisia martinii Labour. Britton	Moon cactus	1b	E	25	Major	No	0	0
911	Plant (t / fw)	Harrisia pomanensis F.A. C. Webber ex Schum.	Midnight lady	1a	E	2	Major	No	0	0
912	Plant (t / fw)	Harrisia tortuosa Britton & Rose.	Spiny snake cactus	1b	E	5	Major	No	0	0
913	Invert. (t)	Hasarius adansoni (Audouin, 1826)	Adanson's house jumper	Unlisted	NA	NA	NE	No	0	0
914	Invert. (t)	Hawaiia minuscula (Binney, 1840)	Minute gem	Unlisted	C3	2	Negligible	No	0	0
915	Microbe	Hebeloma crustuliniforme (Bull.) Quél., 1872	Poison Pie	Unlisted	Introduced	NA	NE	No	0	0
916	Microbe	Hebeloma cylindrosporum Romagn.,1965	No common name found	Unlisted	Introduced	NA	NE	No	0	0
917	Plant (t / fw)	Hedera canariensis Willd.	Canary ivy	3	E	2	Negligible	No	0	0
918	Plant (t / fw)	Hedera helix L.	English ivy	3	E	3	Negligible	No	0	0
919	Plant (t / fw)	Hedychium coccineum Buch.-Ham. ex Sm.	Red ginger lily	1b	E	2	Negligible	No	0	0
920	Plant (t / fw)	Hedychium coronarium J. Koenig.	White ginger lily	1b	E	3	Negligible	No	0	0
921	Plant (t / fw)	Hedychium flavescens Carey ex Roscoe.	Yellow ginger lily	1b	E	6	Negligible	No	0	0
922	Plant (t / fw)	Hedychium gardnerianum Sheppard ex Ker Gawl.	Kahili ginger lily	1b	E	12	Negligible	No	0	0
923	Plant (t / fw)	Heimia myrtifolia Cham. & Schltdl.	Shrubby yellowcrest	Unlisted	E	7	NE	No	0	0
924	Plant (t / fw)	Helianthus annuus L.	Common sunflower	Unlisted	E	64	NE	No	0	0

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925	Plant (t / fw)	Helianthus argophyllus Torr. & A.Gray	Silverleaf sunflower	Unlisted	C2	1	NE	No	0	0
926	Invert. (marine)	Heliaster helianthus (Lamarck, 1816)	No common name found	Unlisted	C2	Harbour, Saldanha Bay	NE	No	0	0
927	Invert. (t)	Helicoverpa armigera Hübner, 1827	Cotton bollworm	Unlisted	B3	Offshore island	NE	No	0	0
928	Invert. (t)	Heliothrips haemorrhoidalis (Bouché, 1833)	Black tea thrips	Unlisted	NA	NA	NE	No	0	0
929	Plant (t / fw)	Heliotropium amplexicaule Vahl	Blue heliotrope	Unlisted	E	8	NE	No	0	0
930	Plant (t / fw)	Heliotropium europaeum L.	European heliotrope	Unlisted	E	2	NE	No	0	0
931	Invert. (t)	Helisoma duryi Wetherby, 1879	Seminole rams-horn	Unlisted	B1	1	Some	No	0	0
932	Invert. (t)	Hellula undalis Fabricius, 1781	Cabbage webworm	Unlisted	B3	2	NE	No	0	0
933	Plant (t / fw)	Helminthotheca echioides (L.) Holub	Bristly oxtongue	Unlisted	E	5	NE	No	0	0
934	Microbe	Helvella crispa (Scop.) Fr., 1822	White Saddle	Unlisted	Naturalised	NA	NE	No	0	0
935	Microbe	Helvella lacunosa Afzel, 1783	Elfin Saddle	Unlisted	Naturalised	NA	NE	No	0	0
936	Invert. (t)	Hemiberlesia lataniae (Signoret, 1869)	Latania scale	Unlisted	NA	NA	NE	No	0	0
937	Reptile	Hemitheconyx caudicinctus (Duméril, 1851)	African fat-tailed gecko	Unlisted	NA	NA	NE	No	0	0
938	Mammal	Hemitragus jemlahicus (C.H. Smith, 1826)	Himalayan tahr	1b	NA	NA	Some	No	0	0
939	Invert. (t)	Hermannia africana (Balogh, 1958)	No common name found	Unlisted	Introduced	KZN, WC, FS, MP	NE	No	0	0
940	Invert. (t)	Hermanniella congoensis Balogh, 1958	No common name found	Unlisted	Introduced	FS	NE	No	0	0
941	Invert. (t)	Hermetia illucens (Linnaeus, 1758)	Black soldier fly	Unlisted	B3	16	NE	No	0	0
942	Plant (t / fw)	Heterocentron subtriplinervium (Link & Otto) A.Braun & C.D.Bouche	Pearlflower	Unlisted	C2	1	NE	No	0	0
943	Reptile	Heterodon nasicus Baird & Girard, 1852	Western hognose snake	Unlisted	NA	NA	NE	No	0	0
944	Invert. (t)	Heterodoxus spiniger (Enderlein, 1909)	Dog louse	Unlisted	NA	NA	NE	No	0	0
945	Invert. (t)	Heteropoda venatoria (Linnaeus, 1767)	Giant crab spider	Unlisted	NA	NA	NE	No	0	0
946	Plant (t / fw)	Hibiscus trionum L.	Bladderweed	Unlisted	E	21	NE	No	0	0
947	Invert. (t)	Hippodamia variegata (Goeze, 1777)	Adonis ladybird	Unlisted	NA	NA	NE	No	0	0
948	Mammal	Hippotragus equinus koba (Gray, 1872)	Western roan	2	NA	NA	Major	Yes	0	0
949	Plant (t / fw)	Holcus lanatus L.	Common velvet grass	Unlisted	C0	Offshore island	NE	No	0	0
950	Plant (t / fw)	Homalanthus populifolius Graham.	Bleeding-heart tree	1b	E	7	Negligible	No	0	0
951	Plant (t / fw)	Hordeum murinum L.	Wild barley	Unlisted	E	6	DD	No	0	0
952	Plant (t / fw)	Houttuynia cordata Thunberg.	Chameleon plant	3	NA	NA	Negligible	No	0	0
953	Invert. (t)	Hyadaphis coriandri (Das, B.C., 1918)	Coriander aphid	Unlisted	NA	NA	NE	No	0	0

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954	Invert. (t)	Hydaphis foeniculi	Honeysuckle aphid	Unlisted	NA	NA	NE	No	0	0
955	Plant (t / fw)	Hydrangea macrophylla (Thunb.) Ser.	Wild barley	Unlisted	C2	1	NE	No	0	0
956	Plant (t / fw)	Hydrilla verticillata (L.f.) Royle.	Hydrilla	1a	C2	2	Major	No	0	0
957	Mammal	Hydrochaeris hydrochaeris (Linnaeus, 1766)	Capybara	2	NA	NA	Negligible	Yes	1	0
958	Plant (t / fw)	Hydrocleys nymphoides Buchenau (Humb. & Bonpl. ex Willd.)	Water poppy	1a	C2	1	Some	Yes	0	0
959	Invert. (t)	Hydroides elegans (Haswell, 1883)	No common name found	Unlisted	B1	1	NE	No	0	0
960	Microbe	Hygrocybe nigrescens (Quél.) Kühner, 1926	No common name found	Unlisted	Naturalised	NA	NE	No	0	0
961	Invert. (t)	Hylaeogena (Hedwigiella) jureceki Obenberger	Leaf-mining jewel beetle	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
962	Invert. (t)	Hylastes angustatus (Herbst, 1793)	No common name found	Unlisted	NA	NA	NE	No	0	0
963	Plant (t / fw)	Hylocereus undatus (Haw.) Britton & Rose	Night-blooming cereus	2	E	17	Some	Yes	0	0
964	Invert. (t)	Hylurgus ligniperda (Fabricius, 1787) Fabricius, 1787	Red-haired bark beetle	Unlisted	NA	NA	NE	No	0	0
965	Plant (t / fw)	Hypericum androsaemum L.	Sweet-amber	1b	NA	NA	Negligible	No	0	0
966	Plant (t / fw)	Hypericum perforatum L.	St. John's wort	2	E	7	Negligible	Yes	0	0
967	Plant (t / fw)	Hypericum pseudohenryi N.Robson	Henry's St John's wort	Unlisted	E	12	NE	No	0	0
968	Amphibian	Hyperolius marmoratus Rapp, 1842	Painted reed frog	Context specific	E	58	Negligible	No	0	0
969	Amphibian	Hyperolius tuberilinguis (Smith, 1849)	Green reed frog	Unlisted	B3	11	DD	No	0	0
970	Invert. (t)	Hyperomyzus lactucae (Linnaeus, 1758)	Blackcurrant aphid	Unlisted	NA	NA	NE	No	0	0
971	Plant (t / fw)	Hypochaeris glabra L.	Smooth cat's ear	Unlisted	C2	3	NE	No	0	0
972	Plant (t / fw)	Hypochaeris radicata L.	Hairy wild lettuce	Unlisted	E	45	NE	No	0	0
973	Plant (t / fw)	Hypoestes phyllostachya Baker	Polka-dot-plant	Unlisted	E	5	NE	No	0	0
974	Invert. (t)	Hypogastrura armata (Nicolet, 1842)	No common name found	Unlisted	NA	NA	NE	No	0	0
975	Invert. (t)	Hypogastrura manubrialis (Tullberg, 1869)	No common name found	Unlisted	Introduced	NC, KZN, WC	NE	No	0	0
976	Invert. (t)	Hypogastrura purpurescens (Lubbock, 1867)	No common name found	Unlisted	Introduced	WC	NE	No	0	0
977	Invert. (t)	Hypogastrura viatica (Tullberg, 1872)	Springtail	Unlisted	Introduced	WC	NE	No	0	0
978	Invert. (t)	Hypogeococcus pungens Granara de Willink	Cactus mealybug	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
979	Fish (fw)	Hypophthalmichthys molitrix Valenciennes, 1844	Silver carp	Context specific	Introduced	3	Some	No	0	0
980	Invert. (t)	Hysteroneura seteriae (Thomas, C., 1878)	Rusty plum aphid	Unlisted	NA	NA	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
981	Invert. (t)	Ibalia leucospoides (Hochenwarth, 1785)	No common name found	Unlisted	NA	NA	NE	No	0	0
982	Invert. (t)	Icerya purchasi Maskell, 1879	Cottony cushion scale	Unlisted	NA	NA	NE	No	0	0
983	Invert. (fw)	Ichthyophthirius multifilis Fouquet, 1876	No common name found	Unlisted	D2	6	Major	No	0	0
984	Reptile	Iguana iguana (Linnaeus, 1758)	Green iguana	Context specific	C1	1	Some	Yes	12	0
985	Microbe	Ileodicttyon gracile Berk., 1845	No common name found	Unlisted	Naturalised	NA	NE	No	0	0
986	Invert. (t)	Illinoia azalea (Mason, P.W., 1925)	No common name found	Unlisted	NA	NA	NE	No	0	0
987	Plant (t / fw)	Impatiens sodenii Engl. & Warb.	Shrub balsam	Unlisted	C2	2	NE	No	0	0
988	Reptile	Indotyphlops braminus (Daudin, 1803)	Brahminy blind snake	Unlisted	E	8	DD	No	0	0
989	Microbe	Inocybe curvipes P. Karst., 1890	No common name found	Unlisted	Introduced	NA	NE	No	0	0
990	Microbe	Inocybe euthelea Peck,1915	No common name found	Unlisted	Introduced	NA	NE	No	0	0
991	Plant (t / fw)	Ipomoea alba L.	Moonflower	1b	E	22	Some	No	0	0
992	Plant (t / fw)	Ipomoea carnea Jacq. subsp. fistulosa (Mart. ex Choisy) D.F.Austin	Morning-glory bush	1b	E	44	Major	No	0	0
993	Plant (t / fw)	Ipomoea hederifolia L.	Ivy-leaf morning glory	Unlisted	E	3	NE	No	0	0
994	Plant (t / fw)	Ipomoea indica (Burm.) Merr.	Morning glory	1b	E	32	Major	No	0	0
995	Plant (t / fw)	Ipomoea nil (L.) Roth	Picotee morning glory	Unlisted	Introduced	1	NE	No	0	0
996	Plant (t / fw)	Ipomoea purpurea (L.) Roth	Japanese Morning glory	1b	E	55	Major	No	0	0
997	Plant (t / fw)	Iris pseudacorus L.	Yellow flag	1a	E	11	Negligible	Yes	0	0
998	Invert. (marine)	Ischyrocerus anguipes Kroyer, 1838	No common name found	Unlisted	E	Rocky, sublittoral Namibia to Mozambique	DD	No	0	0
999	Invert. (t)	Isotomodes productus (Axelson, 1906)	Snow fly	Unlisted	Introduced	WC	NE	No	0	0
1000	Invert. (t)	Isotomurus maculatus Müller	Marsh Springtail	Unlisted	E	Offshore island	NE	No	0	0
1001	Invert. (t)	Isotomurus palustris (Müller, 1776)	No common name found	Unlisted	Introduced	1	NE	No	0	0
1002	Microbe	Itajahya galericulata Möller, 1895	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1003	Plant (t / fw)	Ixora coccinea L.	Flame-of-the-woods	Unlisted	E	2	NE	No	0	0
1004	Plant (t / fw)	Jacaranda mimosifolia D.Don	Jacaranda	1b	E	183	Some	No	0	0
1005	Invert. (t)	Janua heterostropha (Quatrefages, 1865)	No common name found	Unlisted	NA	NA	NE	No	0	0
1006	Invert. (marine)	Janua pagenstecheri (Quatrefages, 1866)	No common name found	Unlisted	C2	Harbours Table Bay to Durban	DD	No	0	0
1007	Plant (t / fw)	Jasminum humile L.	Yellow bush jasmine	Unlisted	E	3	NE	No	0	0
1008	Plant (t / fw)	Jasminum mesnyi Hance	Primrose jasmine	Unlisted	C2	1	NE	No	0	0
1009	Plant (t / fw)	Jasminum polyanthum Franch.	Creeping jasmine	Unlisted	E	2	NE	No	0	0
1010	Invert. (marine)	Jassa marmorata Holmes, 1903	No common name found	Unlisted	C3	Harbours Table Bay to Durban?	DD	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1011	Invert. (marine)	Jassa morinoi Conlan, 1990	No common name found	Unlisted	E	Harbours, subtidal False Bay to KZN	NE	No	0	0
1012	Invert. (marine)	Jassa slatteryi Conlan, 1990	No common name found	Unlisted	E	Harbours, subtidal False Bay to KZN	DD	No	0	0
1013	Plant (t / fw)	Jatropha curcas L.	Physic nut	2	E	3	Some	Yes	0	0
1014	Plant (t / fw)	Jatropha gossypiifolia L.	Cotton-leaf physic nut	1b	E	14	Some	No	0	0
1015	Plant (t / fw)	Juncus effusus L.	Common rush	Unlisted	D1	17	Negligible	No	0	0
1016	Plant (t / fw)	Juniperus pinchotii Sudw.? (identification uncertain)	Red-berry juniper	Unlisted	C2	1	NE	No	0	0
1017	Plant (t / fw)	Juniperus virginiana L.	Red cedar	Context specific	E	11	Negligible	No	0	0
1018	Plant (t / fw)	Kalanchoe beharensis Drake	Elephant's ear kalanchoe	Unlisted	E	2	NE	No	0	0
1019	Microbe	Kirramyces destructans M.J. Wingf. & Crous, 2009	No common name found	1b	NA	NA	NE	No	0	0
1020	Microbe	Kirramyces eucalypti (Cooke & Massee) J. Walker, B. Sutton & Pascoe, 1992	Eucalyptus leaf blotch pathogen	1b	NA	NA	NE	No	0	0
1021	Mammal	Kobus ellipsiprymnus crawshayi (P. L. Sclater, 1894)	Crawshay's waterbuck	2	NA	NA	Some	Yes	0	0
1022	Mammal	Kobus ellipsiprymnus defassa (Ruppell, 1835)	Defassa waterbuck	2	NA	NA	Some	No	1	0
1023	Mammal	Kobus leche kafuensis Haltenorth, 1963	Kafue lechwe	2	NA	NA	Some	Yes	19	0
1024	Mammal	Kobus leche leche Gray, 1850	Red lechwe	2	NA	NA	Some	Yes	165	0
1025	Mammal	Kobus vardonii (Livingstone, 1857)	Puku	2	NA	NA	Some	No	0	0
1026	Plant (t / fw)	Koelreuteria paniculata Laxm.	Golden-rain tree	Unlisted	C2	1	NE	No	0	0
1027	Invert. (t)	Kontikia ventrolineata (Dendy, 1892)	Kontikia flatworm	Unlisted	NA	NA	NE	No	0	0
1028	Plant (t / fw)	Kunzea ericoides (A.Rich.) Joy Thomps.	Burgan, White teatree	1a	C2	1	Major	No	0	0
1029	Fish (fw)	Labeobarbus aeneus (Burchell, 1822)	Smallmouth yellowfish	Unlisted	NA	NA	Negligible	No	0	0
1030	Invert. (t)	Labia minor (Linnaeus, 1758)	Lesser Earwig	Unlisted	NA	NA	NE	No	0	0
1031	Invert. (t)	Labidura riparia (Pallas, 1773)	Giant Earwig	Unlisted	Introduced	4	NE	No	0	0
1032	Microbe	Laccaria fraterna (Sacc.) Pegler, 1965	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1033	Microbe	Laccaria laccata (Scop.)Cooke, 1884	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1034	Microbe	Lactarius deliciosus (L.)Gray, 1821	Saffron Milkcap	Unlisted	Introduced	NA	NE	No	0	0
1035	Microbe	Lactarius hepaticus Plowr., 1905	Liver Milkcap	Unlisted	Introduced	NA	NE	No	0	0
1036	Plant (t / fw)	Lactuca serriola L.	Wild lettuce	Unlisted	E	5	NE	No	0	0
1037	Plant (t / fw)	Lagerstroemia indica L.	Pride-of-India	Unlisted	E	11	NE	No	0	0
1038	Plant (t / fw)	Lagerstroemia speciosa (L.) Pers.	Queen crepe myrtle	Unlisted	C2	1	NE	No	0	0

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1039	Invert. (t)	Lagocheirus funestus Thomson, 1865	Opuntia biocontrol beetle	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1040	Plant (t / fw)	Lamium galeobdolon (L.) L.	Aluminium plant	Unlisted	C2	1	NE	No	0	0
1041	Invert. (t)	Lamprolonchaea smaragdi (Walker,1849)	Tail fly	Unlisted	B3	Offshore island	NE	No	0	0
1042	Reptile	Lampropeltis alterna Brown, 1901	Gray-banded kingsnake	Unlisted	NA	NA	NE	No	0	0
1043	Reptile	Lampropeltis californiae (Blainville, 1835)	California kingsnake	Unlisted	C1	2	DD	No	0	0
1044	Reptile	Lampropeltis calligaster Harlan, 1827	Prairie kingsnake	Unlisted	NA	NA	NE	No	0	0
1045	Reptile	Lampropeltis getula Linnaeus, 1766	Common kingsnake	Unlisted	NA	NA	NE	No	0	0
1046	Reptile	Lampropeltis mexicana Garman, 1884	Mexican kingsnake	Unlisted	NA	NA	NE	No	0	0
1047	Reptile	Lampropeltis pyromelana Cope, 1866	Arizona mountain kingsnake	Unlisted	NA	NA	NE	No	0	0
1048	Reptile	Lampropeltis triangulum sinaloae (Williams, 1978)	Sinaloan milk snake	Unlisted	C1	1	DD	No	0	0
1049	Bird	Lamprotornis iris (Oustalet, 1879)	Emerald starling	Unlisted	NA	NA	NE	No	0	0
1050	Bird	Lamprotornis purpuroptera Rüppell, 1845	Rűppells long-tailed starling	Unlisted	NA	NA	NE	No	0	0
1051	Bird	Lamprotornis superbus Rüppell, 1845	Superb starling	Unlisted	NA	NA	NE	No	0	0
1052	Plant (t / fw)	Lantana camara L.	Lantana	1b	E	312	Severe	No	0	0
1053	Invert. (t)	Lantanophaga pusillidactyla (Walker 1864)	Lantana plume moth	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1054	Invert. (marine)	Laomedea calceolifera (Hincks, 1871)	No common name found	Unlisted	C2	Harbour, Table Bay only	DD	No	0	0
1055	Invert. (t)	Lapaphis pseudobrassicae	False cabbage aphid	Unlisted	NA	NA	NE	No	0	0
1056	Invert. (t)	Lasioderma serricorme (F.)	Cigarette beetle	Unlisted	Introduced	1	NE	No	0	0
1057	Invert. (t)	Latheticus oryzae Waterhouse, 1880	Long-headed flour beetle	Unlisted	NA	NA	NE	No	0	0
1058	Invert. (t)	Latrodectus geometricus Koch, 1841	Brown widow	Unlisted	NA	NA	NE	No	0	0
1059	Invert. (t)	Lauria cylindracea (Da Costa, 1778)	Common chrysalis snail	Unlisted	D2	4	NE	No	0	0
1060	Microbe	Leccinum duriusculum (Schulzer ex Kalchbr.)Singer, 1947	Slate Bolete	Unlisted	Introduced	NA	NE	No	0	0
1061	Invert. (t)	Lehmannia nyctelia (Bourguignat, 1861)	Vine slug	Unlisted	C3	9	Negligible	No	0	0
1062	Bird	Leiothrix argentauris (Hodgson, 1837)	Silver-eared mesia	Unlisted	NA	NA	NE	No	0	0
1063	Invert. (t)	Lema bilineata Germar	Leaf beetle	Unlisted	NA	NA	NE	No	0	0
1064	Plant (t / fw)	Lepidium bonariense L.	Argentine pepper cress	Unlisted	E	13	NE	No	0	0
1065	Plant (t / fw)	Lepidium didymum L.	Swinecress	Unlisted	C2	1	NE	No	0	0
1066	Plant (t / fw)	Lepidium draba L.	Hoary cardaria	1b	E	4	Major	No	0	0

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1067	Reptile	Lepidodactylus lugubris (Duméril & Bibron, 1836)	Mourning gecko	1b	NA	NA	Negligible	No	0	0
1068	Invert. (t)	Lepisma saccharina Linnaeus, 1758	Silverfish	Unlisted	NA	NA	NE	No	0	0
1069	Fish (fw)	Lepomis macrochirus Rafinesque, 1819	Bluegill	Context specific	Invasive	77	Some	Yes	0	0
1070	Invert. (t)	Leptinotarsa defecta (Stål, 1859)	Satanbos leaf beetle	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	No	RP	0
1071	Invert. (t)	Leptinotarsa texana Schaeffer, 1906	Satanbos leaf beetle	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1072	Invert. (t)	Leptocybe invasa Fisher & La Salle, 2004	Blue gum chalcid wasp	Unlisted	C3	NA	NE	No	0	0
1073	Plant (t / fw)	Leptospermum laevigatum (Gaertn.) F.Muell.	Australian myrtle	1b	E	30	Major	No	0	0
1074	Plant (t / fw)	Lespedeza cuneata (Dum. Cours.) G.Don	Bush clover	Unlisted	E	15	NE	No	0	0
1075	Plant (t / fw)	Leucaena leucocephala (Lam.) De Wit.	Leucaena	2	E	69	Major	Yes	0	0
1076	Invert. (t)	Leucania loreyi (Duponchel, 1827)	False army worm	Unlisted	NA	NA	NE	No	0	0
1077	Plant (t / fw)	Leucanthemum vulgare Lam.	Oxeye daisy	Unlisted	E	4	NE	No	0	0
1078	Plant (t / fw)	Leymus angustus (Trin.) Pilg.	Altai wildrye	Unlisted	Introduced	NA	NE	No	0	0
1079	Plant (t / fw)	Leymus chinensis (Trin.) Tzvelev	False wheatgrass	Unlisted	Introduced	NA	NE	No	0	0
1080	Plant (t / fw)	Leymus ramosus (C.Richt.) Tzvelev	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1081	Reptile	Liasis mackloti Duméril and Bibron, 1844	Freckled python	Unlisted	NA	NA	NE	No	0	0
1082	Reptile	Liasis olivaceus Gray, 1842	Olive python	Unlisted	NA	NA	NE	No	0	0
1083	Invert. (marine)	Ligia exotica Roux, 1828	Wharf Roach	Unlisted	C2	Durban harbour only	DD	No	0	0
1084	Plant (t / fw)	Ligustrum japonicum Thun.	Japanese wax-leaved privet	Context specific	E	3	Negligible	No	0	0
1085	Plant (t / fw)	Ligustrum lucidum W.T. Aiton	Chinese wax-leaved privet	Context specific	E	29	Some	No	0	0
1086	Plant (t / fw)	Ligustrum ovalifolium Hassk.	Californian privet	Context specific	E	1	Some	No	0	0
1087	Plant (t / fw)	Ligustrum sinense Lour.	Chinese privet	Context specific	E	12	Some	No	0	0
1088	Plant (t / fw)	Ligustrum vulgare L.	Common privet	Context specific	E	3	Some	No	0	0
1089	Plant (t / fw)	Lilium formosanum Wallace	Formosa lily	1b	E	39	Negligible	No	0	0
1090	Invert. (t)	Limacus flavus (Linnaeus, 1758)	Yellow gardenslug	Unlisted	C3	17	Some	No	0	0
1091	Invert. (t)	Limax maximus Linnaeus, 1758	Leopard slug	Unlisted	D2	1	Some	No	0	0
1092	Invert. (t)	Limnophyes minimus (Meigen, 1818)	Midge	Unlisted	E	Offshore island	NE	No	0	0
1093	Invert. (marine)	Limnoria quadripunctata Holthuis, 1949	Quadripunctate Gribble	Unlisted	C2	Harbours Table Bay to PE	DD	No	0	0

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1094	Invert. (marine)	Limnoria tripunctata Menzies, 1951	Tripunctate Gribble	Unlisted	C2	Harbours Table Bay to PE	DD	No	0	0
1095	Plant (t / fw)	Limonium perezii (Stapf) F.T.Hubb.	Canary sea lavender	Unlisted	C2	2	NE	No	0	0
1096	Plant (t / fw)	Limonium sinuatum (L.) Mill.	Statice	Context specific	E	41	Negligible	No	0	0
1097	Plant (t / fw)	Linaria dalmatica (L.) Mill	Dalmatian toadflax	1b	E	5	Negligible	No	0	0
1098	Plant (t / fw)	Linaria maroccana Hook.f.	Baby snapdragon	Unlisted	C2	1	NE	No	0	0
1099	Plant (t / fw)	Linaria vulgaris P.Miller.	Common toadflax	1b	C2	1	Some	No	0	0
1100	Invert. (t)	Linepithema humile (Mayr, 1868)	Argentine ant	1b	C3	36	Severe	No	0	0
1101	Invert. (t)	Linognathus setosus (Von Olfers, 1816)	Dog sucking louse	Unlisted	NA	NA	NE	No	0	0
1102	Invert. (t)	Linognathus vituli (Linnaeus, 1758)	Long-nosed cattle louse	Unlisted	NA	NA	NE	No	0	0
1103	Invert. (t)	Liothrips tractabilis Mound & Pereyra, 2008	Pompom thrips	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	No	RP	0
1104	Invert. (t)	Lipaphis pseudobrassicae (Davis, 1914)	False cabbage aphid	Unlisted	NA	NA	NE	No	0	0
1105	Invert. (t)	Lipeurus caponis (Linnaeus, 1758)	Poultry wing louse	Unlisted	NA	NA	NE	No	0	0
1106	Invert. (t)	Liposcelis bostrychophila Badonnel, 1931	No common name found	Unlisted	NA	NA	NE	No	0	0
1107	Plant (t / fw)	Liquidambar styraciflua L.	Sweet gum	Unlisted	E	2	NE	No	0	0
1108	Invert. (t)	Liriomyza huidobrensis (Blanchard, 1926)	Potato leaf miner	Unlisted	B3	NA	NE	No	0	0
1109	Invert. (t)	Liriomyza trifolii Burgess, 1880	Serpentine leaf mine	Unlisted	NA	NA	NE	No	0	0
1110	Invert. (t)	Listroderes costirostris Schoenherr, 1823	Vegetable weevil	Unlisted	NA	NA	NE	No	0	0
1111	Invert. (t)	Listronotus setosipennis	Stem-boring weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1112	Amphibian	Litoria albolabris (Wandolleck, 1911)	Wandolleck's white-lipped tree frog	Unlisted	B2	1	DD	No	0	0
1113	Amphibian	Litoria caerulea (White, 1790)	Great green tree-frog	Prohibited	B2	1	DD	No	0	0
1114	Plant (t / fw)	Litsea glutinosa (Lour.) C. B. Rob.	Indian laurel	1b	E	5	Negligible	No	0	0
1115	Invert. (marine)	Littorina saxatilis (Olivi, 1792)	Rough Periwinkle	Unlisted	E	Estuaries/ lagoons: Berg, Langebaan, Knysna only	DD	No	0	0
1116	Plant (t / fw)	Lolium multiflorum Lam.	Ryegrass	Unlisted	E	15	Negligible	No	0	0
1117	Plant (t / fw)	Lolium perenne L.	Perennial ryegrass	Unlisted	Introduced	NA	NE	No	0	0
1118	Plant (t / fw)	Lolium rigidum Gaudin	Wimmera ryegrass	Unlisted	Introduced	NA	NE	No	0	0
1119	Plant (t / fw)	Lolium species (unidentified)	Rye grasses	Unlisted	E	6	NE	No	0	0
1120	Bird	Lonchura oryzivora (Linnaeus, 1758)	Java Sparrow	Unlisted	NA	NA	NE	No	0	0

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1121	Invert. (t)	Longitarsus bethae Savini & Escalona	Root feeder	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1122	Plant (t / fw)	Lonicera japonica Thunb.'Halliana'	Japanese or Hall's honeysuckle	3	E	13	Negligible	No	0	0
1123	Bird	Lophortyx californicus (Shaw, 1798)	California quail	Unlisted	NA	NA	NE	No	0	0
1124	Bird	Lophura nycthemera (Linnaeus, 1758)	Silver pheasant	Unlisted	NA	NA	NE	No	0	0
1125	Invert. (t)	Lucilia sericata (Meigen, 1826)	Common green bottle fly	Unlisted	Introduced	7	NE	No	0	0
1126	Plant (t / fw)	Ludwigia peruviana (L.) H. Hara	Water-primrose	1a	NA	NA	Major	Yes	0	0
1127	Invert. (t)	Lumbricus castaneus Savigny, 1826	Earthworm	Unlisted	Introduced	KZN	NE	No	0	0
1128	Invert. (t)	Lumbricus rubellus Hoffmeister, 1843	Red earthworm	Unlisted	Introduced	KZN	NE	No	0	0
1129	Plant (t / fw)	Lupinus angustifolius L.	Blue lupine	Unlisted	E	17	NE	No	0	0
1130	Plant (t / fw)	Lupinus luteus L.	Yellow lupine	Unlisted	E	5	NE	No	0	0
1131	Bird	Luscinia megarhynchos C. L. Brehm, 1831	Nightingale	Unlisted	NA	NA	NE	No	0	0
1132	Plant (t / fw)	Luzula cf. multiflora (Ehrh) Lej.	Woodrush	1a	E	Offshore island	Negligible	No	0	0
1133	Reptile	Lygodactylus angularis Gunther, 1893	Angulate dwarf gecko	Unlisted	C1	1	DD	No	0	0
1134	Plant (t / fw)	Lygodium japonicum (Thunb.) Sw.	Japanese climbing fern	Unlisted	C2	2	NE	No	0	0
1135	Invert. (fw)	Lymnaea columella Say, 1817	Amphibious pond snail	1b	NA	NA	Some	No	0	0
1136	Invert. (marine)	Lyrodus pedicellatus (Quatrefages, 1849)	Blacktip Shipworm	Unlisted	C2	Harbour, Simonstown only	DD	No	0	0
1137	Invert. (t)	Lysathia species (unidentified)	Leaf feeder	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1138	Microbe	Lysurus cruciatus (Lepr. & Mont.) Henn., 1902	No common name found	Unlisted	Naturalised	NA	NE	No	0	0
1139	Plant (t / fw)	Lythrum hyssopifolia L.	Hyssop loosestrife	1b	E	2	Some	No	0	0
1140	Plant (t / fw)	Lythrum salicaria L.	Purple loosestrife	1a	C2	1	Some	Yes	0	0
1141	Mammal	Macaca fascicularis Raffles, 1821	Crab-eating macaque	2	NA	NA	Major	Yes	0	0
1142	Microbe	Macrobiotus richtersi Murray, 1911	Water bear	Unlisted	Introduced	GP, WC, KZN	NE	No	0	0
1143	Reptile	Macrochelys temminckii (Troost in Harlan, 1835	Alligator snapper turtle	2	NA	NA	Negligible	Yes	2	0
1144	Microbe	Macrolepiota procera (Scop.) Singer, 1948	No common name found	Unlisted	Naturalised	NA	NE	No	0	0
1145	Plant (t / fw)	Macroptilium atropurpureum (DC.) Urb.	Purple-bean	Unlisted	E	2	NE	No	0	0
1146	Invert. (t)	Macrosiphonella sanborni	Chrysanthemum aphid	Unlisted	C3	NA	NE	No	0	0
1147	Invert. (t)	Macrosiphum euphorbiae (Thomas, C.)	Potato aphid	Unlisted	E	Offshore island	Negligible	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1148	Invert. (t)	Macrosiphum rosae (Linnaeus, 1758)	Rose aphid	Unlisted	C3	NA	NE	No	0	0
1149	Invert. (t)	Mada polluta (Mulsant, 1850)	Lady beetle	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1150	Mammal	Madoqua kirkii Günther, 1880	Damara dik-dik	3	NA	NA	Negligible	No	0	0
1151	Plant (t / fw)	Maireana brevifolia (R.Br.) P.G.Wilson	Small-leaf bluebush	Unlisted	C2	1	NE	No	0	0
1152	Plant (t / fw)	Malus pumila Mill.	Paradise apple	Unlisted	E	5	NE	No	0	0
1153	Plant (t / fw)	Malva assurgentiflora (Kellogg) M.F.Ray	Island mallow	Unlisted	C2	1	NE	No	0	0
1154	Plant (t / fw)	Malva dendromorpha M.F.Ray	Tree mallow	1b	E	32	Negligible	No	0	0
1155	Plant (t / fw)	Malva multiflora (Cav.) Soldano, Banfi & Galasso	Cretan-hollyhock	Unlisted	E	1	NE	No	0	0
1156	Plant (t / fw)	Malva parviflora L.	Small mallow	Unlisted	E	3	NE	No	0	0
1157	Plant (t / fw)	Malva verticillata L.	Mallow	1b	E	4	Negligible	No	0	0
1158	Plant (t / fw)	Malvastrum coromandelianum (L.) Garcke	Prickly malvastrum	1b	E	16	Negligible	No	0	0
1159	Plant (t / fw)	Malvaviscus penduliflorus DC.	Mazapan	Unlisted	E	3	NE	No	0	0
1160	Plant (t / fw)	Mangifera indica L.	Mango	Unlisted	E	13	NE	No	0	0
1161	Plant (t / fw)	Manihot esculenta Crantz	Bitter cassava	Unlisted	E	14	NE	No	0	0
1162	Plant (t / fw)	Manihot grahamii Hook.	Hardy cassava	Unlisted	E	17	NE	No	0	0
1163	Plant (t / fw)	Maranta leuconeura E.Morren	Prayerplant	Unlisted	C2	1	NE	No	0	0
1164	Plant (t / fw)	Marsilea mutica Mett.	Australian waterclover	1a	NA	NA	Negligible	No	0	0
1165	Invert. (t)	Maruca vitrata Fabricius, 1787	Maruca pod borer	Unlisted	C3	NA	NE	No	0	0
1166	Plant (t / fw)	Medicago sativa L.	Lucerne	Unlisted	E	53	NE	No	0	0
1167	Invert. (t)	Megalothorax minimus Willem	No common name found	Unlisted	E	Offshore island	NE	No	0	0
1168	Invert. (t)	Megalyra fasciipennis Westwood in Griffith, 1832	No common name found	Unlisted	NA	NA	NE	No	0	0
1169	Invert. (t)	Megamelus scutellaris Berg, 1883	No common name found	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1170	Invert. (t)	Megaselia scalaris (Loew, 1866)	Scuttle fly	Unlisted	NA	NA	NE	No	0	0
1171	Plant (t / fw)	Melaleuca hypericifolia Sm.	Red-flowering tea tree	1a	E	4	Negligible	No	0	0
1172	Plant (t / fw)	Melaleuca nesophila F.Muell.	Mauve honey myrtle	Unlisted	C2	1	NE	No	0	0
1173	Plant (t / fw)	Melaleuca parvistaminea Byrnes	Rough-barked honey myrtle	Unlisted	C2	1	NE	No	0	0
1174	Plant (t / fw)	Melaleuca quinquenervia (Cav.) S.T.Blake	Bottle brush tree	Context specific	E	3	Negligible	No	0	0
1175	Plant (t / fw)	Melaleuca wilsonii F.Muell.	Paperbark tree	Unlisted	C2	1	NE	No	0	0
1176	Microbe	Melampsora ricini Pass., 1873	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1177	Microbe	Melampsora species (unidentified)	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1178	Invert. (t)	Melanaphis sacchari (Zehntner, 1897)	Sugarcane aphid	Unlisted	NA	NA	NE	No	0	0

APPENDIX 3 – SPECIES

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1179	Bird	Melanocorypha bimaculata (Ménétriés, 1832)	Bimaculated lark	Unlisted	NA	NA	NE	No	0	0
1180	Invert. (t)	Melanterius acaciae Lea	Acacia seed weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1181	Invert. (t)	Melanterius compactus Lea	Acacia seed weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1182	Invert. (t)	Melanterius maculatus Lea	Acacia seed weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1183	Invert. (t)	Melanterius servulus Pascoe	Acacia seed weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1184	Invert. (t)	Melanterius ventralis Lea, 1899	Acacia seed weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1185	Plant (t / fw)	Melastoma malabathricum L.	Violet honey-myrtle	Unlisted	C2	1	NE	No	0	0
1186	Plant (t / fw)	Melia azedarach L.	Seringa	Context specific	E	507	Some	No	0	0
1187	Plant (t / fw)	Melilotus albus Medik.	White sweet clover	Unlisted	E	9	NE	No	0	0
1188	Plant (t / fw)	Melilotus indicus (L.) All.	white sweet clover	Unlisted	E	9	NE	No	0	0
1189	Invert. (t)	Meloidogyne javanica (Treub, 1885)	Root-knot nematode	Unlisted	NA	NA	NE	No	0	0
1190	Invert. (t)	Meloidogyne partityla Kleynhans,1986	Pecan nut nematode	1b	NA	NA	Some	No	0	0
1191	Bird	Melopsittacus undulatus (Shaw, 1805)	Budgerigar	Unlisted	Introduced	1	NE	No	0	0
1192	Invert. (t)	Menacanthus stramineus (Nitzsch, 1818)	Poultry body louse	Unlisted	NA	NA	NE	No	0	0
1193	Invert. (t)	Menemerus bivittatus (Dufour, 1831)	Gray wall jumper	Unlisted	NA	NA	NE	No	0	0
1194	Invert. (t)	Menopon gallinae (Linnaeus, 1758)	Poultry shaft louse	Unlisted	NA	NA	NE	No	0	0
1195	Bird	Merops malimbicus Shaw, 1805	Rosy beeater	Unlisted	NA	NA	NE	No	0	0
1196	Invert. (t)	Mesogastrura libyca (Caroli, 1914)	No common namw found	Unlisted	NA	NA	NE	No	0	0
1197	Invert. (t)	Metamasius spinolae (Gyllenhal)	Stem borer	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1198	Invert. (t)	Metaphire californica Kinberg, 1866	No common name found	Unlisted	Introduced	KZN	NE	No	0	0
1199	Invert. (t)	Metaphire quadragenaira Perrier 1872	No common name found	Unlisted	Introduced	WC	NE	No	0	0
1200	Plant (t / fw)	Metasequoia glyptostroboides Hu & W.C.Cheng	Dawn redwood	Unlisted	E	2	NE	No	0	0
1201	Invert. (marine)	Metridium dianthus Linnaeus 1761,	Sea Anemone	3	C2	Harbour (Table Bay) and subtidal (Agulhas Bank)	DD	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1202	Plant (t / fw)	Metrosideros excelsa Sol. ex Gaertn.	New Zealand Christmas tree	Context specific	E	3	Negligible	Yes	0	0
1203	Invert. (marine)	Microcosmus squamiger Michaelsen, 1927	Plumose anemone	Unlisted	E	Harbours, subtidal False Bay to KZN	DD	No	0	0
1204	Fish (fw)	Micropterus dolomieu Lacepède, 1802	Small-mouth bass	Context specific	Invasive	60	Severe	Yes	1	0
1205	Fish (fw)	Micropterus floridanus (LeSueur, 1822) x M. salmoides	Hybrid bass	Context specific	NA	NA	NE	No	0	0
1206	Fish (fw)	Micropterus floridanus Lesueur, 1822	Florida bass	Context specific	Introduced	1	Some	Yes	0	0
1207	Fish (fw)	Micropterus punctulatus (Rafinesque, 1819)	Spotted bass	Context specific	Invasive	43	Some	Yes	0	0
1208	Fish (fw)	Micropterus salmoides (Lacepède, 1802)	Large-mouth bass	Context specific	Invasive	122	Major	Yes	2	0
1209	Invert. (t)	Microscolex dubius (Fletcher, 1887)	Earthworm	Unlisted	Introduced	FS, EC, WC	NE	No	0	0
1210	Invert. (t)	Microscolex phosphoreus (Dugès, 1837)	Earhworm	Unlisted	Introduced	LP	NE	No	0	0
1211	Plant (t / fw)	Microsorum scandens (G. Forst.) Tindale	Christmas tree	Unlisted	C2	1	NE	No	0	0
1212	Invert. (t)	Milax gagates (Draparnaud, 1801)	Greenhouse slug	Unlisted	C3	19	Negligible	No	0	0
1213	Plant (t / fw)	Mimosa albida Humb. & Bonpl. ex Willd.	Chik chish	Unlisted	E	2	NE	No	0	0
1214	Plant (t / fw)	Mimosa pigra L.	Giant sensitive plant	1b	E	8	Major	No	0	0
1215	Plant (t / fw)	Mimosa pudica L.	Sensitive plant	Unlisted	E	8	NE	No	0	0
1216	Plant (t / fw)	Mirabilis jalapa L.	Four-o'clock	1b	E	57	Negligible	No	0	0
1217	Invert. (marine)	Mirofolliculina limnoriae (Giard,1883)	Striate Piddock	Unlisted	C2	Harbour, Table Bay only (so far)	DD	No	0	0
1218	Plant (t / fw)	Misopates orontium (L.) Raf.	Lesser snapdragon	Unlisted	E	3	NE	No	0	0
1219	Bird	Molothrus bonariensis (Gmelin, 1789)	Shiny cowbird	3	NA	NA	Major	No	0	0
1220	Plant (t / fw)	Momordica charantia L.	Bitter cucumber	Unlisted	C2	1	NE	No	0	0
1221	Invert. (t)	Monelliopsis pecanis Bissell, 1983	Yellow pecan aphid	Unlisted	NA	NA	NE	No	0	0
1222	Invert. (marine)	Monocorophium acherusicum (Costa, 1857)	No common name found	Unlisted	C3	Namibia to Durban	DD	No	0	0
1223	Plant (t / fw)	Monstera deliciosa Liebm.	Swiss-cheese plant	Unlisted	E	2	NE	Yes	0	0
1224	Plant (t / fw)	Montanoa hibiscifolia Benth.	Tree daisy	1b	E	13	Some	No	0	0
1225	Microbe	Morchella esculenta (L.) Pers., 1801	Yellow Morel	Unlisted	Naturalised	NA	NE	No	0	0
1226	Reptile	Morelia amethistina (Schneider, 1801)	Amethistine python	Context specific	NA	NA	Some	Yes	0	0
1227	Reptile	Morelia bredli Gow, 1981	Centralian carpet python	Unlisted	NA	NA	NE	No	0	0
1228	Reptile	Morelia spilotes (Lacépède, 1804)	Diamond python	2	NA	NA	Some	No	13	0
1229	Reptile	Morelia viridis Schlegel, 1872	Green tree python	Unlisted	NA	NA	NE	No	0	0
1230	Plant (t / fw)	Moringa oleifera Lam.	Horse-radish tree	Unlisted	E	1	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1231	Invert. (t)	Moritziella corticalis (Kaltenbach, 1867)	Oak bark phylloxera	Unlisted	NA	NA	NE	No	0	0
1232	Plant (t / fw)	Morus alba L.	White mulberry	3	E	154	Negligible	No	0	0
1233	Plant (t / fw)	Murraya paniculata (L.) Jack.	Orange jasmine	Context specific	E	2	Negligible	Yes	1	0
1234	Mammal	Mus musculus Linnaeus, 1758	House mouse	1b	E	Offshore island	Major	No	0	0
1235	Plant (t / fw)	Musa species (unidentified)	Banana trees	Unlisted	E	5	NE	No	0	0
1236	Bird	Musophaga violacea Isert, 1788	Violet turaco	Unlisted	NA	NA	NE	No	0	0
1237	Bird	Myiopsitta monachus (Boddaert, 1783)	Monk parakeet	Unlisted	NA	NA	NE	No	0	0
1238	Mammal	Myocastor coypus (Molina, 1782)	Coypu	2	NA	NA	Some	Yes	0	0
1239	Plant (t / fw)	Myoporum insulare R.Br.	Manatoka	3	E	8	Negligible	No	0	0
1240	Plant (t / fw)	Myoporum laetum G.Forst.	New Zealand manatoka	3	C2	1	Negligible	No	0	0
1241	Plant (t / fw)	Myoporum montanum R.Br.	Manatoka	3	E	14	Negligible	No	0	0
1242	Invert. (marine)	Myosotella myosotis (Draparnaud, 1801)	Mouse Ear Snail	Unlisted	E	Estuaries, Knysna to Port Alfred	DD	No	0	0
1243	Plant (t / fw)	Myriophyllum aquaticum (Vell.) Verdc.	Parrot's feather	1b	E	58	Some	No	0	0
1244	Plant (t / fw)	Myriophyllum spicatum L.	Spiked water-milfoil	1b	E	15	Some	No	0	0
1245	Microbe	Myrothecium roridum Tode, 1790	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1246	Plant (t / fw)	Myrtillocactus geometrizans (Mart.) Console	Bilberry cactus	1a	E	5	Negligible	No	0	0
1247	Invert. (marine)	Mytilus galloprovincialis Lamarck, 1819	Mediterranean mussel	2	E	Rocky intertidal west and south coasts	Major	No	0	0
1248	Invert. (t)	Myzocallis castanicola Baker, A.C., 1917	Oak aphid	Unlisted	NA	NA	NE	No	0	0
1249	Invert. (t)	Myzus ascalonicus Doncaster	Shallot Aphid	Unlisted	E	Offshore island	Negligible	No	0	0
1250	Invert. (t)	Myzus persicae (Sulzer, 1776)	Green peach aphid	Unlisted	B3	NA	NE	No	0	0
1251	Reptile	Naja haje (Linnaeus 1758)	Egyptian cobra	Unlisted	NA	NA	NE	No	0	0
1252	Reptile	Naja kaouthia Lesson, 1831	Monocled cobra	Unlisted	NA	NA	NE	No	0	0
1253	Reptile	Naja melanoleuca Hallowell, 1857	Forest cobra	Unlisted	C1	20	DD	No	0	0
1254	Reptile	Naja pallida Boulenger, 1896	Red spitting cobra	Unlisted	NA	NA	NE	No	0	0
1255	Reptile	Naja siamensis Laurenti, 1768	Indo-Chinese spitting cobra	Unlisted	NA	NA	NE	No	0	0
1256	Reptile	Naja sputatrix Boie, 1827	Javan spitting cobra	Unlisted	NA	NA	NE	No	0	0
1257	Invert. (t)	Nala lividipes (Dufour, 1820)	No common name found	Unlisted	NA	NA	NE	No	0	0
1258	Bird	Nandayus nenday (Vieillot, 1823)	Black-hooded conure	Unlisted	NA	NA	NE	No	0	0
1259	Plant (t / fw)	Nandina domestica Thunb.	Chinese-bamboo	Unlisted	E	1	NE	No	0	0
1260	Invert. (t)	Nanophyes species (unidentified)	Weevil	Unlisted	C3	NA	NE	No	0	0
1261	Plant (t / fw)	Nassella neesiana (Trin. & Rupr.) Barkworth	Chilean needle grass	Unlisted	C2	2	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1262	Plant (t / fw)	Nassella tenuissima (Trin.) Barkworth	White tussock	1b	E	1	Negligible	No	0	0
1263	Plant (t / fw)	Nassella trichotoma (Nees) Hack. ex Arechav.	Nassella tussock	1b	E	2	Major	No	0	0
1264	Plant (t / fw)	Nasturtium officinale R.Br.	Watercress	2	E	18	Some	Yes	4	0
1265	Invert. (t)	Naupactus leucoloma Boheman, 1840	Whitefringed beetle	Unlisted	C3	NA	NE	No	0	0
1266	Invert. (t)	Nealcidion cereicola (Fisher)	Longhorn beetle	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1267	Invert. (marine)	Neanthes succinea (Leuckart, 1847)	Pileworm	Unlisted	Introduced	Southeast coast: warm-temperate	NE	No	0	0
1268	Invert. (t)	Neanura muscorum (Templeton, 1835)	No common name found	Unlisted	Introduced	EC	NE	No	0	0
1269	Invert. (t)	Neltume arizonensis (Schaeffer, 1904)	Black-legged ham beetle	Unlisted	NA	NA	NE	No	0	0
1270	Invert. (t)	Neltumius arizonensis (Schaeffer)	Prosopis seed beetle	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1271	Invert. (t)	Nematogenia lacuum (Beddard, 1893)	Earthworm	Unlisted	Introduced	KZN	NE	No	0	0
1272	Invert. (t)	Nemertodrilus kellneri (Michaelsen, 1912)	Earhworm	Unlisted	Introduced	FS	NE	No	0	0
1273	Invert. (t)	Nemertodrilus kruegeri (Zicsi and Reinecke, 1992)	Earthworm	Unlisted	Introduced	LP	NE	No	0	0
1274	Invert. (t)	Nemertodrilus transvaalensis (Zicsi and Reinecke, 1992)	Earhworm	Unlisted	Introduced	LP	NE	No	0	0
1275	Invert. (t)	Neochetina bruchi Hustache, 1926	Stem borer weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1276	Invert. (fw)	Neochetina eichhorniae (Warner, 1970)	Mottled water hyacinth weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	No	RP	0
1277	Invert. (marine)	Neodexiospira brasiliensis (Grube, 1872)	Spiral fan worm	Unlisted	E	Rocky intertidal Cape Town to Port Elizabeth	DD	No	0	0
1278	Invert. (t)	Neodiplogrammus quadrivittatus (Olivier)	Trunk-boring curculionid	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1279	Invert. (fw)	Neohydronomus affinis Hustache	Waterlettuce weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	No	RP	0
1280	Invert. (t)	Neohydronomus pulchellus (Hustache 1926)	No common name found	Unlisted	NA	NA	NE	No	0	0
1281	Invert. (t)	Neopygmephorus species (unidentified)	No common name found	Unlisted	NA	Offshore island	NE	No	0	0
1282	Invert. (t)	Neoseiulus californicus (McGregor, 1954)	Predatory mite	Unlisted	NA	NA	NE	No	0	0
1283	Invert. (t)	Neotoxoptera oliveri (Essig, 1935)	Marigold aphid	Unlisted	NA	NA	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1284	Plant (t / fw)	Nephrolepis cordifolia L.	Erect sword fern	Context specific	E	25	Some	No	0	0
1285	Plant (t / fw)	Nephrolepis exaltata (L.) Schott	Sword fern	Context specific	E	22	NE	No	0	0
1286	Plant (t / fw)	Nerium oleander L.	Oleander	1b	E	16	Some	No	0	0
1287	Invert. (t)	Nezara viridula (Linnaeus, 1758)	Green stinkbug	Unlisted	NA	NA	NE	No	0	0
1288	Plant (t / fw)	Nicandra physalodes (L.) Gaertn.	Apple-of-Peru	1b	E	12	Negligible	No	0	0
1289	Plant (t / fw)	Nicotiana glauca Graham	Wild tobacco	1b	E	233	Major	No	0	0
1290	Plant (t / fw)	Nicotiana tabacum L.	Tobacco	Unlisted	E	3	NE	No	0	0
1291	Plant (t / fw)	Nierembergia linariifolia Graham var. glabriuscula (Dunal) A.A.Cocucci & Hunz.	Nierembergia	Unlisted	E	1	NE	No	0	0
1292	Invert. (fw)	Niphograpta albiguttalis Warren	Water hyacinth moth	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	No	RP	0
1293	Invert. (t)	Nodocepheus hammerae Balogh, 1961	No common name found	Unlisted	Introduced	FS, WC, KZN	NE	No	0	0
1294	Invert. (t)	Nomophila species (unidentified)	Moth	Unlisted	B3	Offshore island	NE	No	0	0
1295	Plant (t / fw)	Nopalea cochenillifera (L.) Salm-Dyck	Cochineal cactus	Unlisted	E	3	NE	No	0	0
1296	Amphibian	Notophthalmus viridescens (Rafinesque, 1820)	Red-spotted newt	Prohibited	B2	1	DD	No	0	0
1297	Bird	Numida meleagris galeata Linnaeus, 1758	West African helmeted guineafowl	3	E	1138	Negligible	No	0	0
1298	Plant (t / fw)	Nuphar lutea (L.) Sm.	Yellow water-lily	1a	NA	NA	Some	No	0	0
1299	Plant (t / fw)	Nymphaea mexicana Zucc.	Yellow water lilies	1b	E	6	Some	No	0	0
1300	Plant (t / fw)	Nymphaea x marliacea Lat.-Marl.	Hybrid water lily	Unlisted	E	4	NE	No	0	0
1301	Bird	Nymphicus hollandicus (Kerr, 1792)	Cockatiel	Unlisted	NA	NA	NE	No	0	0
1302	Plant (t / fw)	Nymphoides peltata (S.G.Gmel.) Kuntze	Gringed water lily	1a	C2	1	Negligible	No	0	0
1303	Invert. (marine)	Obelia bidentata Clark, 1875	Doubletoothed Hydroid	Unlisted	C3	Harbours, range in doubt	DD	No	0	0
1304	Invert. (marine)	Obelia dichotoma (Linnaeus, 1758)	Sea Thread Hydroid	Unlisted	C3	Harbours, Lamberts Bay to Algoa Bay (dubious)	DD	No	0	0
1305	Invert. (marine)	Obelia geniculata (Linnaeus, 1758)	Bell Hydroid	Unlisted	C3	Harbours sublittoral (distibution dubious)	DD	No	0	0
1306	Invert. (t)	Ochetellus sp. near glaber (Mayr, 1862)	Ant	Unlisted	C3	NA	Negligible	No	0	0
1307	Plant (t / fw)	Ochetophila trinervis (Gillies ex Hook.) Poepp. ex Endl.	Floating-heart	Unlisted	NA	Offshore island	Negligible	No	0	0
1308	Invert. (t)	Ocnerodrilus africanus (Beddard, 1893)	No common name found	Unlisted	Introduced	KZN	NE	No	0	0
1309	Invert. (t)	Ocnerodrilus occidentalis Eisen, 1878	No common name found	Unlisted	Introduced	FS, NW	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1310	Invert. (t)	Octalasion cyaneum (Savigny, 1826)	Earthworm	Unlisted	Introduced	EC	NE	No	0	0
1311	Invert. (t)	Octolasion lacteum (Onrley, 1881)	Earthworm	Unlisted	Introduced	All provinces	NE	No	0	0
1312	Invert. (t)	Octotoma scabripennis Guérin-Méneville, 1844	Leaf beetle	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1313	Invert. (marine)	Odessia maeotica (Ostroumoff, 1896)	No common name found	Unlisted	E	Estuaries N KZN	DD	No	0	0
1314	Plant (t / fw)	Odontonema cuspidatum (Nees) Kuntze	Scarlet firespike	Unlisted	E	2	NE	No	0	0
1315	Invert. (t)	Oecanthus pellucens (Scopoli, 1763)	Italian tree cricket,	Unlisted	NA	NA	NE	No	0	0
1316	Invert. (t)	Oecobius navus (Blackwall, 1859)	Disc web spiders	Unlisted	NA	NA	NE	No	0	0
1317	Plant (t / fw)	Oenothera biennis L.	Common evening-primrose	Unlisted	E	20	NE	No	0	0
1318	Plant (t / fw)	Oenothera drummondii Hook. subsp. drummondii	Beach evening-primrose	Unlisted	C2	1	NE	No	0	0
1319	Plant (t / fw)	Oenothera glazioviana Micheli	Evening-primrose	Unlisted	E	19	NE	No	0	0
1320	Plant (t / fw)	Oenothera indecora Cambess.	Evening-primrose	Unlisted	C2	2	NE	No	0	0
1321	Plant (t / fw)	Oenothera jamesii Torr. & A.Gray	Evening-primrose	Unlisted	E	17	NE	No	0	0
1322	Plant (t / fw)	Oenothera laciniata Hill	Cutleaf evening-primrose	Unlisted	C2	1	NE	No	0	0
1323	Plant (t / fw)	Oenothera lindheimeri (Engelm. & A.Gray) W.L.Wagner & Hoch)	Lindheimer's beeblossom	Unlisted	E	3	NE	No	0	0
1324	Plant (t / fw)	Oenothera rosea L'Herit. ex Aiton	Butterfly flower	Unlisted	E	23	NE	No	0	0
1325	Plant (t / fw)	Oenothera sinuosa W.L.Wagner & Hoch	Wavy-leaf gaura	3	NA	NA	Negligible	No	0	0
1326	Plant (t / fw)	Oenothera stricta Ledeb. ex Link	Sweet sundrop	Unlisted	E	30	NE	No	0	0
1327	Plant (t / fw)	Oenothera tetraptera Cav.	White evening-primrose	Unlisted	C2	1	NE	No	0	0
1328	Invert. (t)	Oligotoma saundersii (Westwood, 1837)	Saunders embiid	Unlisted	NA	NA	NE	No	0	0
1329	Plant (t / fw)	Olyra latifolia L.	Olyra latifolia	Unlisted	E	8	NE	No	0	0
1330	Invert. (t)	Ommatoiulus moreleti (Lucas, 1860)	Portuguese black millipede	Unlisted	Introduced	WC	NE	No	0	0
1331	Fish (fw)	Oncorhynchus mykiss (Walbaum, 1792)	Rainbow trout	Unlisted	Naturalised	12	Major	No	0	0
1332	Invert. (t)	Opeas hannense (Rang, 1831)	Dwarf awlsnail	Unlisted	C3	NA	Negligible	No	0	0
1333	Invert. (t)	Ophelimus maskelli (Ashmead, 1900)	Eucalyptus gall wasp	Unlisted	NA	NA	NE	No	0	0
1334	Invert. (marine)	Ophiactis savignyi (Müller & Troschel, 1842)	Savigny's Brittle Star	Unlisted	C3	Harbour, Durban	DD	No	0	0
1335	Invert. (t)	Ophiomyia camarae Spencer, 1963	Leaf miner	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0

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1336	Invert. (t)	Ophiomyia lantanae Froggatt, 1919	Seed miner	Unlisted (Biocontrol agent with permit)	Invasive	1	Negligible	Yes	RP	0
1337	Microbe	Ophiostoma quercus (Georgev.) Nannf., 1934	No common name found	Unlisted	Naturalised	NA	NE	No	0	0
1338	Invert. (t)	Opsius stactogalus Fieber, 1866	Tamarix leafhopper	Unlisted	Naturalised	2	NE	No	0	0
1339	Plant (t / fw)	Opuntia aurantiaca Lindl.	Jointed cactus	1b	E	32	Some	No	0	0
1340	Plant (t / fw)	Opuntia elata Link & Otto ex Salm-Dyck	Orange tuna	1b	E	23	Some	No	0	0
1341	Plant (t / fw)	Opuntia engelmannii Salm-Dyck ex Engelm.	Small round-leaved prickly pear	1b	E	68	Some	No	0	0
1342	Plant (t / fw)	Opuntia ficus-indica (L.) Mill.	Mission prickly pear	1b	E	658	Some	No	0	0
1343	Plant (t / fw)	Opuntia humifusa Raf. (Raf.)	Large-flowered prickly pear	1b	E	90	Some	No	0	0
1344	Plant (t / fw)	Opuntia leucotricha DC.	Aaron's-beard prickly-pear	1b	E	6	Some	No	0	0
1345	Plant (t / fw)	Opuntia microdasys (Lehm.) Pfeiff.	Yellow bunny-ears	1b	E	37	Some	No	0	0
1346	Plant (t / fw)	Opuntia monacantha Haw.	Cochineal prickly pear	1b	E	45	Some	No	0	0
1347	Plant (t / fw)	Opuntia pubescens J.C.Wendl. ex Pfeiff.	Velvet bur cactus	1a	C2	1	Some	No	0	0
1348	Plant (t / fw)	Opuntia robusta J.C.Wendl.	Blue-leaf cactus (spiny form)	1a	E	242	Some	No	0	0
1349	Plant (t / fw)	Opuntia robusta J.C.Wendl.	Blue-leaf cactus (spineless cultivars)	Unlisted	E	354	Some	No	0	0
1350	Plant (t / fw)	Opuntia salmiana J.Parm. ex Pfeiff.	Bur cactus	1a	C2	1	Some	No	0	0
1351	Plant (t / fw)	Opuntia spinulifera Salm-Dyck.	Saucepan cactus	1b	E	4	Some	No	0	0
1352	Plant (t / fw)	Opuntia stricta (Haw.) Haw. var. dillenii (Ker Gawl.) L.D.Benson	Australian pest pear	1b	E	5	NE	No	0	0
1353	Plant (t / fw)	Opuntia stricta (Haw.) Haw. var. stricta (Ker Gawl.) L.D.Benson	Australian pest pear	1b	E	132	Some	No	0	0
1354	Plant (t / fw)	Opuntia tomentosa Salm-Dyck.	Velvet opuntia	1b	E	6	Some	No	0	0
1355	Invert. (marine)	Orchestia gammarella (Pallas, 1766)	No common name found	Unlisted	E	Estuaries and Lagoons, Berg River to Milnerton	DD	No	0	0
1356	Fish (fw)	Oreochromis aureus (Steindachner, 1864)	Blue Tilapia	Unlisted	NA	NA	NE	No	0	0
1357	Fish (fw)	Oreochromis niloticus (Linnaeus, 1758)	Nile tilapia	Context specific	Introduced	9	Major	Yes	61	4
1358	Invert. (t)	Oribatula setosa Evans, 1953	No common name found	Unlisted	Introduced	KZN, FS, LP, EC	NE	No	0	0
1359	Plant (t / fw)	Orobanche minor Sm.	Lesser broomrape	1b	E	1	Negligible	No	0	0
1360	Plant (t / fw)	Orobanche ramosa L.	Blue broomrape	1b	NA	NA	Some	No	0	0
1361	Invert. (t)	Orosius albicinctus Distant, 1918	Leaf hopper	Unlisted	NA	NA	NE	No	0	0
1362	Invert. (t)	Orthezia insignis Browne, 1887	Lantana bug	Unlisted	NA	NA	NE	No	0	0

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1363	Invert. (t)	Orthogalumna terebrantis Wallwork	No common name found	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1364	Invert. (t)	Orthotomicus erosus Bright & Skidmore, 1997	Mediterranean pine beetle.	Unlisted	C3	NA	NE	No	0	0
1365	Reptile	Orthriophis taeniurus freisei	Beauty rat snake	Unlisted	C1	2	DD	No	0	0
1366	Mammal	Oryctolagus cuniculus Linnaeus, 1758	European rabbit	Context specific	NA	NA	Some	No	0	0
1367	Mammal	Oryx dammah Cretzschmar, 1826	Scimitar-horned Oryx	2	NA	NA	Negligible	Yes	22	0
1368	Invert. (t)	Oryzaephilus mercator (Fauvel, 1889)	Merchant grain beetle	Unlisted	NA	NA	NE	No	0	0
1369	Invert. (t)	Oryzaephilus surinamensis (Linnaeus, 1758)	Saw-toothed grain beetle	Unlisted	NA	NA	NE	No	0	0
1370	Plant (t / fw)	Oryzopsis hymenoides (Roem. & Schult.) Ricker ex Piper	Indian ricegrass	Unlisted	Introduced	NA	NE	No	0	0
1371	Invert. (t)	Ostearius melanopygius (Cambridge, 1879) (cosmopolitan)	Sheetweb	Unlisted	NA	NA	NE	No	0	0
1372	Invert. (t)	Otala punctata (Muller, 1774)	Freckled Edible Snail	Unlisted	C3	2	DD	No	0	0
1373	Invert. (t)	Oulema trilineata (L.)	Three-lined potato beetle	Unlisted	NA	NA	NE	No	0	0
1374	Mammal	Ovis aries musimon Pallas, 1811	Mouflon	2	NA	NA	Negligible	No	1	0
1375	Plant (t / fw)	Oxalis corniculata L.	Creeping oxalis	Unlisted	E	23	NE	No	0	0
1376	Plant (t / fw)	Oxalis latifolia Kunth	Red garden sorrel	Unlisted	E	5	NE	No	0	0
1377	Invert. (t)	Oxidus gracilis (Koch, 1847)	Greenhouse millipede	Unlisted	NA	NA	NE	No	0	0
1378	Invert. (t)	Oxychilus alliarius (Miller, 1822)	Garlic snail	Unlisted	C3	9	Some	No	0	0
1379	Invert. (t)	Oxychilus cellarius (Muller, 1774)	Cellar Glass-snail	Unlisted	C3	10	NE	No	0	0
1380	Invert. (t)	Oxychilus draparnaudi (Beck, 1837)	Drapanaud's Glass Snai	Unlisted	D2	8	Some	No	0	0
1381	Bird	Oxyura jamaicensis (Gmelin, 1789)	Northern ruddy duck	Prohibited	Introduced	1	NE	Yes	0	0
1382	Invert. (marine)	Pachycordyle navis (Millard, 1959)	Brackish Hydroid	Unlisted	C2	Harbour Table Bay only	DD	No	0	0
1383	Reptile	Paleosuchus palpebrosus Cuvier, 1807	Cuvier's dwarf caiman	Unlisted	NA	NA	NE	No	0	0
1384	Plant (t / fw)	Pandanus species (unidentified)	Screw-pine	Unlisted	C2	1	NE	No	0	0
1385	Plant (t / fw)	Panicum acrotrichum Hook.f.	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1386	Plant (t / fw)	Panicum miliaceum L.	Proso millet	Unlisted	Introduced	NA	NE	No	0	0
1387	Plant (t / fw)	Panicum obtusum Kunth	Vine mesquite	Unlisted	Introduced	NA	NE	No	0	0
1388	Plant (t / fw)	Panicum phragmitoides Stapf	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1389	Plant (t / fw)	Panicum plenum Hitchc. & Chase	Bulb panic grass	Unlisted	Introduced	NA	NE	No	0	0
1390	Plant (t / fw)	Panicum prolutum F.Muell.	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1391	Plant (t / fw)	Panicum virgatum L.	Switchgrass	Unlisted	Introduced	NA	NE	No	0	0

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1392	Invert. (t)	Panonychus citri (McGregor, 1916)	Citrus red mite	Unlisted	NA	NA	NE	No	0	0
1393	Invert. (t)	Panonychus ulmi (Koch 1836)	European red mite	Unlisted	NA	NA	NE	No	0	0
1394	Reptile	Pantherophis alleghaniensis (Holbrook, 1836)	Eastern rat snake	Unlisted	C1	1	DD	No	0	0
1395	Reptile	Pantherophis guttatus (Linnaeus, 1766)	Corn snake	Unlisted	C1	7	DD	No	0	0
1396	Reptile	Pantherophis obsoletus (Say, 1823)	Western rat snake	Unlisted	NA	NA	NE	No	0	0
1397	Invert. (t)	Pantomorus cervinus (Boheman, 1840)	Fuller rose weevil	Unlisted	C3	NA	NE	No	0	0
1398	Plant (t / fw)	Papaver rhoeas L.	Corn poppy	Unlisted	E	9	NE	No	0	0
1399	Invert. (t)	Papillocepheus areolatus Mahunka, 1987	Polkadot Cod	Unlisted	Introduced	WC	NE	No	0	0
1400	Invert. (marine)	Paracerceis sculpta (Holmes, 1904)	No common name found	Unlisted	C2	Harbour Port Elizabeth	DD	No	0	0
1401	Plant (t / fw)	Paraserianthes lophantha (Willd.) I.C.Nielsen	Australian albizia	1b	E	44	Some	No	0	0
1402	Invert. (t)	Parasteatoda tepidariorum (Koch, 1841)	Common house spider	Unlisted	NA	NA	NE	No	0	0
1403	Invert. (t)	Paratullbergia callipygos (Börner, 1902)	No common name found	Unlisted	Introduced	WC	NE	No	0	0
1404	Invert. (t)	Pareuchaetes insulata (Walker)	Yellow-winged Pareuchaetes	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1405	Invert. (t)	Parisotoma notabilis (Schäffer)	No common name found	Unlisted	E	WC	NE	No	0	0
1406	Plant (t / fw)	Parkinsonia aculeata L.	Jerusalem thorn	1b	E	20	Major	No	0	0
1407	Invert. (t)	Parlatoria pergandii Comstock, 1881	Chaff scale	Unlisted	NA	NA	NE	No	0	0
1408	Bird	Paroaria coronata (J. F. Miller, 1776)	Red-crested Cardinal	Unlisted	NA	NA	NE	No	0	0
1409	Plant (t / fw)	Parthenium hysterophorus L.	Famine weed	1b	E	70	Some	No	0	0
1410	Plant (t / fw)	Parthenocissus quinquefolia (L.) Planch.	Virginia creeper	Unlisted	E	3	NE	No	0	0
1411	Plant (t / fw)	Paspalidium flavidum (Retz.) A.Camus	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1412	Plant (t / fw)	Paspalum dilatatum Poir.	Common paspalum	Unlisted	E	31	NE	No	0	0
1413	Plant (t / fw)	Paspalum distichum L.	Couch paspalum	Unlisted	C2	15	NE	No	0	0
1414	Plant (t / fw)	Paspalum notatum Flüggé	Bahia grass	Unlisted	C2	7	NE	No	0	0
1415	Plant (t / fw)	Paspalum quadrifarium Lam.	Tussock paspalum	1a	E	3	Some	No	0	0
1416	Plant (t / fw)	Paspalum urvillei Steud.	Tall paspalum	Unlisted	E	23	NE	No	0	0
1417	Plant (t / fw)	Paspalum virgatum L.	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1418	Microbe	Passalora ageratinae Crous & A.R. Wood	No common name found	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1419	Bird	Passer domesticus Linnaeus, 1758	House sparrow	3	E	1758	Some	No	0	0
1420	Plant (t / fw)	Passiflora caerulea L.	Blue passion flower	1b	E	18	Negligible	No	0	0

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1421	Plant (t / fw)	Passiflora edulis Sims.	Purple granadilla	Context specific	E	36	Negligible	No	0	0
1422	Plant (t / fw)	Passiflora suberosa L.	Devil's pumpkin	1b	E	9	Negligible	No	0	0
1423	Plant (t / fw)	Passiflora subpeltata Ortega.	Granadina	1b	E	31	Negligible	No	0	0
1424	Plant (t / fw)	Passiflora tripartita (A.Juss.) Poiret	Banana poka	Unlisted	E	2	NE	No	0	0
1425	Plant (t / fw)	Passiflora? mollissima (Kunth) L.H.Bailey	Banana poka	1b	E	4	Negligible	No	0	0
1426	Invert. (t)	Paulinia acuminata (De Geer, 1773)	Salvinia grasshopper	Unlisted	NA	NA	NE	No	0	0
1427	Plant (t / fw)	Paulownia tomentosa (Thunb.) Steud.	Empress tree	1a	Introduced	1	NE	No	0	0
1428	Bird	Pavo cristatus Linnaeus, 1758	Common peafowl	Unlisted	E	102	NE	No	0	0
1429	Microbe	Paxillus involutus (Batsch)Fr., 1838	Poison Pax	Unlisted	Introduced	NA	NE	No	0	0
1430	Invert. (t)	Pectinophora gossypiella Saunders, 1843	Pink bollworm	Unlisted	NA	NA	NE	No	0	0
1431	Invert. (t)	Pedrocortesella africana Pletzen, 1963	No common name found	Unlisted	Introduced	All provinces	NE	No	0	0
1432	Reptile	Pelodiscus sinensis (Wiegmann, 1835)	Chinese softshell terrapins	1b	C1	1	DD	No	0	0
1433	Invert. (t)	Pemphigus populitransversus Riley, C.V., 1879	Poplar gall aphid	Unlisted	NA	NA	NE	No	0	0
1434	Plant (t / fw)	Peniocereus serpentinus (Lag. & Rodr.) N.P.Taylor	Serpent cactus	1b	E	4	Negligible	No	0	0
1435	Invert. (marine)	Pennaria disticha (Goldfuss, 1820)	Feathered Hydroid	Unlisted	E	Harbour and littoral, sublitoral KZN	DD	No	0	0
1436	Plant (t / fw)	Pennisetum clandestinum Hochst. ex Chiov.	Kikuyu grass	Context specific	E	28	Some	No	0	0
1437	Plant (t / fw)	Pennisetum glaucum (L.) R.Br.	Pearl millet	Unlisted	Introduced	NA	NE	No	0	0
1438	Plant (t / fw)	Pennisetum purpureum Schumach.	Elephant grass	2	E	69	Some	Yes	0	0
1439	Plant (t / fw)	Pennisetum setaceum (Forssk.) Chiov.	Fountain grass	1b	E	161	Negligible	No	0	0
1440	Plant (t / fw)	Pennisetum villosum R.Br. Fresen.	Feathertop	1b	E	23	Negligible	No	0	0
1441	Invert. (t)	Pentalonia nigronervosa Coquerel, 1859	Banana aphid	Unlisted	NA	NA	NE	No	0	0
1442	Fish (fw)	Perca fluviatilis (Linnaeus, 1758)	Perch	Context specific	Introduced	2	Negligible	No	0	0
1443	Plant (t / fw)	Pereskia aculeata Mill.	Pereskia	1b	E	49	Some	No	0	0
1444	Invert. (marine)	Perforatus perforatus (Bruguière, 1789)	Common Barnacle	Unlisted	C3	Harbours Mossel Bay to Saldanha	DD	No	0	0
1445	Invert. (t)	Perionyx excavatas Perrier 1872	Blue worms	Unlisted	Introduced	NW,KZN	NE	No	0	0
1446	Invert. (t)	Periplaneta americana (Linnaeus, 1758)	American cockroach	Unlisted	Introduced	3	NE	No	0	0
1447	Invert. (t)	Perkinsiella saccharicida Kirkaldy, 1903	Sugarcane Planthopper	Unlisted	NA	NA	NE	No	0	0
1448	Invert. (marine)	Perna viridis Linnaeus, 1758	Asian green mussel	Prohibited	C2	Harbour, Durban	DD	No	0	0
1449	Plant (t / fw)	Persea americana Mill.	Avocado pear	Unlisted	E	7	NE	No	0	0

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1450	Plant (t / fw)	Persicaria capitata (Buch.-Ham. ex D.Don) H. Gross	Knotweed	1b	C2	12	Negligible	No	0	0
1451	Plant (t / fw)	Persicaria hydropiper (L.) Delarbre	Water-pepper	Unlisted	E	14	NE	No	0	0
1452	Plant (t / fw)	Persicaria lapathifolia (L.) Delarbre	Spotted knotweed	Unlisted	E	40	NE	No	0	0
1453	Plant (t / fw)	Petiveria alliacea L.	Guinea hen-weed	Unlisted	E	1	NE	No	0	0
1454	Microbe	Phakopsora apoda (Har. & Pat.) Mains, 1938	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1455	Microbe	Phakopsora pachyrhizi Syd. & P. Syd., 1914	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1456	Plant (t / fw)	Phalaris aquatica L.	Bulbous canary grass	Unlisted	Introduced	NA	NE	No	0	0
1457	Plant (t / fw)	Phalaris arundinacea L.	Reed canary grass	Unlisted	Introduced	NA	NE	No	0	0
1458	Plant (t / fw)	Phalaris coerulescens Desf.	Sunolgrass	Unlisted	Introduced	NA	NE	No	0	0
1459	Bird	Phasianus colchicus Linnaeus, 1758	Common pheasant	Unlisted	NA	NA	NE	No	0	0
1460	Invert. (t)	Phasmatodea species (Jacobson & Bianchi, 1902)	Stick insect	3	NA	NA	Negligible	No	0	0
1461	Reptile	Phelsuma madagascariensis Gray, 1831	Madagascar day gecko	Unlisted	NA	NA	NE	No	0	0
1462	Invert. (t)	Phenacoccus madeirensis Green, 1923	Madeira mealybug	1b	NA	NA	Some	No	0	0
1463	Invert. (t)	Phenacoccus manihoti Matile-Ferrero, 1977	Cassava mealybug	Unlisted	NA	NA	NE	No	0	0
1464	Invert. (t)	Phenacoccus parvus Morrison, 1924	Lantana mealybug	Unlisted	NA	NA	NE	No	0	0
1465	Invert. (t)	Phenrica guerini Bechyné	Leaf-mining moth	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1466	Invert. (t)	Philoscia muscorum (Scopoli, 1763)	Common striped woodlouse	Unlisted	Introduced	KZN	NE	No	0	0
1467	Plant (t / fw)	Phlebodium aureum (L.) J. Sm.	Golden polypody	Unlisted	E	3	NE	No	0	0
1468	Plant (t / fw)	Phleum pratense L.	Timothy grass	Unlisted	Introduced	NA	NE	No	0	0
1469	Plant (t / fw)	Phleum species (unidentified)	Timothy	Unlisted	Introduced	NA	NE	No	0	0
1470	Plant (t / fw)	Phoenix canariensis Chabaud	Canary date palm	Unlisted	E	1	NE	Yes	0	0
1471	Plant (t / fw)	Phoenix dactylifera L.	Real date palm	Unlisted	E	4	NE	No	0	0
1472	Invert. (t)	Pholcus phalangioides (Fuesslin, 1775)	Longbodied cellar spider	Unlisted	NA	NA	NE	No	0	0
1473	Invert. (t)	Phoracantha recurva Newman, 1840	Eucalyptus longhorned borer	Unlisted	C3	3	NE	No	0	0
1474	Invert. (t)	Phoracantha semipunctata (Fabricius, 1775)	Australian Eucalyptus longhorn	Unlisted	Introduced	2	NE	No	0	0
1475	Plant (t / fw)	Phormium tenax J.R.Forst. & G.Forst.	New Zealand flax	Unlisted	E	8	NE	No	0	0
1476	Amphibian	Phrynomantis bifasciatus (Smith, 1847)	Banded rubber frog	Unlisted	B3	46	DD	No	0	0
1477	Invert. (t)	Phthiracarus schauenbergi (Mahunka, 1988)	No common name found	Unlisted	Introduced	KZN	NE	No	0	0
1478	Invert. (t)	Phthorimaea operculella Zeller, 1873	Potato tuber moth	Unlisted	B3	NA	NE	No	0	0

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1479	Plant (t / fw)	Phyla canescens (Kunth) Greene	Daisy lawn	Unlisted	E	2	NE	No	0	0
1480	Invert. (t)	Phyllocnistis citrella Stainton, 1856	Citrus leafminer	Unlisted	C3	NA	NE	No	0	0
1481	Plant (t / fw)	Physalis angulata L.	Wild gooseberry	Unlisted	C2	3	NE	No	0	0
1482	Plant (t / fw)	Physalis peruviana L.	Cape gooseberry	Unlisted	E	12	NE	No	0	0
1483	Plant (t / fw)	Physalis viscosa L.	Sticky gooseberry	Unlisted	E	16	NE	No	0	0
1484	Invert. (t)	Physella acuta (Draparnaud, 1805)	European physa	Unlisted	NA	NA	NE	No	0	0
1485	Reptile	Physignathus cocincinus Cuvier, 1829	Chinese water dragon	Unlisted	NA	NA	NE	No	0	0
1486	Reptile	Physignathus lesueurii Gray, 1831	Australian water dragon	Unlisted	NA	NA	NE	No	0	0
1487	Plant (t / fw)	Phytolacca americana L.	American pokeweed	1b	E	9	Negligible	No	0	0
1488	Plant (t / fw)	Phytolacca dioica L.	Belhambra	3	E	38	Major	No	0	0
1489	Plant (t / fw)	Phytolacca octandra L.	Forest inkberry	1b	E	56	Negligible	No	0	0
1490	Microbe	Phytophthora cinnamomi Rands, 1922	Fungus-like pathogen	1b	NA	NA	NE	No	0	0
1491	Microbe	Phytophthora kemoviae Brasier, 2005	Fungus-like pathogen	1b	NA	NA	NE	No	0	0
1492	Microbe	Phytophthora pinifolia Alv. Durán, Gryzenh. & M.J. Wingf., 2008	Fungus-like pathogen	1b	NA	NA	NE	No	0	0
1493	Invert. (t)	Pieris brassicae (Linnaeus, 1758)	Large cabbage white butterfly	Unlisted	B3	9	NE	No	0	0
1494	Invert. (marine)	Pinauay larynx (Ellis & Solander, 1786)	No common name found	Unlisted	C3	Harbour (Table Bay) and False Bay	DD	No	0	0
1495	Invert. (marine)	Pinauay ralphi (Bale 1884)	No common name found	Unlisted	C2	Harbout, Table Bay, Durban	DD	No	0	0
1496	Invert. (t)	Pineus boerneri Annand, 1928	Pine woolly aphid	Unlisted	C3	NA	NE	No	0	0
1497	Invert. (t)	Pineus pini (Geoffroy, 1762)	Pine woolly aphid	Unlisted	NA	NA	NE	No	0	0
1498	Invert. (marine)	Pinnixa occidentalis Rathbun, 1894	Western Pea Crab	Unlisted	E	Salhanda Bay only	DD	No	0	0
1499	Plant (t / fw)	Pinus canariensis C.Sm	Canary pine	3	E	6	Negligible	No	0	0
1500	Plant (t / fw)	Pinus elliottii Engelm.	Slash pine	Context specific	E	33	Major	Yes	0	0
1501	Plant (t / fw)	Pinus halepensis Mill.	Aleppo pine	Context specific	E	71	Major	No	0	0
1502	Plant (t / fw)	Pinus patula Schiede ex Schltdl. & Cham.	Patula pine	2	E	71	Major	Yes	3	0
1503	Plant (t / fw)	Pinus pinaster Aiton	Cluster pine	Context specific	E	94	Major	Yes	4	0
1504	Plant (t / fw)	Pinus pinea L.	Umbrella pine	Unlisted	E	9	NE	No	0	0
1505	Plant (t / fw)	Pinus radiata D.Don	Monterey pine	Context specific	E	63	Major	Yes	4	0
1506	Plant (t / fw)	Pinus roxburghii Sarg.	Chir pine	2	E	24	Some	Yes	0	0
1507	Plant (t / fw)	Pinus taeda L.	Loblolly pine	2	E	10	Negligible	Yes	0	0
1508	Invert. (t)	Piophila casei (Linnaeus, 1758)	Cheese fly	Unlisted	NA	NA	NE	No	0	0
1509	Microbe	Pisolithus arhizus (Cooke & Massee) G. Cunn., 1931	Bohemian Truffle	Unlisted	Introduced	NA	NE	No	0	0

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1510	Microbe	Pisolithus microcarpus (Cooke & Massee) G. Cunn., 1931	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1511	Microbe	Pisolithus tinctorius (Pers.) Coker & Couch, 1928	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1512	Invert. (t)	Pissodes nemorensis Germar, 1824	Deodar Weevil	Unlisted	C3	NA	NE	No	0	0
1513	Plant (t / fw)	Pistia stratiotes L.	Water lettuce	1b	E	35	Major	No	0	0
1514	Plant (t / fw)	Pittosporum crassifolium Banks & Sol. ex A.Cunn.	Karo, Stiff-leaved cheesewood	3	C2	2	Negligible	No	0	0
1515	Plant (t / fw)	Pittosporum undulatum Vent.	Australian cheesewood	1b	E	12	Some	No	0	0
1516	Reptile	Pituophis catenifer Blainville, 1835	Pacific gopher snake	Unlisted	NA	NA	NE	No	0	0
1517	Reptile	Pituophis deppei Duméril, 1853	Mexican bull snake	Unlisted	NA	NA	NE	No	0	0
1518	Reptile	Pituophis melanoleucus Daudin, 1803	Eastern pine snake	Unlisted	C1	1	DD	No	0	0
1519	Plant (t / fw)	Pityrogramma calomelanos (L.) Link	Golden fern	Unlisted	C2	13	NE	No	0	0
1520	Invert. (t)	Planococcus citri (Risso, 1813) Risso, 1813	Citrus mealy bug	Unlisted	NA	NA	NE	No	0	0
1521	Invert. (t)	Planococcus ficus (Signoret, 1875)	Vine mealybug	Unlisted	C3	NA	NE	No	0	0
1522	Plant (t / fw)	Plantago lanceolata L.	Narrow-leaved ribwort	Unlisted	E	32	NE	No	0	0
1523	Plant (t / fw)	Plantago major L.	Broad-leaved ribwort	Unlisted	E	6	NE	No	0	0
1524	Plant (t / fw)	Plantago virginica L.	Dwarf plantain	Unlisted	E	8	NE	No	0	0
1525	Plant (t / fw)	Platanus x acerifolia (Aiton) Willd.	London plane	Unlisted	E	2	NE	No	0	0
1526	Invert. (marine)	Platorchestia platensis (Krøyer, 1845)	No common name found	Unlisted	E	Estuaries and Lagoons, Langebaan to Algoa Bay	DD	No	0	0
1527	Plant (t / fw)	Platycerium bifurcatum (Cav.) C.Chr.	Staghorn fern	Unlisted	E	5	NE	No	0	0
1528	Plant (t / fw)	Plectranthus barbatus var. grandis Andrews	Abyssinian' coleus	1b	E	68	Negligible	No	0	0
1529	Invert. (t)	Plexippus paykulli (Audouin, 1826)	Pantropical jumper	Unlisted	NA	NA	NE	No	0	0
1530	Bird	Ploceus nigerrimus Vieillot, 1819	Vieillot's black weaver	Unlisted	NA	NA	NE	No	0	0
1531	Invert. (t)	Plodia interpunctella (Hubner, [1813])	Indian meal moth	Unlisted	NA	NA	NE	No	0	0
1532	Invert. (t)	Plutella xylostella (L.)	Diamond-back moth	Unlisted	E	1	Some	No	0	0
1533	Plant (t / fw)	Poa annua L.	Annual meadow grass	Unlisted	E	8	Some	No	0	0
1534	Plant (t / fw)	Poa compressa L.	Canada bluegrass	Unlisted	Introduced	NA	NE	No	0	0
1535	Plant (t / fw)	Poa pratensis L.	Kentucky bluegrass	Context specific	D2	1	Some	No	0	0
1536	Plant (t / fw)	Poa trivialis L.	Rough bluegrass	Unlisted	Introduced	NA	NE	No	0	0
1537	Fish (fw)	Poecilia reticulata Peters, 1859	Guppy	Unlisted	Introduced	7	Some	No	0	0
1538	Reptile	Pogona vitticeps Ahl, 1926	Central bearded dragon	Unlisted	C1	1	DD	No	0	0

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1539	Invert. (t)	Pogonognathellus flavescens (Tullberg)	Springtail	Unlisted	D2	Offshore island	NE	No	0	0
1540	Bird	Poicephalus rueppellii (G. R. Gray, 1849)	Ruppell's parrot	Unlisted	NA	NA	NE	No	0	0
1541	Bird	Poicephalus rufiventris (Rüppell, 1845)	African orangebellied parrot	Unlisted	NA	NA	NE	No	0	0
1542	Invert. (t)	Polistes dominula (Christ, 1791)	European Paper Wasp	1b	C3	1	Some	No	0	0
1543	Invert. (t)	Polycera hedgpethi Marcus, 1964	Hedgpeth's dorid	Unlisted	NA	NA	NE	No	0	0
1544	Invert. (marine)	Polydora cf. websteri Hartman, 1943	Oyster Mudworm	Unlisted	B2	Aquaculture	DD	No	0	0
1545	Invert. (marine)	Polydora hoplura Claparède, 1869	No common name found	Unlisted	E	Harbours, Aquaculture	DD	No	0	0
1546	Plant (t / fw)	Polygonum aviculare L.	Prostrate knotweed	Unlisted	C2	6	NE	No	0	0
1547	Invert. (t)	Polyphagotarsonemus latus (Banks, 1904)	Broad mite	Unlisted	NA	NA	NE	No	0	0
1548	Invert. (t)	Polyplax spinulosa (Burmeister, 1839)	Spined rat louse	Unlisted	NA	NA	NE	No	0	0
1549	Plant (t / fw)	Polypodium aureum L.J.Sm.	Rabbits-foot fern	Context specific	C2	3	Negligible	No	0	0
1550	Plant (t / fw)	Polypogon monspeliensis (L.) Desf.	Beardgrass	Unlisted	E	13	NE	No	0	0
1551	Invert. (t)	Pomacea diffusa Blume, 1957	Spike-topped apple snail	Unlisted	NA	NA	NE	No	0	0
1552	Plant (t / fw)	Pomaderris kumeraho A. Cunn.	Kumarahou	Unlisted	C2	1	NE	No	0	0
1553	Plant (t / fw)	Pontederia cordata L.	Pickerel weed	1b	E	10	Negligible	No	0	0
1554	Invert. (t)	Pontodrilus litoralis (Grube, 1855)	No common name found	Unlisted	Introduced	KZN	NE	No	0	0
1555	Invert. (t)	Pontomorus cervinus (Boheman, 1840)	Fuller rose weevil	Unlisted	C3	NA	NE	No	0	0
1556	Invert. (t)	Pontoscolex corethrurus (Müller, 1856)	No common name found	Unlisted	Introduced	MP,KZN, EC, WC,NW, GP, LP	NE	No	0	0
1557	Reptile	Popeia popeiorum Smith, 1937	Pope's pit viper	Unlisted	NA	NA	NE	No	0	0
1558	Plant (t / fw)	Populus × canescens (Aiton) Sm.	Grey poplar	2	E	484	NE	Yes	0	0
1559	Plant (t / fw)	Populus alba L.	White poplar	2	E	18	Negligible	Yes	0	0
1560	Plant (t / fw)	Populus alba/canescens	White or grey poplars	Unlisted	E	99	NE	No	0	0
1561	Plant (t / fw)	Populus deltoides Marshall	Match poplar	Unlisted	E	75	NE	No	0	0
1562	Plant (t / fw)	Populus nigra L. var. italica Münchh.	Lombardy poplar	Unlisted	E	55	NE	No	0	0
1563	Invert. (t)	Porcellio laevis Latreille, 1804	Swift woodlouse	Unlisted	Introduced	WC	NE	No	0	0
1564	Invert. (t)	Porcellio scaber Latreille, 1804	Common rough woodlouse	Unlisted	C3	Offshore island	Negligible	No	0	0
1565	Plant (t / fw)	Portulaca oleracea L.	Purslane	Unlisted	E	6	NE	No	0	0
1566	Plant (t / fw)	Portulaca quadrifida L.	Pusley	Unlisted	C2	15	NE	No	0	0
1567	Plant (t / fw)	Potamogeton nodosus Poir.	Longleaf pondweed	Unlisted	E	4	NE	No	0	0
1568	Invert. (t)	Prays citri Millière, 1873	Citrus flower moth	Unlisted	NA	NA	NE	No	0	0
1569	Invert. (t)	Prinerigone vagans (Audouin, 1826)	No common name found	Unlisted	E	Offshore island	NE	No	0	0

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1570	Reptile	Proatheris superciliaris Peters, 1854	Lowland swamp viper	Unlisted	NA	NA	NE	No	0	0
1571	Invert. (fw)	Procambarus clarkii (Girard, 1852)	Red swamp crayfish	Prohibited	D2	4	Severe	No	0	0
1572	Invert. (t)	Procecidochares utilis Stone, 1947	Eupatorium gall fly	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1573	Invert. (t)	Prociphilus fraxinifolii (Riley, C.V., 1879)	Leafcurl ash aphid	Unlisted	NA	NA	NE	No	0	0
1574	Invert. (t)	Procontarinia matteiana Kieffer & Cecconi, 1906	Leaf-gall midge	Unlisted	NA	NA	NE	No	0	0
1575	Invert. (t)	Proisotoma minuta (Tullberg, 1871)	Springtail	Unlisted	Introduced	WC, KZN, FS, EC	NE	No	0	0
1576	Plant (t / fw)	Prosopis glandulosa or velutina	Mesquite	Unlisted	E	305	NE	No	0	0
1577	Plant (t / fw)	Prosopis glandulosa Torr. var. torreyana (L.D.Benson) M.C.Johnst.	Honey mesquite	Context specific	E	112	Severe	No	0	0
1578	Plant (t / fw)	Prosopis velutina Wooton	Velvet mesquite	Context specific	E	5	Severe	No	0	0
1579	Invert. (t)	Prostephanus truncatus (Horn, 1878)	Larger grain borer	1a	NA	NA	NE	No	0	0
1580	Invert. (t)	Proteroiulus fuscus (Am Stein, 1857)	Snake millipede	Unlisted	Introduced	WC	NE	No	0	0
1581	Plant (t / fw)	Prunus armeniaca L.	Apricot	Unlisted	E	22	NE	No	0	0
1582	Plant (t / fw)	Prunus persica (L.) Batsch	Peach	Unlisted	E	219	NE	No	0	0
1583	Plant (t / fw)	Prunus serotina Ehrh.	Black cherry	1b	E	3	Some	No	0	0
1584	Plant (t / fw)	Psathyrostachys juncea (Fisch.) Nevski	Russian wildrye	Unlisted	Introduced	NA	NE	No	0	0
1585	Invert. (t)	Pseudaulacaspis pentagona (Targioni Tozzetti, 1886)	Mulberry scale	Unlisted	NA	NA	NE	No	0	0
1586	Microbe	Pseudocercospora formosana (W. Yamam.)Deighton, 1976	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1587	Microbe	Pseudocercospora rubi (Sacc.) Deighton, 1976	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1588	Invert. (t)	Pseudococcus calceolariae (Maskell, 1879)	Citrophilus mealybug	1b	NA	NA	Some	No	0	0
1589	Invert. (t)	Pseudococcus viburni (Signoret, 1875)	Obscure mealybug	Unlisted	NA	NA	NE	No	0	0
1590	Invert. (fw)	Pseudodactlogyrus acheilognathi Yamaguthi, 1934	Gill flukes	Unlisted	D2	5	Severe	No	0	0
1591	Invert. (fw)	Pseudodactlogyrus anguillae (Yin and Sproston, 1948)	Gill flukes	Unlisted	C3	2	Severe	No	0	0
1592	Invert. (t)	Pseudosinella alba (Packard, 1873)	No common name found	Unlisted	Introduced	WC, EC	NE	No	0	0
1593	Plant (t / fw)	Psidium × durbanensis Baijnath ined.	Durban guava	1b	E	2	NE	No	0	0
1594	Plant (t / fw)	Psidium cattleianum Sabine Fosberg	Strawberry guava	1b	E	16	Some	No	0	0
1595	Plant (t / fw)	Psidium guajava L.	Guava	Context specific	E	157	Some	Yes	0	0
1596	Plant (t / fw)	Psidium guineense Sw.	Brazilian guava	1b	E	1	Some	No	0	0

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1597	Invert. (t)	Psila rosae (Fabricius, 1794)	Carrot rust fly	Unlisted	NA	NA	NE	No	0	0
1598	Bird	Psittacula cyanocephala (Linnaeus, 1766)	Plum-headed parakeet	Unlisted	Introduced	1	NE	No	0	0
1599	Bird	Psittacula krameri Scopoli, 1769	Rose-ringed parakeet	2	C3	20	Negligible	Yes	81	0
1600	Invert. (t)	Psychoda parthenogenetica Tonnoir	No common names found	Unlisted	E	Offshore island	NE	No	0	0
1601	Plant (t / fw)	Pteris tremula R.Br.	Australian bracken	Unlisted	C2	4	NE	No	0	0
1602	Plant (t / fw)	Pterocarya stenoptera C.DC.	Chinese wing-nut	Unlisted	C2	1	NE	No	0	0
1603	Fish (fw)	Pterygoplichthys disjunctivus (Weber, 1991)	Vermiculated sailfin catfish	Context specific	Introduced	2	Negligible	No	0	0
1604	Microbe	Puccinia eupatorii Dietel	No common name found	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1605	Microbe	Puccinia lagenophorae Cooke, 1884	No common name found	Unlisted	Naturalised	NA	NE	No	0	0
1606	Microbe	Puccinia malvacearum Bertero ex Mont., 1852	Hollyhock Rust	Unlisted	Introduced	NA	NE	No	0	0
1607	Microbe	Puccinia psidii	Myrtaceae rust	Prohibited	Naturalised	NA	NE	No	0	0
1608	Microbe	Puccinia thaliae Dietel, 1899	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1609	Plant (t / fw)	Pueraria montana (Lour.) Merr. var. lobata (Willd.) Maesen & S.M.Almeida	Kudzu vine	1a	E	10	Major	No	0	0
1610	Invert. (t)	Pulex irritans Linnaeus, 1758	Human flea	Unlisted	NA	NA	NE	No	0	0
1611	Invert. (t)	Pulvinaria psidii Maskell, 1893	Green shield scale	Unlisted	NA	NA	NE	No	0	0
1612	Plant (t / fw)	Punica granatum L.	Pomegranate	Unlisted	E	18	NE	No	0	0
1613	Bird	Pycnonotus cafer Linnaeus, 1766	Red-vented bulbul	2	NA	NA	Negligible	Yes	0	0
1614	Bird	Pycnonotus jocosus Linnaeus, 1758	Red-whiskered bulbul	2	Introduced	1	Negligible	Yes	0	0
1615	Invert. (fw)	Pygmaeodrilus arausionensis (Michaelsen, 1910)	No common name found	Unlisted	Introduced	FS, LP, MP	NE	No	0	0
1616	Plant (t / fw)	Pyracantha angustifolia (Franch.) C.K.Schneid.	Yellow firethorn	1b	E	151	Some	No	0	0
1617	Plant (t / fw)	Pyracantha coccinea M. Roem.	Red firethorn	1b	E	4	Some	No	0	0
1618	Plant (t / fw)	Pyracantha crenatoserrata (Hance) Rehd.	Chinese firethorn	1b	NA	NA	Some	No	0	0
1619	Plant (t / fw)	Pyracantha crenulata M. Roem. (Roxb. ex D.Don).	Himalayan firethorn	1b	E	33	Some	No	0	0
1620	Plant (t / fw)	Pyracantha koidzumii Rehder (Hayata).	Formosa firethorn	1b	NA	NA	Some	No	0	0
1621	Plant (t / fw)	Pyrostegia venusta (Ker Gawl.) Miers	Golden shower	Unlisted	E	2	NE	No	0	0
1622	Bird	Pyrrhura rupicola (Tschudi, 1844)	Black-capped conure	Unlisted	NA	NA	NE	No	0	0
1623	Plant (t / fw)	Pyrus species (unidentified)	Pear tree	Unlisted	E	5	NE	No	0	0
1624	Microbe	Pythium irregulare Buisman, 1927	No common name found	Unlisted	Naturalised	NA	NE	No	0	0
1625	Reptile	Python bivittatus (Kuhl, 1820)	Burmese python	2	NA	NA	NE	No	16	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1626	Reptile	Python curtus Schlegel, 1872	Blood python	Unlisted	NA	NA	NE	No	0	0
1627	Reptile	Python molurus bivittatus Kuhl, 1820	Burmese python	Unlisted	C1	2	Negligible	No	0	0
1628	Reptile	Python natalensis x molurus (Smith, 1840)	Southern African python x Burmese python	1a	Naturalised	176	Some	No	0	0
1629	Reptile	Python regius Shaw, 1802	Ball python	Unlisted	NA	NA	NE	No	0	0
1630	Reptile	Python reticulatus Schneider, 1801	Reticulated python	Unlisted	C1	1	DD	No	0	0
1631	Amphibian	Pyxicephalus adspersus Tschudi, 1838	African bullfrog	Unlisted	C0	32	DD	No	0	0
1632	Invert. (t)	Quadrastichus erythrinae Kim, 2004	Erythrina gall wasp	Unlisted	NA	NA	NE	No	0	0
1633	Plant (t / fw)	Quercus acutissima Carruth.	Bristle oak	Unlisted	C2	1	NE	No	0	0
1634	Plant (t / fw)	Quercus canariensis Willd.	Algerian oak	Unlisted	C2	1	NE	No	0	0
1635	Plant (t / fw)	Quercus cerris L.	Turkey oak	Unlisted	E	2	NE	No	0	0
1636	Plant (t / fw)	Quercus palustris Münchh.	Pin oak	Unlisted	E	6	NE	No	0	0
1637	Plant (t / fw)	Quercus robur L.	English oak	Unlisted	E	33	NE	No	0	0
1638	Plant (t / fw)	Quercus suber L.	Cork oak	Unlisted	E	1	NE	No	0	0
1639	Invert. (t)	Radix rubiginosa (Michelin, 1831)	No common name found	Unlisted	NA	NA	NE	No	0	0
1640	Invert. (t)	Radopholus similis (Cobb 1893)	Burrowing nematode	1b	NA	NA	Some	No	0	0
1641	Reptile	Ramphotyphlops braminus (Daudin, 1803)	Brahminy blind snake	Unlisted	Introduced	3	NE	No	0	0
1642	Invert. (t)	Raoiella indica Hirst, 1924	Red palm mite	Unlisted	NA	NA	NE	No	0	0
1643	Plant (t / fw)	Raphanus raphanistrum L.	Wild radish	Unlisted	E	14	NE	No	0	0
1644	Plant (t / fw)	Rapistrum rugosum (L.) All.	Wild mustard	Unlisted	E	55	NE	No	0	0
1645	Mammal	Rattus norvegicus (Berkenhout, 1769)	Brown rat	Context specific	Naturalised	2	Major	No	0	0
1646	Mammal	Rattus rattus (Linnaeus, 1758)	House rat	Context specific	Naturalised	19	Major	No	0	0
1647	Mammal	Rattus tanezumi Temminck, 1844	Asian house rat	Context specific	NA	NA	Negligible	No	0	0
1648	Plant (t / fw)	Ravenala madagascariensis Sonn.	Traveller's-palm	Unlisted	C2	1	NE	No	0	0
1649	Plant (t / fw)	Reseda lutea L.	Cut-leaf mignonette	Unlisted	C2	2	NE	No	0	0
1650	Plant (t / fw)	Reynoutria × bohemica Chrtek & Chrtková	Bohemian knotweed	Unlisted	C2	1	NE	No	0	0
1651	Reptile	Rhacodactylus auriculatus Bavay, 1869	New Caledonia bumpy gecko	Unlisted	NA	NA	NE	No	0	0
1652	Reptile	Rhacodactylus ciliatus Guichenot, 1866	Crested gecko	Unlisted	NA	NA	NE	No	0	0
1653	Plant (t / fw)	Rhaphiolepis indica (L.) Lindl.	Indian hawthorn	Unlisted	C2	1	NE	No	0	0
1654	Invert. (t)	Rhinocyllus conicus Froelich, 1792	Thistle-head weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1655	Invert. (t)	Rhipicephalus microplus Canestrini, 1888	Asian blue tick	Unlisted	C3	41	NE	No	0	0
1656	Microbe	Rhizopogon luteolus Fr., 1817	No common name found	Unlisted	Introduced	NA	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1657	Microbe	Rhizopogon roseolus (Corda) Th. Fr., 1909	Blushing Beard Truffl	Unlisted	Introduced	NA	NE	No	0	0
1658	Microbe	Rhizopogon rubescens (Tul. & C. Tul., 1845)	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1659	Invert. (t)	Rhodobium porosum (Sanderson, 1900)	Shiny rose aphid	Unlisted	NA	NA	NE	No	0	0
1660	Plant (t / fw)	Rhododendron species (unidentified)	Rhododendron	Unlisted	C2	1	NE	No	0	0
1661	Invert. (t)	Rhopalosiphum padi (L.)	Bird cherry-oat aphid	Unlisted	E	Offshore island	Negligible	No	0	0
1662	Invert. (t)	Rhopalosiphus maidis (Fitch, 1856)	Corn leaf aphid	Unlisted	C3	NA	NE	No	0	0
1663	Plant (t / fw)	Rhus glabra L.	Scarlet sumach	3	NA	NA	Negligible	No	0	0
1664	Invert. (t)	Rhyacionia buoliana Schiffermüller, 1775	European pine shoot moth	Unlisted	NA	NA	NE	No	0	0
1665	Reptile	Rhynchophis boulengeri Mocquard, 1897	Rhinoceros rat snake	Unlisted	NA	NA	NE	No	0	0
1666	Invert. (t)	Rhyssomatus marginatus Fåhraeus	Seed feeding weevil	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1667	Invert. (t)	Rhyzopertha dominica (Fabricius, 1792)	Lesser grain borer	Unlisted	NA	NA	NE	No	0	0
1668	Plant (t / fw)	Richardia brasiliensis Gomes	Tropical richardia	Unlisted	E	11	NE	No	0	0
1669	Plant (t / fw)	Richardia humistrata (Cham. & Schlechtd.) Steud.	Peelton richardia	Unlisted	C2	2	NE	No	0	0
1670	Plant (t / fw)	Richardia scabra L.	Mexican clover	Unlisted	E	2	NE	No	0	0
1671	Plant (t / fw)	Ricinus communis L.	Castor-oil plant	2	E	375	Some	Yes	0	0
1672	Plant (t / fw)	Rivina humilis L.	Rivina, Bloodberry	1b	E	21	Some	No	0	0
1673	Plant (t / fw)	Robinia pseudoacacia L.	Black locust	1b	E	119	Some	No	0	0
1674	Invert. (t)	Rodolia cardinalis (Mulsant, 1850)	Vedalia beetle	Unlisted	NA	NA	NE	No	0	0
1675	Plant (t / fw)	Roldana petasitis (Sims) H. Rob. & Brettell	Velvet groundsel	Unlisted	C2	1	NE	No	0	0
1676	Plant (t / fw)	Rosa × odorata (hort. ex Andrews) Sweet? (identification uncertain)	Tea rose	Unlisted	E	4	NE	No	0	0
1677	Plant (t / fw)	Rosa multiflora Thunb.	Multiflora rose	Unlisted	E	15	NE	No	0	0
1678	Plant (t / fw)	Rosa rubiginosa L.	Eglantine, Sweetbriar	1b	E	77	Some	No	0	0
1679	Plant (t / fw)	Rubus cuneifolius Pursh.	American bramble	1b	E	86	Some	No	0	0
1680	Plant (t / fw)	Rubus cuneifolius x proteus C.H.Stirt.	American bramble	1b	NA	NA	NE	No	0	0
1681	Plant (t / fw)	Rubus ellipticus Smith	Asian wild raspberry	1a	E	2	Some	No	0	0
1682	Plant (t / fw)	Rubus flagellaris Willd.	Bramble	1b	E	3	Some	No	0	0
1683	Plant (t / fw)	Rubus fruticosus Lour.	European blackberry	2	E	41	Some	Yes	0	0
1684	Plant (t / fw)	Rubus immixtus Gustafsson.	Hogsback raspberry	1b	C2	4	Some	No	0	0
1685	Plant (t / fw)	Rubus niveus Thunberg.	Ceylon raspberry	1b	E	7	Some	No	0	0
1686	Plant (t / fw)	Rubus pascuus L.H.Bailey? (identification uncertain)	Chesapeake blackberry	Unlisted	E	3	NE	No	0	0
1687	Plant (t / fw)	Rubus phoenicolasius Maxim.	Japanese wineberry	Unlisted	E	1	NE	No	0	0
1688	Plant (t / fw)	Rubus rosifolius Sm.	Raspberry	Unlisted	E	10	NE	No	0	0
1689	Plant (t / fw)	Ruellia simplex C.Wright	Mexican blue-bells	Unlisted	E	2	NE	No	0	0

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1690	Plant (t / fw)	Rumex acetosella L.	Sheep sorrel	Context specific	C2	21	Negligible	No	0	0
1691	Plant (t / fw)	Rumex crispus L.	Curly dock	Unlisted	E	17	NE	No	0	0
1692	Plant (t / fw)	Rumex usambarensis (Engl. ex Dammer) Dammer	East African dock	1b	E	4	Negligible	No	0	0
1693	Invert. (t)	Ruminia decollata (Linnaeus, 1758)	Decollate snail	Unlisted	NA	NA	DD	No	0	0
1694	Mammal	Rusa unicolor (Kerr, 1792)	Sambar deer	2	NA	NA	Negligible	Yes	0	0
1695	Microbe	Russula caerulea Fr., 1838	Humpback Brittlegill	Unlisted	Introduced	NA	NE	No	0	0
1696	Microbe	Russula capensis A. Pearson, 1950	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1697	Microbe	Russula cyanoxantha (Schaeff.) Fr., 1863	Charcoal Burner	Unlisted	Introduced	NA	NE	No	0	0
1698	Microbe	Russula fallax sensu Cooke	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1699	Microbe	Russula grisea Fr., 1838	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1700	Microbe	Russula pectinata Fr., 1838	Lounahapero	Unlisted	Introduced	NA	NE	No	0	0
1701	Microbe	Russula sardonia Fr., 1838	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1702	Microbe	Russula sororia Fr., 1838	Sepia Brittlegill	Unlisted	Introduced	NA	NE	No	0	0
1703	Microbe	Russula xerampelina (Schaeff.) Fr., 1838	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1704	Plant (t / fw)	Rytidosperma pilosum (R.Br.) Connor and Edgar	Hairy wallaby grass	Unlisted	Introduced	NA	NE	No	0	0
1705	Plant (t / fw)	Rytidosperma semiannulare (Labill.) Connor and Edgar	Tasmanian wallaby grass	Unlisted	Introduced	NA	NE	No	0	0
1706	Plant (t / fw)	Saccharum officinarum L.	Sugar cane	Unlisted	E	7	NE	No	0	0
1707	Invert. (marine)	Sagartia ornata (Holdsworth, 1855)	Elegant anemone	3	C3	Lagoon, Langebaan only	Some	No	0	0
1708	Plant (t / fw)	Sagina procumbens L.	Birdeye pearlwort	Context specific	D1	Offshore island	Negligible	No	0	0
1709	Plant (t / fw)	Sagittaria latifolia Willd.	Common arrowhead	Unlisted	E	1	NE	No	0	0
1710	Plant (t / fw)	Sagittaria platyphylla (Engelm.) J.G.Sm.	Delta arrowhead	1a	E	10	Negligible	No	0	0
1711	Invert. (t)	Salbia haemorrhoidalis Guenee, 1854	Lantana leaftier	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1712	Plant (t / fw)	Salix babylonica L.	Weeping willow	Unlisted	E	310	NE	No	0	0
1713	Plant (t / fw)	Salix caprea L.	Pussy willow	Unlisted	E	10	NE	No	0	0
1714	Plant (t / fw)	Salix fragilis L.	Crack willow	Unlisted	E	66	NE	No	0	0
1715	Fish (fw)	Salmo salar Linnaeus, 1758	Atlantic salmon	Unlisted	NA	NA	NE	No	0	0
1716	Fish (fw)	Salmo trutta (Linnaeus, 1758	Brown trout	Unlisted	Introduced	2	Major	No	0	0
1717	Plant (t / fw)	Salsola kali L.	Tumbleweed	1b	E	9	Negligible	No	0	0
1718	Plant (t / fw)	Salsola tragus L.	Tumbleweed	1b	E	171	Negligible	No	0	0
1719	Fish (fw)	Salvelinus fontinalis (Mitchill, 1814)	Brook trout	Unlisted	Introduced	1	NE	No	0	0
1720	Plant (t / fw)	Salvia coccinea Buc'hoz ex Etl.	Scarlet sage	Unlisted	E	14	NE	No	0	0
1721	Plant (t / fw)	Salvia tiliifolia Vahl.	Lindenleaf sage	1b	E	15	Negligible	No	0	0
1722	Plant (t / fw)	Salvia verbenaca L.	Wild sage	Unlisted	E	51	NE	No	0	0

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1723	Plant (t / fw)	Salvinia minima Baker.	Small salvinia	1b	E	2	Some	No	0	0
1724	Plant (t / fw)	Salvinia molesta D.S.Mitch.	Kariba weed	1b	E	37	Major	No	0	0
1725	Plant (t / fw)	Sambucus canadensis L.	Canadian elder	1b	E	19	Negligible	No	0	0
1726	Plant (t / fw)	Sambucus nigra L.	European elder	1b	E	9	Negligible	No	0	0
1727	Plant (t / fw)	Sansevieria trifasciata Prain	Mother-in-law's-tongue	Unlisted	C2	1	NE	No	0	0
1728	Fish (fw)	Sarotherodon galilaeus (Linnaeus, 1758)	Mango tilapia	Unlisted	NA	NA	NE	No	0	0
1729	Plant (t / fw)	Sasa ramosa (Makino) Makino & Shibata	Dwarf yellow-striped bamboo	3	NA	NA	Negligible	No	0	0
1730	Invert. (t)	Scaptomyza oxyphallus Tsacas	No common name found	Unlisted	C3	Offshore island	NE	No	0	0
1731	Plant (t / fw)	Schedonnardus paniculatus (Nutt.) Trel.	Tumble grass	Unlisted	Introduced	NA	NE	No	0	0
1732	Plant (t / fw)	Schefflera actinophylla (Endl.) Harms	Australian cabbage tree	Context specific	E	8	Negligible	No	0	0
1733	Plant (t / fw)	Schefflera arboricola (Hayata) Merr. 1928	Dwarf umbrella tree	3	E	3	Negligible	No	0	0
1734	Plant (t / fw)	Schefflera elegantissima (hort. Veitch ex Mast.) Lowry & Frodin	False aralia	Context specific	E	2	Negligible	No	0	0
1735	Plant (marine)	Schimmelmannia elegans Baardseth	Red algae	1b	C2	Harbour Table Bay only	DD	No	0	0
1736	Plant (t / fw)	Schinus molle L.	Pepper tree	Unlisted	E	155	NE	No	0	0
1737	Plant (t / fw)	Schinus terebinthifolius Raddi	Brazilian pepper tree	Context specific	E	14	Negligible	No	0	0
1738	Amphibian	Schismaderma carens (Smith, 1848)	African split-skin toad	Unlisted	B3	68	DD	No	0	0
1739	Plant (t / fw)	Schizachyrium scoparium (Michx.) Nash	Little bluestem	Unlisted	Introduced	NA	NE	No	0	0
1740	Invert. (t)	Schizaphis graminum (Rondani, 1852)	Greenbug	Unlisted	C3	NA	NE	No	0	0
1741	Invert. (t)	Schizaphis minuta (Van der Goot, 1917)	No common name found	Unlisted	NA	NA	NE	No	0	0
1742	Invert. (t)	Schizaphis rotundiventris (Signoret, 1860)	Oil palm aphid	Unlisted	NA	NA	NE	No	0	0
1743	Plant (t / fw)	Schizolobium parahyba (Vell.) S.F.Blake	Parasol tree	Unlisted	E	3	NE	No	0	0
1744	Plant (t / fw)	Schkuhria pinnata (Lam.) Kuntze ex Thell.	Dwarf marigold	Unlisted	E	23	NE	No	0	0
1745	Invert. (t)	Schlettererius cinctipes (Cresson, 1880)	No common name found	Unlisted	NA	NA	NE	No	0	0
1746	Mammal	Sciurus carolinensis Gmelin, 1788	Grey squirrel	Context specific	Naturalised	3	Negligible	No	0	0
1747	Microbe	Scleroderma cepa Pers., 1801	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1748	Microbe	Scleroderma citrinum Pers., 1801	Common Earthball	Unlisted	Introduced	NA	NE	No	0	0
1749	Microbe	Scleroderma verrucosum (Bull.) Pers., 1801	Scaly Earthball	Unlisted	Introduced	NA	NE	No	0	0
1750	Amphibian	Sclerophrys gutturalis (Power, 1927)	African common toad	Unlisted	D2	3	Some	No	0	0
1751	Invert. (t)	Scotophaeus blackwalli (Thorell, 1871)	Mouse spider	Unlisted	NA	NA	NE	No	0	0

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1752	Invert. (t)	Scutigera coleoptrata (Linnaeus, 1758)	House centipede	Unlisted	Introduced	WC,KZN,EC	NE	No	0	0
1753	Invert. (t)	Scutovertex subspinipes Balogh, 1959	No common name found	Unlisted	Introduced	LP	NE	No	0	0
1754	Invert. (t)	Scytodes fusca (Walckenaer, 1837)	Spitting spider	Unlisted	NA	NA	NE	No	0	0
1755	Invert. (t)	Scytodes thoracica (Latreille, 1802)	Spitting spider	Unlisted	NA	NA	NE	No	0	0
1756	Invert. (t)	Selenothrips rubrocinctus (Giard, 1901).	Redbanded thrips	Unlisted	NA	NA	NE	No	0	0
1757	Invert. (t)	Sellnickochthonius foliatifer Mahunka, 1982	No common name found	Unlisted	Introduced	WC	NE	No	0	0
1758	Invert. (marine)	Semimytilus algosus (Gould, 1850)	Bisexual mussel	1b	E	Rocky intertidal West Coast	Some	No	0	0
1759	Plant (t / fw)	Senecio species (unidentified)	Ragworts	Unlisted	E	55	NE	No	0	0
1760	Plant (t / fw)	Senna alata (L.) Roxb.	Candlestick senna	Unlisted	E	2	NE	No	0	0
1761	Plant (t / fw)	Senna bicapsularis (L.) Roxb.	Rambling cassia	1b	E	25	Negligible	No	0	0
1762	Plant (t / fw)	Senna corymbosa (Lam.) H.S.Irwin & Barneby	Argentine senna	Unlisted	E	11	NE	No	0	0
1763	Plant (t / fw)	Senna didymobotrya (Fresen.) H.S.Irwin & Barneby	Peanut butter cassia	Context specific	E	116	Negligible	No	0	0
1764	Plant (t / fw)	Senna hirsuta (L.) H.S.Irwin & Barneby	Hairy senna	1b	E	11	Negligible	No	0	0
1765	Plant (t / fw)	Senna multiglandulosa (Jacq.) Irwin & Barneby	Downy senna	Unlisted	E	6	NE	No	0	0
1766	Plant (t / fw)	Senna obtusifolia (L.) Irwin & Barneby	Sicklepod senna	Unlisted	E	7	NE	No	0	0
1767	Plant (t / fw)	Senna occidentalis (L.) Link	Stinking weed	1b	E	81	Negligible	No	0	0
1768	Plant (t / fw)	Senna pendula var. glabrata H.S.Irwin & Barneby (Willd.)	Climbing cassia	1b	E	20	Negligible	No	0	0
1769	Plant (t / fw)	Senna septemtrionalis (Viv.) H.S.Irwin & Barneby	Arsenic bush	1b	E	76	Negligible	No	0	0
1770	Plant (t / fw)	Sesbania punicea (Cav.) Benth.	Red sesbania	1b	E	252	Negligible	No	0	0
1771	Plant (t / fw)	Setaria species (unidentified)	Bristle grass	Unlisted	Introduced	NA	NE	No	0	0
1772	Bird	Sicalis flaveola Linnaeus, 1766	Saffron finch	2	NA	NA	Negligible	Yes	0	0
1773	Plant (t / fw)	Sigesbeckia orientalis L.	St Paul's wort	Unlisted	E	4	NE	No	0	0
1774	Invert. (t)	Silba adipata (McAlpine, 1956)	Black fig fly	Unlisted	NA	NA	NE	No	0	0
1775	Plant (t / fw)	Silene dioica (L.) Clairv.	Red campion	Unlisted	C2	1	NE	No	0	0
1776	Plant (t / fw)	Silybum marianum (L.) Gaertn.	Milk thistle	Unlisted	E	8	NE	No	0	0
1777	Invert. (marine)	Simplaria pseudomilitaris (Thiriot-Quievreux, 1965)	No common name found	Unlisted	C2	Estuaries	DD	No	0	0
1778	Invert. (t)	Sipha flava (Forbes, S.A., 1885)	Yellow sugarcane aphid	Unlisted	NA	NA	NE	No	0	0
1779	Invert. (t)	Sipha maydis Passerini, 1860	No common name found	Unlisted	NA	NA	NE	No	0	0
1780	Invert. (t)	Siphoninus phillyreae (Haliday 1835)	Ash whitefly	Unlisted	NA	NA	NE	No	0	0

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1781	Invert. (t)	Sirex noctilio (Fabricius, 1793)	Sirex woodwasp	Unlisted	NA	NA	NE	No	0	0
1782	Reptile	Sistrurus miliarius Linnaeus, 1766	Pigmy rattlesnake	Unlisted	NA	NA	NE	No	0	0
1783	Plant (t / fw)	Sisymbrium orientale L.	Indian hedge mustard	Unlisted	E	7	NE	No	0	0
1784	Plant (t / fw)	Sisyrinchium angustifolium Mill.	Narrow-leaf blue-eyed-grass	Unlisted	C2	1	NE	No	0	0
1785	Plant (t / fw)	Sisyrinchium micranthum Cav.	Scourweed	Unlisted	E	7	NE	No	0	0
1786	Invert. (t)	Sitobion avenae (Fabricius, 1775)	English grain aphid	Unlisted	C3	NA	NE	No	0	0
1787	Invert. (t)	Sitophylus granarius Linnaeus, 1785	Granary weevil	Unlisted	NA	NA	NE	No	0	0
1788	Invert. (t)	Sitotroga cerealella Olivier, 1789	Angoumois grain moth	Unlisted	NA	NA	NE	No	0	0
1789	Invert. (t)	Smeringopus pallidus (Blackwall, 1858)	Pale daddy-long-leg	Unlisted	NA	NA	NE	No	0	0
1790	Invert. (t)	Smicronyx lutulentus Dietz, 1894	No common name found	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1791	Invert. (t)	Sminthurinus niger (Lubbock, 1873)	No common name found	Unlisted	Introduced	WC	NE	No	0	0
1792	Invert. (t)	Sminthurus viridis (Linnaeus, 1758)	Clover springtail	Unlisted	Introduced	WC	NE	No	0	0
1793	Invert. (t)	Smynthurodes betae Westwood, 1849	Bean root aphid	Unlisted	NA	NA	NE	No	0	0
1794	Plant (t / fw)	Solanum aculeatissimum Jacq. indigenous? origin uncertain	Devil's apple	Unlisted	E	5	NE	No	0	0
1795	Plant (t / fw)	Solanum betaceum Cav.	Tree tomato	Context specific	E	4	Negligible	No	0	0
1796	Plant (t / fw)	Solanum capsicoides All.	Devil's apple	Unlisted	C2	3	NE	No	0	0
1797	Plant (t / fw)	Solanum chrysotrichum Schltdl.	Giant devil's fig	1b	E	21	Some	No	0	0
1798	Plant (t / fw)	Solanum elaeagnifolium Cav.	Silver-leaf bitter apple	1b	E	36	Some	No	0	0
1799	Plant (t / fw)	Solanum laciniatum Aiton	Kangaroo-apple	Unlisted	E	2	NE	No	0	0
1800	Plant (t / fw)	Solanum lycopersicum L.	Cherry tomato	Unlisted	E	4	NE	No	0	0
1801	Plant (t / fw)	Solanum mauritianum Scop.	Bugweed	1b	E	291	Major	No	0	0
1802	Plant (t / fw)	Solanum pseudocapsicum L.	Jerusalem cherry	1b	E	33	Some	No	0	0
1803	Plant (t / fw)	Solanum rostratum Dunal	Buffalo bitter apple	Unlisted	C2	1	NE	No	0	0
1804	Plant (t / fw)	Solanum seaforthianum Andrews	Potato creeper	1b	E	42	Some	No	0	0
1805	Plant (t / fw)	Solanum sisymbriifolium Lam.	Wild tomato	1b	E	80	Some	No	0	0
1806	Plant (t / fw)	Solanum torvum Sw.	Devil's fig	Unlisted	C2	1	NE	No	0	0
1807	Plant (t / fw)	Solanum viarum Dunal	Tropical soda apple	Unlisted	C2	3	NE	No	0	0
1808	Plant (t / fw)	Solidago altissima L.	Late goldenrod	Unlisted	E	3	NE	No	0	0
1809	Plant (t / fw)	Solidago gigantea Aiton	Early or tall goldenrod	Unlisted	C2	1	NE	No	0	0
1810	Plant (t / fw)	Sonchus asper (L.) Hill	Spiny sow thistle	Unlisted	E	3	NE	No	0	0
1811	Plant (t / fw)	Sonchus oleraceus (L.) L.	Sow thistle	Unlisted	E	14	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1812	Plant (t / fw)	Sonchus species (unidentified)	Sow thistles	Unlisted	E	3	NE	No	0	0
1813	Plant (t / fw)	Sophora cf. davidii (Franch.) Pavol.	Sophora	Unlisted	C2	1	NE	No	0	0
1814	Plant (t / fw)	Sorghastrum nutans (L.) Nash	Indian grass	Unlisted	Introduced	NA	NE	No	0	0
1815	Plant (t / fw)	Sorghum × drummondii (Nees ex Steud.) Millsp. & Chase	Sudan grass	Unlisted	Introduced	NA	NE	No	0	0
1816	Plant (t / fw)	Sorghum halepense (L.) Pers.	Johnson grass	2	E	74	NE	Yes	0	0
1817	Plant (t / fw)	Spartina alterniflora Loisel.	Smooth cordgrass	1a	C2	1	Some	Yes	0	0
1818	Plant (t / fw)	Spartium junceum L.	Spanish broom	Context specific	E	26	Negligible	No	0	0
1819	Plant (t / fw)	Spathodea campanulata P. Beauv.	African flame tree	Context specific	E	13	Negligible	No	0	0
1820	Plant (t / fw)	Sphaeralcea bonariensis (Cav.) Griseb.	No common name found	Unlisted	C2	1	NE	No	0	0
1821	Invert. (marine)	Sphaeroma serratum (Fabricius, 1787)	No common name found	Unlisted	C2	Harbour, Durban	DD	No	0	0
1822	Invert. (marine)	Sphaeroma walkeri Stebbing, 1905	Fouling isopod	Unlisted	C3	Harbour, Durban	DD	No	0	0
1823	Plant (t / fw)	Sphaeropteris cooperi (F. Muell.) R.M.Tryon	Australian tree fern	Unlisted	E	5	NE	Yes	0	0
1824	Plant (t / fw)	Sphagneticola trilobata (L.) Pruski	Singapore daisy	Context specific	E	23	Negligible	No	0	0
1825	Plant (t / fw)	Spiraea cantoniensis Lour.	Cape may	Unlisted	C2	1	NE	No	0	0
1826	Invert. (t)	Spodoptera exigua Hübner, 1803/08	Lesser army worm	Unlisted	B3	2	NE	No	0	0
1827	Invert. (t)	Spolodea recurvalis Fabricius, 1775	Hawaiian beet webworm	Unlisted	C3	NA	NE	No	0	0
1828	Invert. (t)	Spondyliaspis c.f. plicatuloides	Shell lerp psyllid	Unlisted	NA	NA	NE	No	0	0
1829	Plant (t / fw)	Stachytarpheta cayennensis (Rich.) Vahl	Blue snakeweed	3	E	2	Negligible	No	0	0
1830	Plant (t / fw)	Stachytarpheta mutabilis (Jacq.) Vahl	Pink snakeweed	3	E	5	Negligible	No	0	0
1831	Invert. (t)	Steatoda grossa (Koch, 1838)	Cupboard spider	Unlisted	NA	NA	NE	No	0	0
1832	Invert. (t)	Stegobium paniceum (Linnaeus,1758)	Drug store beetle	Unlisted	NA	NA	NE	No	0	0
1833	Plant (t / fw)	Stellaria media (L.) Vill.	Common chickweed	Context specific	C2	7	Negligible	No	0	0
1834	Plant (t / fw)	Stenocarpus sinuatus (A. Cunn.) Endl.	Firewheel tree	Unlisted	C2	1	NE	No	0	0
1835	Plant (t / fw)	Stenocereus cf. pruinosus (Otto ex Pfeiff.) Buxb.	Pitaya	Unlisted	C2	1	NE	No	0	0
1836	Invert. (t)	Stenopelmus rufinasus Gyllenhal, 1835	Frond feeder	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1837	Invert. (t)	Sternochetus mangiferae (Fabricius, 1775)	Mango seed weevil	Unlisted	NA	NA	NE	No	0	0
1838	Plant (t / fw)	Stictocardia beraviensis (Vatke) Hallier f.	'Hawaiian' sunset vine	Unlisted	C2	1	NE	No	0	0

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1839	Plant (t / fw)	Stipa capensis Thunb.	Mediterranean needle-grass	Unlisted	Introduced	NA	DD	No	0	0
1840	Bird	Streptopelia decaoto (Frivaldszky, 1838)	Eurasian collared dove	Unlisted	NA	NA	NE	No	0	0
1841	Bird	Streptopelia turtur (Linnaeus, 1758)	European turtle dove	Unlisted	NA	NA	NE	No	0	0
1842	Bird	Struthio camelus	Ostrich	Unlisted	Introduced	1	NE	No	0	0
1843	Bird	Sturnus vulgaris Linnaeus, 1758	Eurasian or Common starling	3	E	504	Some	No	0	0
1844	Invert. (marine)	Styela plicata (Lesueur, 1823)	No common name found	Unlisted	E	Harbours	DD	No	0	0
1845	Plant (t / fw)	Styphnolobium japonicum (L.) Schott	Japanese pagoda tree	Unlisted	E	2	NE	No	0	0
1846	Invert. (marine)	Suberites ficus (Johnston, 1842)	Sea orange	Unlisted	E	Harbours, Luderitz to Table bay	DD	No	0	0
1847	Invert. (t)	Subulina octona (Bruguiere, 1789)	Miniature awlsnail	Unlisted	Introduced	1	DD	No	0	0
1848	Microbe	Suillus bellinii (Inzenga) Kuntze, 1898	Bolet de Bellini	Unlisted	Introduced	NA	NE	No	0	0
1849	Microbe	Suillus bovinus (L.)Roussel, 1796	Bovine Bolete	Unlisted	Introduced	NA	NE	No	0	0
1850	Microbe	Suillus granulatus (L.) Roussel, 1796	Weeping Bolete	Unlisted	Introduced	NA	NE	No	0	0
1851	Microbe	Suillus luteus (L.)Roussel, 1796	The Slippery Jack	Unlisted	Introduced	NA	NE	No	0	0
1852	Microbe	Suillus salmonicolor (Frost) Halling, 1983	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1853	Invert. (t)	Sulcobruchus subsuturalis (Pic, 1929)	Seed feeder	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	No	RP	0
1854	Mammal	Sus scrofa Linnaeus, 1758	Domestic pig	Context specific	NA	NA	Major	No	0	0
1855	Plant (t / fw)	Syncarpia glomulifera (Sm.) Nied.	Turpentine tree	Unlisted	E	6	NE	No	0	0
1856	Plant (t / fw)	Syngonium podophyllum Schott	Goose foot	Context specific	E	9	Negligible	Yes	0	0
1857	Plant (t / fw)	Syzygium cumini (L.) Skeels	Jambolan	1b	E	10	Negligible	No	0	0
1858	Plant (t / fw)	Syzygium jambos (L.) Alston	Rose apple	3	E	1	Negligible	No	0	0
1859	Plant (t / fw)	Syzygium paniculatum Gaertn.	Australian water pear	Unlisted	E	9	NE	No	0	0
1860	Bird	Taeniopygia guttata (Vieillot, 1817)	Zebra finch	Unlisted	NA	NA	NE	No	0	0
1861	Plant (t / fw)	Tagetes minuta L.	Khaki weed	Unlisted	E	39	NE	No	0	0
1862	Invert. (t)	Takecallis taiwanus (Takahashi, 1926)	Takahashi	Unlisted	NA	NA	NE	No	0	0
1863	Plant (t / fw)	Talinum paniculatum (Jacq.) Gaertn.	Jewels-of-Opar	Unlisted	E	3	NE	No	0	0
1864	Plant (t / fw)	Tamarix aphylla (L.) H.Karst.	Athel tree	1b	NA	NA	Negligible	No	0	0
1865	Plant (t / fw)	Tamarix chinensis Lour.	Chinese tamarisk	1b	E	8	Negligible	No	0	0
1866	Plant (t / fw)	Tamarix gallica L.	French tamarisk	1b	NA	NA	Negligible	No	0	0
1867	Plant (t / fw)	Tamarix ramosissima Ledeb.	Pink tamarisk	1b	E	7	Major	No	0	0

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1868	Plant (t / fw)	Tamarix species (unidentified)	Tamarisks	Unlisted	E	130	NE	No	0	0
1869	Invert. (fw)	Tarebia granifera Lamarck, 1816	Quilted melania snail	1b	E	Estuaries, KZN	Negligible	No	0	0
1870	Invert. (t)	Tarsonemus waitei Banks, 1912	Barn funnel weaver	Unlisted	NA	NA	NE	No	0	0
1871	Plant (t / fw)	Taxodium distichum (L.) Rich.	Swamp cypress	Unlisted	E	5	NE	No	0	0
1872	Plant (t / fw)	Tecoma cf. fulva subsp. garrocha (Hieron.) J.R.I.Wood	Orange trumpet flower	Unlisted	C2	1	NE	No	0	0
1873	Plant (t / fw)	Tecoma stans (L.) Juss. ex Kunth	Yellow bells	1b	E	138	Negligible	No	0	0
1874	Plant (t / fw)	Tecoma tenuiflora (DC.) Fabris	Trumpetbush	Unlisted	C2	1	NE	No	0	0
1875	Invert. (t)	Tegenaria domestica (Clerck, 1757)	Funnel weaver spiders	Unlisted	Introduced	2	NE	No	0	0
1876	Invert. (t)	Teleonemia scrupulosa Stål, 1873	Lantana lace bug	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1877	Invert. (t)	Teleonemia vulgata Drake & Hambleton, 1940	True bugs	Unlisted	NA	NA	NE	No	0	0
1878	Plant (t / fw)	Telopea speciosissima (Sm.) R.Br.	Waratah	Unlisted	C2	1	NE	No	0	0
1879	Invert. (t)	Tenebrio molitor Linnaeus, 1758	Yellow mealworm	Unlisted	NA	NA	NE	No	0	0
1880	Plant (t / fw)	Tephrocactus articulatus (Pfeiff.) Backeb	Pine cone cactus	1a	E	32	Negligible	Yes	0	0
1881	Microbe	Teratosphaeria cryptica (Cooke) Crous & U. Braun, 2007	No common name found	1b	NA	NA	NE	No	0	0
1882	Invert. (marine)	Teredo navalis Linnaeus, 1758	Common shipworm	Unlisted	E	Harbours only, widespread	DD	No	0	0
1883	Reptile	Terrapene ornata Agassiz, 1857	Ornate box turtle	Unlisted	C1	1	DD	No	0	0
1884	Invert. (t)	Testacella maugei Ferussac, 1819	Mauge's Shelled Slug	Unlisted	C3	3	Negligible	No	0	0
1885	Invert. (t)	Tetragnatha boydi (Cambridge, 1898)	Longjawed orbweavers	Unlisted	Introduced	2	NE	No	0	0
1886	Invert. (t)	Tetragnatha nitens (Audouin, 1826)	No common name found	Unlisted	NA	NA	NE	No	0	0
1887	Invert. (t)	Tetragnatha vermiformis Emerton, 1884	No common name found	Unlisted	NA	NA	NE	No	0	0
1888	Invert. (t)	Tetranychus evansi Baker & Pritchard, 1960	Spider mite	Unlisted	NA	NA	NE	No	0	0
1889	Invert. (t)	Tetranychus urticae Koch 1836	Two-spotted spider mite	Unlisted	NA	NA	NE	No	0	0
1890	Invert. (marine)	Thais blanfordi (Melvill, 1893)	No common name found	Unlisted	E	Harbour, Durban	DD	No	0	0
1891	Invert. (marine)	Thais tissoti (Petit de la Saussaye, 1852)	No common name found	Unlisted	E	Harbour, rocky shore KZN	DD	No	0	0
1892	Reptile	Thamnophis marcianus Baird & Girard, 1853	Checkered garter snake	Unlisted	NA	NA	NE	No	0	0
1893	Invert. (t)	Thaumastocoris peregrinus Carpintero & Dellapé, 2006	Bronze bug	Unlisted	C3	NA	NE	No	0	0
1894	Invert. (t)	Theba pisana (Müller, 1774)	white garden snail	Unlisted	D2	61	Major	No	0	0

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1895	Invert. (t)	Thecacera pennigera (Montagu, 1815)	Winged thecacera	Unlisted	NA	NA	NE	No	0	0
1896	Microbe	Thelephora intybacea Pers., 1801	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1897	Microbe	Thelephora penicillata (Pers.) Fr., 1821	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1898	Microbe	Thelephora terrestris Ehrh., 1787	Earthfan	Unlisted	Introduced	NA	NE	No	0	0
1899	Invert. (t)	Theridula opulenta (Walckenaer, 1841)	No common name found	Unlisted	NA	NA	NE	No	0	0
1900	Invert. (t)	Therioaphis trifolii f. maculata (Buckton, 1899)	No common name found	Unlisted	NA	NA	NE	No	0	0
1901	Plant (t / fw)	Thevetia peruviana (Pers.) K. Schum.	Yellow oleander	1b	E	1	Negligible	No	0	0
1902	Invert. (t)	Thrips tabaci Lindeman, 1889	Onion thrips	Unlisted	B3	NA	NE	No	0	0
1903	Plant (t / fw)	Thuidium delicatulum (Hedw.) Schimp	Delicate fern moss	Unlisted	C3	Offshore island	Negligible	No	0	0
1904	Plant (t / fw)	Thunbergia grandiflora (Roxb. ex Rottl.) Roxb.	Blue trumpetvine	Unlisted	E	8	NE	No	0	0
1905	Invert. (t)	Thysanoplusia orichalcea (Fabricius, 1775)	Slender burnished brass	Unlisted	C3	NA	NE	No	0	0
1906	Plant (t / fw)	Tibouchina elegans (Gardner) Cogn.	Glory bush	Unlisted	C2	1	NE	No	0	0
1907	Plant (t / fw)	Tibouchina granulosa (Desr.) Cogn.	Glory bush tree	Unlisted	C2	1	NE	No	0	0
1908	Plant (t / fw)	Tibouchina mutabilis (Vell.) Cogn.	No common name found	Unlisted	C2	1	NE	No	0	0
1909	Plant (t / fw)	Tibouchina urvilleana (DC.) Cogn.	Purple glory bush	Unlisted	C2	1	NE	No	0	0
1910	Fish (fw)	Tilapia zillii (Gervais, 1848)	Redbelly tilapia	Unlisted	NA	NA	NE	No	0	0
1911	Reptile	Tiliqua gigas Schneider, 1801	Giant bluetongue skink	Unlisted	NA	NA	NE	No	0	0
1912	Plant (t / fw)	Tillandsia usneoides (L.) L.	Spanish-moss	Unlisted	C2	1	NE	No	0	0
1913	Reptile	Timon lepidus Daudin, 1802	Ocellated lizard	Unlisted	NA	NA	NE	No	0	0
1914	Fish (fw)	Tinca tinca (Linnaeus, 1758)	Tench	Context specific	Introduced	4	Negligible	No	0	0
1915	Invert. (t)	Tinea pellionella Linnaeus, 1758	Case-bearing clothes moth	Unlisted	NA	NA	NE	No	0	0
1916	Plant (t / fw)	Tipuana tipu (Benth.) Kuntze	Tipu tree	3	E	48	Negligible	No	0	0
1917	Plant (t / fw)	Tithonia diversifolia (Hemsl.) A.Gray	Mexican sunflower	1b	E	67	Some	No	0	0
1918	Plant (t / fw)	Tithonia rotundifolia S.F.Blake (Mill.)	Red sunflower	1b	E	34	Negligible	No	0	0
1919	Plant (t / fw)	Tithonia tubaeformis (Jacq.) Cass.	No common name found	Unlisted	C2	1	NE	No	0	0
1920	Invert. (t)	Tomocerus minor (Lubbock, 1862)	Collembola	Unlisted	NA	NA	NE	No	0	0
1921	Plant (t / fw)	Toona ciliata M.Roem.	Toon tree	3	E	22	Negligible	No	0	0
1922	Plant (t / fw)	Torilis arvensis (Huds.) Link.	Spreading hedge-parsley	Unlisted	C2	4	NE	No	0	0
1923	Plant (t / fw)	Toxicodendron succedaneum (L.) Kuntze	Wax tree	1b	E	8	Some	No	0	0
1924	Invert. (t)	Toxoptera citricidus Kirkaldy, 1907	Black citrus aphid	Unlisted	NA	NA	NE	No	0	0

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1925	Reptile	Trachemys scripta elegans (Wied, 1838)	Red-eared slider	2	C1	2	DD	No	1	0
1926	Invert. (t)	Trachymela tincticollis (Blackburn, 1896)	No common name found	Unlisted	C3	NA	NE	No	0	0
1927	Plant (t / fw)	Tradescantia fluminensis Vell.	White-flowered wandering Jew	1b	E	20	Negligible	No	0	0
1928	Plant (t / fw)	Tradescantia pallida (Rose) D.R.Hunt	Purple heart	Unlisted	C2	1	NE	No	0	0
1929	Plant (t / fw)	Tradescantia zebrina hort. ex Bosse	Wandering Jew	1b	E	12	Negligible	No	0	0
1930	Mammal	Tragelaphus derbianus Gray, 1847	Derby eland	2	NA	NA	Negligible	Yes	0	0
1931	Mammal	Tragelaphus eurycerus Ogilby, 1837	Bongo	1a	NA	NA	Negligible	No	0	0
1932	Mammal	Tragelaphus imberbis Blyth, 1869	Lesser kudu	1a	NA	NA	Negligible	No	0	0
1933	Mammal	Tragelaphus spekii Speke, 1863	Sitatunga	2	NA	NA	Negligible	Yes	0	0
1934	Plant (t / fw)	Tragopogon dubius Scop.	Yellow salsify	Unlisted	E	4	NE	No	0	0
1935	Invert. (t)	Travisia forbesii Johnston, 1840	No common name found	Unlisted	NA	NA	NE	No	0	0
1936	Invert. (t)	Trialeurodes vaporariorum (Westwood, 1856)	Glasshouse whitefly	Unlisted	NA	NA	NE	No	0	0
1937	Invert. (t)	Trichapion lativentre (Béguin-Billecocq)	No common name found	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1938	Invert. (t)	Trichilogaster acaciaelongifoliae (Froggatt, 1892)	Chalcid wasp	Unlisted (Biocontrol agent with permit)	Invasive	5	Negligible	Yes	RP	0
1939	Invert. (t)	Trichilogaster signiventris (Girault)	Acacia gall wasp	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1940	Plant (t / fw)	Trichocereus pachanoi Britton & Rose	San Pedro cactus	Unlisted	C2	1	NE	No	0	0
1941	Plant (t / fw)	Trichocereus spachianus (Lem.) Riccob	Torch cactus	Unlisted	E	123	NE	No	0	0
1942	Invert. (fw)	Trichocorixa verticalis (Fieber, 1851)	No common name found	Unlisted	D2	2	Some	No	0	0
1943	Invert. (fw)	Trichodina acuta Lom, 1961	No common name found	Unlisted	D2	6	Negligible	No	0	0
1944	Microbe	Tricholoma albobrunneum (Pers.)P. Kumm., 1871	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1945	Microbe	Tricholoma eucalypticum A. Pearson, 1950	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1946	Microbe	Tricholoma meridianum A. Pearson, 1950	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1947	Microbe	Tricholoma saponaceum (Fr.) P. Kumm., 1871	Soapy Knight	Unlisted	Introduced	NA	NE	No	0	0
1948	Microbe	Tricholoma ustale (Fr.)P. Kumm., 1871	Burnt Knight	Unlisted	Introduced	NA	NE	No	0	0
1949	Plant (t / fw)	Tridax procumbens (L.) L.	Tridax daisy	Unlisted	E	9	NE	No	0	0
1950	Invert. (t)	Trigonogenius globulus Solier, 1849	Globular spider beetle	Unlisted	NA	NA	NE	No	0	0

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1951	Reptile	Trimeresurus albolabris (Gray, 1842)	White-lipped pit viper	Unlisted	NA	NA	NE	No	0	0
1952	Reptile	Trimeresurus puniceus Boie, 1827	Ashy pit viper	Unlisted	NA	NA	NE	No	0	0
1953	Reptile	Trioceros (Chamaeleo) jacksonii (Boulenger, 1896)	Jackson's chameleon	Context specific	NA	NA	Some	Yes	0	0
1954	Reptile	Trioceros (Chamaeleo) melleri (Gray, 1865)	Meller's chameleon	Context specific	NA	NA	Some	Yes	0	0
1955	Plant (t / fw)	Triplaris americana L.	Ant tree	1a	E	5	Negligible	No	0	0
1956	Plant (t / fw)	Triticum aestivum L.	Volunteer wheat	Unlisted	C2	1	NE	No	0	0
1957	Amphibian	Triturus cristatus (Laurenti, 1768)	Northern crested newt	Unlisted	B1	1	DD	No	0	0
1958	Invert. (t)	Trogoderma granarium (Everts, 1899)	Khapra beetle	1b	Introduced	1	Major	No	0	0
1959	Invert. (t)	Trogoderma inclusum LeConte, 1854	Larger cabinet beetle	Unlisted	NA	NA	NE	No	0	0
1960	Invert. (t)	Trogoderma variabile Ballion, 1878	Warehouse beetle	Unlisted	NA	NA	NE	No	0	0
1961	Plant (t / fw)	Tropaeolum majus L.	Nasturtium	Unlisted	E	24	NE	No	0	0
1962	Plant (t / fw)	Tropaeolum speciosum Poepp. & Endl.	Chilean flame creeper	3	NA	NA	Negligible	No	0	0
1963	Microbe	Tuber rapaeodorum Tul. & C. Tul., 1843	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1964	Invert. (t)	Tunga penetrans Linnaeus, 1758	Chigoe flea	Unlisted	NA	NA	NE	No	0	0
1965	Reptile	Tupinambis merianae Duméril & Bibron, 1839	Argentine black and white tegu	Unlisted	NA	NA	NE	No	0	0
1966	Plant (t / fw)	Turnera ulmifolia L.	Yellow-alder	Unlisted	C2	1	NE	No	0	0
1967	Invert. (t)	Tylenchulus semipenetrans Cobb, 1913	Citrus nematode	Unlisted	NA	NA	NE	No	0	0
1968	Plant (t / fw)	Ulex europaeus L.	European gorse	1a	E	7	Negligible	No	0	0
1969	Plant (t / fw)	Ulmus minor Mill.	English elm	Unlisted	E	4	NE	No	0	0
1970	Plant (t / fw)	Ulmus parvifolia Jacq.	Chinese elm	Unlisted	E	20	NE	No	0	0
1971	Invert. (t)	Uloborus plumipes (Lucas, 1846)	Feather-legged lace weaver	Unlisted	NA	NA	NE	No	0	0
1972	Invert. (t)	Uloborus walckenaerius (Latreille, 1806)	No common name found	Unlisted	NA	NA	NE	No	0	0
1973	Reptile	Uromastyx acanthinura Bell, 1825	North African spiny-tailed lizard	Unlisted	NA	NA	NE	No	0	0
1974	Microbe	Uromycladium acaciae (Cooke)P. Syd. & Syd., 1914	No common name found	Unlisted	Introduced	NA	NE	No	0	0
1975	Microbe	Uromycladium species (unidentified)	No common name found	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1976	Microbe	Uromycladium tepperianum (Sacc.) McAlpine	Acacia gall rust fungus	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1977	Invert. (t)	Uroplata girardi Pic, 1934	Leaf miner	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
1978	Invert. (t)	Urozelotes rusticus (Koch, 1872)	Ground spider	Unlisted	NA	NA	NE	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1979	Plant (t / fw)	Vallisneria spiralis L.	Coiled vallisneria	Unlisted	E	4	NE	No	0	0
1980	Invert. (t)	Vallonia costata (Muller, 1774)	Costate vallonia	Unlisted	C3	5	Negligible	No	0	0
1981	Invert. (t)	Vallonia pulchella (Muller, 1774)	Lovely vallonia	Unlisted	C3	17	NE	No	0	0
1982	Invert. (t)	Vanessa cardui (L.)	Painted lady	Unlisted	D2	154	NE	No	0	0
1983	Reptile	Varanus acanthurus Boulenger, 1885	Ridgetail monitor	Unlisted	NA	NA	NE	No	0	0
1984	Reptile	Varanus exanthematicus Bosc, 1792	Savanna monitor	Unlisted	NA	NA	NE	No	0	0
1985	Reptile	Varanus salvator (Laurenti, 1768)	Common water monitor	3	NA	NA	Negligible	No	0	0
1986	Invert. (t)	Varroa destructor Anderson & Trueman, 2000	Varroa mite	1b	C3	All provinces	Negligible	No	0	0
1987	Plant (t / fw)	Verbascum thapsus L.	Common mullein	Unlisted	E	12	NE	No	0	0
1988	Plant (t / fw)	Verbascum virgatum Stokes	Twiggy mullein	Unlisted	E	7	NE	No	0	0
1989	Plant (t / fw)	Verbena bonariensis L.	Wild verbena	1b	E	285	Major	No	0	0
1990	Plant (t / fw)	Verbena brasiliensis Vell.	Brazilian verbena	1b	E	42	Major	No	0	0
1991	Plant (t / fw)	Verbena incompta P.W.Michael	Common clasping vervain	Unlisted	E	20	NE	No	0	0
1992	Plant (t / fw)	Verbena litoralis Kunth	Seashore verbena	Unlisted	E	4	NE	No	0	0
1993	Plant (t / fw)	Verbena officinalis L.	European verbena	Unlisted	E	24	NE	No	0	0
1994	Plant (t / fw)	Verbena rigida Spreng.	Veined verbena	1b	E	52	Major	No	0	0
1995	Plant (t / fw)	Verbesina encelioides (Cav.) Benth. & Hook.f. ex A.Gray	Golden crownbeard	Unlisted	E	42	NE	No	0	0
1996	Invert. (t)	Vertigo antivertigo (Draparnaud, 1801)	No common name found	Unlisted	Introduced	1	DD	No	0	0
1997	Invert. (t)	Vespula germanica (Fabricius, 1793)	European wasp	1b	C3	1	Negligible	No	0	0
1998	Invert. (t)	Vilhenabates minutus (Balogh, 1958)	No common name found	Unlisted	Introduced	KZN, MP	NE	No	0	0
1999	Plant (t / fw)	Vinca major L.	Greater periwinkle	1b	E	27	Negligible	No	0	0
2000	Plant (t / fw)	Vinca minor L.	Lesser periwinkle	1b	NA	NA	NE	No	0	0
2001	Plant (t / fw)	Viola hederacea Labill.	Australian violet	Unlisted	E	1	NE	No	0	0
2002	Plant (t / fw)	Viola priceana Pollard	Confederate violet	Unlisted	C2	1	NE	No	0	0
2003	Reptile	Vipera ammodytes Linnaeus, 1758	Nose-horned viper	Unlisted	NA	NA	NE	No	0	0
2004	Reptile	Vipera raddei Boettger, 1890	Caucasus viper	Unlisted	NA	NA	NE	No	0	0
2005	Invert. (t)	Viteus vitifoliae (Fitch,1855)	Grapevine phylloxera	Unlisted	NA	NA	NE	No	0	0
2006	Plant (t / fw)	Vitex agnus-castus L.	Lilac chastetree	Unlisted	C2	1	NE	No	0	0
2007	Plant (t / fw)	Vitex trifolia L.	Indian three-leaf vitex	1b	E	4	Major	No	0	0
2008	Plant (t / fw)	Vitis species (unidentified)	Grape	Unlisted	E	2	NE	No	0	0
2009	Invert. (t)	Vitrea contracta (Westerlund, 1871)	Contracted glass-snail	Unlisted	C3	1	Negligible	No	0	0
2010	Invert. (t)	Vitrea crystallina (Muller, 1774)	Land snail	Unlisted	Introduced	2	Negligible	No	0	0
2011	Plant (t / fw)	Washingtonia species (unidentified)	Washingtonia palm	Unlisted	E	4	NE	No	0	0
2012	Invert. (marine)	Watersipora subtorquata (d'Orbigny, 1852)	Red-rust bryozoan	Unlisted	E	Rocky intertidal west and south coasts	DD	No	0	0

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	DISTRIBUTION	IMPACT STATUS	RISK ASSESSMENT COMPLETED	PERMITS GRANTED	PERMITS REFUSED
2013	Plant (t / fw)	Wigandia urens var. caracasana (Kunth) (Ruiz & Pav.) D.N.Gibson	Wigandia	3	E	7	Negligible	No	0	0
2014	Plant (t / fw)	Wisteria floribunda (Willd.) DC	Japanese wisteria	Unlisted	C2	1	NE	No	0	0
2015	Plant (t / fw)	Xanthium spinosum L.	Spiny cocklebur	1b	E	47	Major	No	0	0
2016	Plant (t / fw)	Xanthium strumarium L.	Large cocklebur	1b	E	176	Major	No	0	0
2017	Invert. (marine)	Xantho incisus H. Milne Edwards, 1834	Montagu's Crab	Unlisted	B2	Aquaculture	DD	No	0	0
2018	Invert. (t)	Xenopsylla cheopis (Rothschild, 1903)	Oriental rat flea	Unlisted	NA	NA	NE	No	0	0
2019	Amphibian	Xenopus laevis x gilli (Daudin, 1802) Rose & Hewitt, 1927	African clawed toad x Cape (Gill's) platanna	1b	C3	NA	Major	No	0	0
2020	Invert. (t)	Xenylla maritima Tullberg, 1869	No common name found	Unlisted	Introduced	WC, EC, KZN, NW	NE	No	0	0
2021	Microbe	Xerocomus badius Fr.: Fr.) E.-J. Gilbert	Bay Boletus	Unlisted	Introduced	NA	NE	No	0	0
2022	Microbe	Xerocomus chrysenteron (Bull.)Quél., 1888	Red Cracking Bolete	Unlisted	Introduced	NA	NE	No	0	0
2023	Fish (fw)	Xiphophorus hellerii Heckel, 1848	Green Swordtail	Unlisted	NA	NA	Negligible	No	0	0
2024	Invert. (t)	Xyleborinus saxeseni (Ratzeburg 1834)	Fruit-tree pinhole borer	Unlisted	NA	NA	NE	No	0	0
2025	Plant (t / fw)	Youngia japonica (L.) DC.	Oriental false hawksbeard	Unlisted	E	6	NE	No	0	0
2026	Plant (t / fw)	Yucca aloifolia L.	Spanish bayonet	Unlisted	E	16	NE	No	0	0
2027	Bird	Zenaida macroura (Linnaeus, 1758)	Mourning dove	Unlisted	NA	NA	NE	No	0	0
2028	Invert. (t)	Zetorchella pedestris Berlese, 1916	No common name found	Unlisted	Introduced	LP	NE	No	0	0
2029	Invert. (t)	Zetorchella vargai Berlese, 1917	No common name found	Unlisted	Introduced	LP, WC	NE	No	0	0
2030	Invert. (t)	Zeuxidiplosis giardi (Kieffer, 1896).	St Johns wort midge	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0
2031	Plant (t / fw)	Zinnia peruviana (L.) L.	Redstar zinnia	Unlisted	E	62	NE	No	0	0
2032	Invert. (t)	Zonitoides arboreus (Say, 1817)	Quick gloss	Unlisted	D2	49	Negligible	No	0	0
2033	Invert. (t)	Zygogramma bicolorata Pallister, 1953	Leaf beetle	Unlisted (Biocontrol agent with permit)	Invasive	NA	Negligible	Yes	RP	0

LIST 2 Alien species that do not occur in South Africa, but are either prohibited, or have been eradicated from South Africa, or are listed as invasive in the regulations, but are known not to occur in South Africa.

For a description of the entries to different columns, see the descriptive notes at the start of list 1.

	HIGH LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	IMPACT STATUS	RISK ASS. COMPLETED	PERMITS GRANTED	PERMITS REFUSED
1	Fish (fw)	*Abramis* species	Bream	Prohibited	A0	NE	No	0	0
2	Plant (t / fw)	*Acaena pallida* (Kirk) Allen	Pale biddy-biddy	Prohibited	A0	NE	No	0	0
3	Fish (fw)	*Acantharchus* species	Mud sunfish	Prohibited	A0	NE	No	0	0
4	Invert. (t)	*Achatina fulica* (Férussac, 1821)	Giant African snail	Prohibited	A0	NE	Yes	0	0
5	Fish (fw)	*Acheilognathus* species	Bitterling	Prohibited	A0	NE	No	0	0
6	Plant (t / fw)	*Achnatherum caudatum* (Trin.) S.W.L.Jacobs & J. Everett	Spear grass	Prohibited	A0	NE	No	0	0
7	Fish (fw)	*Acipenser* species	Sturgeon	Prohibited	A0	NE	No	0	0
8	Plant (t / fw)	*Aegilops cylindrica* Host	Jointed goat grass	Prohibited	A0	NE	No	0	0
9	Plant (t / fw)	*Aegilops geniculata* Roth	Ovate goat grass	Prohibited	A0	NE	No	0	0
10	Plant (t / fw)	*Aegilops* species	Goat grasses	Prohibited	A0	NE	No	0	0
11	Plant (t / fw)	*Aegilops triuncialis* L.	Barb goat grass	Prohibited	A0	NE	No	0	0
12	Plant (t / fw)	*Aeginetia* species	Aeginetia species	Prohibited	A0	NE	No	0	0
13	Plant (t / fw)	*Aeschynomene rudis* Benth.	Zigzag joint-vetch	Prohibited	A0	NE	No	0	0
14	Reptile	*Agama agama africana* (Hallowell, 1844)	Common agama	Prohibited	A0	NE	No	0	0
15	Reptile	*Agama agama boensis* Monard 1940	No common name found	Prohibited	A0	NE	No	0	0
16	Reptile	*Agama lebretoni* Wagner, Barej & Schmitz, 2009	No common name found	Prohibited	A0	NE	No	0	0
17	Reptile	*Agama mucosoensis* Hellmich, 1957	Mucoso gama	Prohibited	A0	NE	No	0	0
18	Reptile	*Agama parafricana* Trape, Mediannikov & Trape, 2012	No common name found	Prohibited	A0	NE	No	0	0
19	Reptile	*Agama paragama* Grandison, 1968	False Agama	Prohibited	A0	NE	No	0	0
20	Reptile	*Agama savattieri* Rochebrune 1884	No common name found	Prohibited	A0	NE	No	0	0
21	Reptile	*Agama tassiliensis* Geniez, Padial & Crochet, 2011	No common name found	Prohibited	A0	NE	No	0	0
22	Reptile	*Agama wagneri* Trape, Mediannikov & Trape, 2012	Common gama,	Prohibited	A0	NE	No	0	0
23	Mammal	*Alcelaphus buselaphus* (Pallas, 1766)	Hartebeest	Prohibited	A0	NE	No	0	0
24	Bird	*Alectoris rufa* (Linnaeus, 1758)	Red-legged partridge	Prohibited	A0	NE	Yes	0	0
25	Invert. (t)	*Aleurodicus destructor* (Mackie, 1912).	Coconut whitefly	Prohibited	A0	NE	No	0	0
26	Invert. (t)	*Aleurodicus dispersus* Russell, 1965	Spiralling whitefly	Prohibited	A0	NE	No	0	0
27	Plant (t / fw)	*Allium paniculatum* L.	Mediterranean onion	Prohibited	A0	NE	No	0	0
28	Plant (t / fw)	*Allium vineale* L.	Wild garlic	Prohibited	A0	NE	No	0	0
29	Plant (t / fw)	*Altemanthera philoxeroides* (Mart.) Griseb.	Alligator weed	Prohibited	A0	NE	No	0	0
30	Invert. (t)	*Amblypelta lutescens* (Distant, 1911)	Banana spotting bug	Prohibited	A0	NE	No	0	0
31	Plant (t / fw)	*Ambrosia trifida* L.	Giant ragweed	Prohibited	A0	NE	No	0	0
32	Amphibian	*Ambystoma tigrinum* (Green, 1825)	Tiger salamander	Prohibited	A0	NE	No	0	0
33	Fish (fw)	*Ameiurus* species	Bullheads	Prohibited	A0	NE	No	0	0
34	Fish (fw)	*Amia calva* Linnaeus, 1766	Bowfin	Prohibited	A0	NE	No	0	0
35	Fish (fw)	*Amphilius* species	Catfish	Prohibited	A0	NE	No	0	0
36	Fish (fw)	*Anabas* species	Climbing fish	Prohibited	A0	NE	No	0	0
37	Invert. (t)	*Anastrepha ludens* (Loew, 1873)	Mexican fruit fly	Prohibited	A0	NE	No	0	0
38	Invert. (t)	*Anastrepha obliqua* (Macquart, 1835)	West Indian fruit fly	Prohibited	A0	NE	No	0	0
39	Invert. (t)	*Anastrepha pseudoparallela* (Loew, 1873)	Fruit fly	Prohibited	A0	NE	No	0	0

	HIGH LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	IMPACT STATUS	RISK ASS. COMPLETED	PERMITS GRANTED	PERMITS REFUSED
40	Invert. (t)	*Anastrepha serpentina* (Wiedemann, 1830)	Sapodilla fruit fly	Prohibited	A0	NE	No	0	0
41	Invert. (t)	*Anastrepha striata* Schiner, 1868	Guava fruit fly	Prohibited	A0	NE	No	0	0
42	Invert. (t)	*Anastrepha suspensa* (Loew, 1862)	Caribbean fruit fly	Prohibited	A0	NE	No	0	0
43	Plant (t / fw)	*Andropogon bicornis* L.	West Indian foxtail grass	Prohibited	A0	NE	No	0	0
44	Plant (t / fw)	*Andropogon virginicus* L.	Broom-sedge	Prohibited	A0	NE	No	0	0
45	Fish (fw)	*Anguilla* species	Eels	Prohibited	A0	NE	No	0	0
46	Plant (t / fw)	*Annona glabra* L.	Pond apple	Prohibited	A0	NE	No	0	0
47	Reptile	*Anolis distichus* Cope, 1861	Bark anole	Prohibited	A0	NE	No	0	0
48	Reptile	*Anolis sagrei* Duméril and Bibron, 1837	Brown anole	Prohibited	A0	NE	No	0	0
49	Invert. (t)	*Anoplophora glabripennis* (Motschulsky, 1853)	Asian long-horned beetle	Prohibited	A0	NE	No	0	0
50	Invert. (t)	Any species of the genera *Varroa*, *Euvarroa* or *Tropilaelaps*	Varroa mite, brood mite or Asian bee mites	Prohibited	A0	NE	No	0	0
51	Fish (fw)	*Aphanius* species	Minnow/Killifish	Prohibited	A0	NE	No	0	0
52	Invert. (t)	*Aphelenchoides fragariae* (Ritzema - Bos, 1891) Christie, 1932	Strawberry foliar nematode	Prohibited	A0	NE	No	0	0
53	Fish (fw)	*Aplocheilichthys* species	Killifish	Prohibited	A0	NE	No	0	0
54	Fish (fw)	*Arapaima gigas* (Schinz, 1822)	Arapaima	Prohibited	A0	NE	No	0	0
55	Invert. (t)	*Archips argyrospilus* (Walker, 1863)	Fruit tree leaf-roller	Prohibited	A0	NE	No	0	0
56	Invert (marine)	*Argopecten purpuratus* (Lamarck, 1819)	Chilean scallop	Prohibited	A0	NE	No	0	0
57	Invert. (t)	*Argyrotaenia citrana* (Fernald, 1899)	Orange tortrix moth	Prohibited	A0	NE	No	0	0
58	Plant (t / fw)	*Artemisia verlotiorum* Lamotte	Chinese mugwort	Prohibited	A0	NE	No	0	0
59	Invert (marine)	*Asterias amurensis* Lütken, 1871	Japanese Pacific seastar	Prohibited	A0	NE	No	0	0
60	Invert. (t)	*Aulacaspis yasumatsui* Takagi, 1977	Asian cycad scale	Prohibited	A0	NE	No	0	0
61	Plant (t / fw)	*Azolla* species	Azolla species	Prohibited	A0	NE	No	0	0
62	Plant (t / fw)	*Baccharis halimifolia* L.	Groundsel bush	Prohibited	A0	NE	No	0	0
63	Invert. (t)	*Bactrocera aquilonis* (May, 1965)	Orange tortrix moth	Prohibited	A0	NE	No	0	0
64	Invert. (t)	*Bactrocera carambolae* Drew & Hancock, 1994	Carambola fruit fly	Prohibited	A0	NE	No	0	0
65	Invert. (t)	*Bactrocera caryeae* (Kapoor, 1971)	Fruit fly	Prohibited	A0	NE	No	0	0
66	Invert. (t)	*Bactrocera correcta* (Bezzi, 1916)	Guava fruit fly	Prohibited	A0	NE	No	0	0
67	Invert. (t)	*Bactrocera cucurbitae* (Coquillett, 1899)	Melon fly	Prohibited	A0	NE	No	0	0
68	Invert. (t)	*Bactrocera dorsalis* (Hendel, 1912)	Oriental fruit fly	Prohibited	A0	NE	No	0	0
69	Invert. (t)	*Bactrocera facialis* (Coquillett, 1909)	Fruit fly	Prohibited	A0	NE	No	0	0
70	Invert. (t)	*Bactrocera frauenfeldi* (Schiner, 1868)	Mango fruit fly	Prohibited	A0	NE	No	0	0
71	Invert. (t)	*Bactrocera jarvisi* (Tryon,1927)	Jarvis' fruit fly	Prohibited	A0	NE	No	0	0
72	Invert. (t)	*Bactrocera kandiensis* Drew & Hancock, 1994	Fruit fly	Prohibited	A0	NE	No	0	0
73	Invert. (t)	*Bactrocera kirki* (Frogg, 1911)	Fruit fly	Prohibited	A0	NE	No	0	0
74	Invert. (t)	*Bactrocera latifrons* (Hendel, 1915)	Malaysian fruit fly	Prohibited	A0	NE	No	0	0
75	Invert. (t)	*Bactrocera melanotus* (Coquillett, 1909)	Black fruit fly	Prohibited	A0	NE	No	0	0
76	Invert. (t)	*Bactrocera musae* (Tryon, 1927)	Banana fruit fly	Prohibited	A0	NE	No	0	0
77	Invert. (t)	*Bactrocera neohumeralis* (Hardy, 1951)	Fruit fly	Prohibited	A0	NE	No	0	0
78	Invert. (t)	*Bactrocera occipitalis* (Bezzi, 1919)	Breadfruit fruit fly	Prohibited	A0	NE	No	0	0
79	Invert. (t)	*Bactrocera papayae* Drew & Hancock, 1994	Asian papaya fruit fly	Prohibited	A0	NE	No	0	0
80	Invert. (t)	*Bactrocera passiflorae* (Froggatt 1911)	Fijian fruit fly	Prohibited	A0	NE	No	0	0
81	Invert. (t)	*Bactrocera philippinensis* Drew & Hancock, 1994	Fruit fly	Prohibited	A0	NE	No	0	0
82	Invert. (t)	*Bactrocera psidii* (Froggatt, 1899)	South sea guava fruit fly	Prohibited	A0	NE	No	0	0

	HIGH LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	IMPACT STATUS	RISK ASS. COMPLETED	PERMITS GRANTED	PERMITS REFUSED
83	Invert. (t)	*Bactrocera pyrifoliae* Drew & Hancock, 1994	Fruit fly	Prohibited	A0	NE	No	0	0
84	Invert. (t)	*Bactrocera tryoni* (Froggatt, 1897)	Queensland fruit fly	Prohibited	A0	NE	No	0	0
85	Invert. (t)	*Bactrocera xanthodes* (Broun, 1904)	Pacific fruit fly	Prohibited	A0	NE	No	0	0
86	Invert. (t)	*Bactrocera zonata* (Saunders, 1842)	Peach fruit fly	Prohibited	A0	NE	No	0	0
87	Fish (fw)	*Bagrus* species	Catfish	Prohibited	A0	NE	No	0	0
88	Microbe	*Banana bunchy top virus* (BBTV) (E.F.Sm.) W.C.Snyder & H.N.Hansen (1940)	Banana bunchy top pathogen	Prohibited	A0	NE	No	0	0
89	Fish (fw)	*Barilius* species	Barbs	Prohibited	A0	NE	No	0	0
90	Fish (fw)	Bathyclarias species	Catfish	Prohibited	A0	NE	No	0	0
91	Invert. (t)	*Belonolaimus longicaudatus* Rau, 1958	Sting nematode	Prohibited	A0	NE	No	0	0
92	Plant (t / fw)	*Berberis glaucocarpa* Stapf	Barberry	Prohibited	A0	NE	No	0	0
93	Plant (t / fw)	*Bifora testiculata* (L.) Roth	Bifora	Prohibited	A0	NE	No	0	0
94	Reptile	*Boiga irregularis* (Bechstein, 1802)	Brown tree snake	Prohibited	A0	NE	No	0	0
95	Mammal	*Bos frontalis* Lambert, 1804	Gaur	Prohibited	A0	NE	Yes	0	0
96	Amphibian	*Bufo bufo* (Linnaeus, 1758)	Common toad	Prohibited	A0	NE	No	0	0
97	Invert. (t)	*Bursaphelenchus cocophilus* (Cobb,1919)	Red ring nematode	Prohibited	A0	NE	No	0	0
98	Invert. (t)	*Bursaphelenchus xylophilus* (Steiner & Buhrer, 1934) 1970	Pine wood nematode	Prohibited	A0	NE	No	0	0
99	Plant (t / fw)	*Cabomba* species	Cabomba species	Prohibited	A0	NE	No	0	0
100	Invert. (t)	*Calacarus brionesae* Keifer, 1963	Papaya leaf edgeroller	Prohibited	A0	NE	No	0	0
101	Plant (t / fw)	*Callistachys lanceolata* Vent.	Native willow	Prohibited	A0	NE	No	0	0
102	Plant (t / fw)	*Calluna vulgaris* (L.) Hall	Common heather	Prohibited	A0	NE	No	0	0
103	Plant (t / fw)	*Calotis lappulacea* Benth.	Bur-daisy	Prohibited	A0	NE	No	0	0
104	Invert (marine)	*Carcinus aestuarii* Nardo, 1847	Mediterranean Green Crab	Unlisted	A0	NE	No	3	0
105	Plant (t / fw)	*Carduus acanthoides* L.	Plumeless thistle	Prohibited	A0	Some	No	0	0
106	Plant (t / fw)	*Carduus pycnocephalus* L.	Italian thistle	Prohibited	A0	Negligible	No	0	0
107	Bird	*Carpodacus mexicanus* (Statius Muller, 1776)	House finch	Prohibited	A0	NE	No	0	0
108	Plant (t / fw)	*Carthamus leucocaulos* Sm.	White-stem distaff thistle	Prohibited	A0	NE	No	0	0
109	Plant (t / fw)	*Carthamus oxyacanthus* M.Bieb.	Wild safflower	Prohibited	A0	NE	No	0	0
110	Plant (t / fw)	*Cassinia arcuata* R.Br.	Chinese shrub	Prohibited	A0	NE	No	0	0
111	Invert. (t)	*Castnia licoides* Boisduval, 1875	Banana stem borer	Prohibited	A0	NE	No	0	0
112	Invert. (t)	*Castnia penelope* Walker, 1854 [1]	Fruit tree borer	Prohibited	A0	NE	No	0	0
113	Mammal	*Castor* species (all species) Linnaeus, 1758	Beaver	Prohibited	A0	NE	No	0	0
114	Plant (marine)	*Caulerpa taxifolia* (Vahl) C.Agardh	Killer algae	Prohibited	A0	NE	No	0	0
115	Plant (t / fw)	*Celastrus orbiculatus* Thunb.	Oriental bittersweet	Prohibited	A0	NE	No	0	0
116	Plant (t / fw)	*Cenchrus echinatus* L.	Southern sandbur grass	Prohibited	A0	NE	No	0	0
117	Plant (t / fw)	*Cenchrus longispinus* (Hack.) Fern.	Mat sandbur	Prohibited	A0	NE	No	0	0
118	Plant (t / fw)	*Centaurea diffusa* Lam.	Diffuse knapweed	Prohibited	A0	NE	No	0	0
119	Plant (t / fw)	*Centaurea iberica* Trevir. & Spreng.	Iberian knapweed	Prohibited	A0	NE	No	0	0
120	Plant (t / fw)	*Centaurea stoebe* Tausch	Spotted knapweed	Prohibited	A0	NE	No	0	0
121	Plant (t / fw)	*Centaurea sulphurea* Willd.	Sicilian star thistle	Prohibited	A0	NE	No	0	0
122	Plant (t / fw)	*Centaurea virgata* Lam. subsp. *squarrosa* (Boiss.) Gugler	Squarrose knapweed	Prohibited	A0	NE	No	0	0
123	Fish (fw)	*Centrarchus* species	Sunfish	Prohibited	A0	NE	No	0	0

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124	Invert. (t)	*Ceroplastes floridensis* Comstock	Florida wax scale	Prohibited	A0	NE	No	0	0
125	Fish (fw)	*Chaca chaca* (Hamilton, 1822)	Angler catfish	Prohibited	A0	NE	No	0	0
126	Fish (fw)	*Channa* species	Snakeheads	Prohibited	A0	NE	No	0	0
127	Fish (fw)	*Chela* species	Minnows	Prohibited	A0	NE	No	0	0
128	Fish (fw)	*Chetia* species	Kurpers	Prohibited	A0	NE	No	0	0
129	Fish (fw)	*Chiloglanis* species	Suckermouth catfish	Prohibited	A0	NE	No	0	0
130	Invert. (t)	*Chloropulvinaria polygonata* Borchsenius, 1957	Mango scale	Prohibited	A0	NE	No	0	0
131	Fish (fw)	*Chologaster cornutus* Agassiz, 1853	Swampfish	Prohibited	A0	NE	No	0	0
132	Fish (fw)	*Chondrostoma* species	Nases	Prohibited	A0	NE	No	0	0
133	Plant (t / fw)	*Chorispora tenella* (Pall.) DC.	Purple mustard	Prohibited	A0	NE	No	0	0
134	Invert. (t)	*Choristoneura rosaceana* (Harris, 1841)	Oblique-banded leaf roller	Prohibited	A0	NE	No	0	0
135	Fish (fw)	*Chrysichthys* species	Catfishes	Prohibited	A0	NE	No	0	0
136	Invert. (t)	*Chrysodeixis eriosoma* (Doubleday, 1843)	Oblique-banded leaf roller	Prohibited	A0	NE	No	0	0
137	Plant (t / fw)	*Chrysopogon aciculatus* (Retz.) Trin.	Golden false beard grass	Prohibited	A0	NE	No	0	0
138	Fish (fw)	*Cichla* species	Peacock bass	Prohibited	A0	NE	No	0	0
139	Plant (t / fw)	*Cirsium japonicum* (Thunb.) Fisch. ex DC.	Japanese thistle	Prohibited	A0	NE	No	0	0
140	Plant (t / fw)	*Cirsium ochrocentrum* A.Gray	Yellow-spine thistle	Prohibited	A0	NE	No	0	0
141	Plant (t / fw)	*Cirsium undulatum* (Nutt.) Spreng.	Wavy-leaf thistle	Prohibited	A0	NE	No	0	0
142	Invert. (t)	*Cisaberoptus kenyae* Keifer,1966.	Mango leafcoating mite	Prohibited	A0	NE	No	0	0
143	Fish (fw)	*Clarias batrachus* (Linnaeus, 1758)	Walking catfish	Prohibited	A0	NE	No	0	0
144	Plant (t / fw)	*Clematis vitalba* L.	Old man's beard	Prohibited	A0	NE	No	0	0
145	Plant (t / fw)	*Clidemia hirta* (L.) D.Don	Koster's curse	Prohibited	A0	NE	No	0	0
146	Invert. (t)	*Cnephasia jactatana* Walker, 1863 .	Black-lyre leaf roller moth	Prohibited	A0	NE	No	0	0
147	Plant (t / fw)	*Coccinia grandis* (L.) Voigt	Ivy gourd	Prohibited	A0	NE	No	0	0
148	Invert. (t)	*Colaspis hypochlora* Lefevre, 1878	Leaf scarring beetle	Prohibited	A0	NE	No	0	0
149	Bird	*Colinus cristatus* (Linnaeus, 1766)	Crested quail	Prohibited	A0	Negligible	Yes	0	0
150	Fish (fw)	*Colossoma* species	Pacu	Prohibited	A0	NE	Yes	0	0
151	Invert. (t)	*Conogethes punctiferalis* (Guenée, 1854	Yellow peach moth	Prohibited	A0	NE	No	0	0
152	Invert. (t)	*Conopomorpha litchiella* Bradley, 1986	Lychee leaf miner	Prohibited	A0	NE	No	0	0
153	Invert (fw)	*Corbicula fluminea* (O.F. Müller, 1774)	Asian clam	Prohibited	A0	NE	No	0	0
154	Fish (fw)	*Coregonus* species	Whitefish	Prohibited	A0	NE	No	0	0
155	Plant (t / fw)	*Cortaderia richardii* (Endl.) Zotov	New Zealand pampas grass	Prohibited	A0	NE	No	0	0
156	Bird	*Corvus brachyrhynchos* C.L. Brehm, 1822	American crow	Prohibited	A0	NE	Yes	0	0
157	Bird	*Corvus frugilegus* Linnaeus, 1758	Rook	Prohibited	A0	NE	Yes	0	0
158	Bird	*Corvus monedula* (Linnaeus, 1758)	Eurasian/ Western jackdaw	Prohibited	A0	NE	No	0	0
159	Fish (fw)	*Cottus* species	Sculpins	Prohibited	A0	NE	No	0	0
160	Plant (t / fw)	*Crassula helmsii* (Kirk) Cockayne	Swamp stonecrop	Prohibited	A0	NE	No	0	0
161	Plant (t / fw)	*Crataegus × sinaica* Boiss.	Azzarola	Prohibited	A0	NE	No	0	0
162	Fish (fw)	*Croilia* species	Goby	Prohibited	A0	NE	No	0	0
163	Plant (t / fw)	*Crupina vulgaris* Pers. ex. Cass.	Common crupina	Prohibited	A0	NE	No	0	0

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164	Invert. (t)	*Cryptophlebia ombrodelta* (Lower, 1898)	Litchi fruit moth	Prohibited	A0	NE	No	0	0
165	Invert. (t)	*Ctenopseustis obliquana* (Walker, 1863)	Brownheaded leafroller	Prohibited	A0	NE	No	0	0
166	Plant (t / fw)	*Cupaniopsis anacardioides* (A.Rich.) Radlk.	Carrotwood	Prohibited	A0	NE	No	0	0
167	Plant (t / fw)	*Cuscuta indecora* Choisy	Large-seeded dodder	Prohibited	A0	NE	No	0	0
168	Plant (t / fw)	*Cuscuta reflexa* Roxb.	Giant dodder	Prohibited	A0	NE	No	0	0
169	Plant (t / fw)	*Cylindropuntia* species	Chollas	Prohibited	A0	NE	No	0	0
170	Plant (t / fw)	*Cymbopogon refractus* (R.Br.) A.Camus	Barbwire grass	Prohibited	A0	NE	No	0	0
171	Fish (fw)	*Cyprinodon* species	Pupfish	Prohibited	A0	NE	No	0	0
172	Plant (t / fw)	*Datura leichhardtii* F.Muell. ex Benth.	Leichhardt's thorn apple	Prohibited	A0	NE	No	0	0
173	Plant (t / fw)	*Datura wrightii* Regel	Hairy thorn apple	Prohibited	A0	NE	No	0	0
174	Plant (t / fw)	*Dioscorea alata* L.	White yam	Prohibited	A0	NE	No	0	0
175	Plant (t / fw)	*Diplotaxis tenuifolia* (L.) DC	Sand rocket	Prohibited	A0	NE	No	0	0
176	Plant (t / fw)	*Dipsacus fullonum* L.	Wild teasel	Prohibited	A0	NE	No	0	0
177	Fish (fw)	*Docimodus* species	Cichild	Prohibited	A0	NE	No	0	0
178	Invert (fw)	*Dreissena polymorpha* (Pallas, 1771)	Zebra mussel, Eurasian zebra mussel	Prohibited	A0	NE	No	0	0
179	Invert (fw)	*Dreissena rostriformis* Deshayes, 1838	Quagga mussel	Prohibited	A0	NE	No	0	0
180	Plant (t / fw)	*Drymaria arenarioides* Humb. & Bonpl. ex Schult.	Lightning weed	Prohibited	A0	NE	No	0	0
181	Invert. (t)	*Dudua aprobola* (Meyrick, 1886)	Leaf curling moth	Prohibited	A0	NE	No	0	0
182	Invert. (t)	*Dysmicoccus neobrevipes* (Beardsley)	Grey pineapple mealybug	Prohibited	A0	NE	No	0	0
183	Plant (t / fw)	*Echium italicum* L.	Italian bugloss	Prohibited	A0	NE	No	0	0
184	Plant (t / fw)	*Eichhornia azurea* (Swartz) Kunth	Anchored water hyacinth	Prohibited	A0	NE	No	0	0
185	Plant (t / fw)	*Eichhornia* species	Water hyacinth species	Prohibited	A0	NE	No	0	0
186	Fish (fw)	*Elassoma* species	Pygmy sunfish	Prohibited	A0	NE	No	0	0
187	Fish (fw)	*Electrophorus electricus* (Linnaeus, 1766)	Electric eel	Prohibited	A0	NE	No	0	0
188	Plant (t / fw)	*Elephantopus moffis* Kunth	Elephant's foot	Prohibited	A0	NE	No	0	0
189	Amphibian	*Eleutherodactylus coqui* Thomas, 1966	Common coqui	Prohibited	A0	NE	No	0	0
190	Amphibian	*Eleutherodactylus planirostris* (Cope, 1862)	Greenhouse frog	Prohibited	A0	NE	No	0	0
191	Bird	*Emberiza citrinella* Linnaeus, 1758	Yellowhammer	Prohibited	A0	NE	No	0	0
192	Plant (t / fw)	*Emex spinosa* (L.) Campd.	Spiny emex	Prohibited	A0	NE	No	0	0
193	Fish (fw)	*Engraulicyprus* species	Lake sardines	Prohibited	A0	NE	No	0	0
194	Fish (fw)	*Enneacanthus* species	Little sunfishes	Prohibited	A0	NE	No	0	0
195	Invert. (t)	*Epiphyas postvittana* (Walker, 1863).	Light brown apple moth	Prohibited	A0	NE	No	0	0
196	Plant (t / fw)	*Equisetum arvense* L.	Field horsetail	Prohibited	A0	NE	No	0	0
197	Invert. (t)	*Erechthias flavistriata* (Walsingham, 1907) Zimmerman, 1978	Sugarcane bud moth	Prohibited	A0	NE	No	0	0
198	Plant (t / fw)	*Erica lusitanica* Rudolphi	Spanish heath	Prohibited	A0	NE	No	0	0
199	Mammal	*Erinaceus europaeus* Linnaeus, 1758	Western European hedgehog	Prohibited	A0	NE	No	0	0
200	Invert (marine)	*Eriocheir sinensis* (H. Milne Edwards)	Chinese mitten crab	Prohibited	A0	NE	No	0	0
201	Invert. (t)	*Erionota thrax* (Linnaeus, 1767)	Banana skipper	Prohibited	A0	NE	No	0	0
202	Fish (fw)	*Esox* species	Pike	Prohibited	A0	NE	No	0	0
203	Invert. (t)	*Euglandina rosea* (Férussac, 1821)	Rosy wolf snail	Prohibited	A0	NE	No	0	0
204	Plant (t / fw)	*Euphorbia oblongata* Griseb.	Eggleaf spurge	Prohibited	A0	NE	No	0	0
205	Plant (t / fw)	*Euphorbia terracina* L.	Geraldton carnation	Prohibited	A0	NE	No	0	0

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206	Fish (fw)	*Eutropius* species	Cichlid	Prohibited	A0	NE	No	0	0
207	Plant (t / fw)	*Fallopia japonica* (Houtt.) Ronse Decr.	Japanese knotweed	Prohibited	A0	NE	No	0	0
208	Invert (marine)	*Fenneropenaeus indicus* (Milne-Edwards, 1837)	Indian prawn	2	A0	Negligible	No	0	0
209	Bird	*Francolinus pondicerianus* (Gmelin, 1789)	Grey francolin	Prohibited	A0	NE	Yes	0	0
210	Fish (fw)	*Fundulus* species	Top minnows	Prohibited	A0	NE	No	0	0
211	Microbe	*Fusarium oxysporum f. sp. cubense* (E.F.Sm.) W.C.Snyder & H.N.Hansen (1940)	Panama wilt disease	Prohibited	A0	NE	No	0	0
212	Fish (fw)	*Galaxias* species	Galaxiids	Prohibited	A0	NE	No	0	0
213	Fish (fw)	*Gambusia* species	Mosquito-fish	Prohibited	A0	NE	No	0	0
214	Fish (fw)	*Gasterosteus* species	Sticklebacks	Prohibited	A0	NE	No	0	0
215	Plant (t / fw)	*Gaura drummondii* (Spach) Torr. & A.Gray	Drummond's gaura	Prohibited	A0	NE	No	0	0
216	Fish (fw)	*Gephyroglanis* species	Catfish	Prohibited	A0	NE	No	0	0
217	Mammal	*Giraffa camelopardalis* (Linnaeus, 1758)	Giraffe (except the South African giraffe)	Prohibited	A0	NE	No	0	0
218	Invert. (t)	*Globodera pallida* (Stone, 1973)) Behrens, 1975	Pale cyst nematode	Prohibited	A0	NE	No	0	0
219	Fish (fw)	*Glossogobius* species	Gobies	Prohibited	A0	NE	No	0	0
220	Plant (t / fw)	*Gmelina asiatica* L.	Badhara bush	Prohibited	A0	NE	No	0	0
221	Fish (fw)	*Gobio* species	Gudgeons	Prohibited	A0	NE	No	0	0
222	Fish (fw)	*Gymnallabes* species	Air-breathing catfish	Prohibited	A0	NE	No	0	0
223	Plant (t / fw)	*Gymnocoronis spilanthoides* DC.	Senegal tea plant	Prohibited	A0	NE	No	0	0
224	Plant (t / fw)	*Halimodendron halodendron* (Pall.) Voss	Russian salt tree	Prohibited	A0	NE	No	0	0
225	Plant (t / fw)	*Halogeton glomeratus* (M.Bieb.) C.A.Mey.	Halogeton	Prohibited	A0	NE	No	0	0
226	Plant (t / fw)	*Harrisia* species	Prickly apples	Prohibited	A0	NE	No	0	0
227	Plant (t / fw)	*Harungana madagascariensis* Lam. ex Poir.	Dragon's blood tree	Prohibited	A0	NE	No	0	0
228	Plant (t / fw)	*Helianthus ciliaris* DC.	Blueweed	Prohibited	A0	NE	No	0	0
229	Reptile	*Hemidactylus frenatus* Duméril & Bibron, 1836	Common house gecko	Prohibited	A0	NE	No	0	0
230	Reptile	*Hemidactylus garnotii* Duméril and Bibron, 1836	Indo-Pacific gecko	Prohibited	A0	NE	No	0	0
231	Reptile	*Hemidactylus turcicus* (Linnaeus, 1758)	Mediterranean gecko	Prohibited	A0	NE	No	0	0
232	Mammal	*Herpestes auropunctatus* (Hodgson, 1836)	Small Indian mongoose	Prohibited	A0	NE	No	0	0
233	Mammal	*Herpestes javanicus* (É. Geoffroy Saint-Hilaire, 1818)	Javan mongoose	Prohibited	A0	NE	No	0	0
234	Fish (fw)	*Heterobranchus* species	Air-breathing catfish	Prohibited	A0	NE	No	0	0
235	Invert. (t)	*Heterodera glycines* Ichinohe, 1952	Soybean cyst nematode	Prohibited	A0	NE	No	0	0
236	Invert. (t)	*Heterodera goettingiana* Liebscher, 1892	Pea cyst nematode	Prohibited	A0	NE	No	0	0
237	Plant (t / fw)	*Hieracium aurantiacum* L.	Orange hawkweed	Prohibited	A0	NE	No	0	0
238	Plant (t / fw)	*Hieracium pilosella* L.	Mouse-ear hawkweed	Prohibited	A0	NE	No	0	0
239	Plant (t / fw)	*Hieracium praealtum* Vill. ex Gochnat	King devil	Prohibited	A0	NE	No	0	0
240	Mammal	*Hippotragus niger* (Harris, 1838)	Sable antelope	Prohibited	A0	NE	No	0	0
241	Invert. (t)	*Holopothrips ananasi* Costa Lima	Ananas thrips	Prohibited	A0	NE	No	0	0
242	Fish (fw)	*Hucho hucho* (Linnaeus, 1758)	Danube salmon	Prohibited	A0	NE	No	0	0
243	Fish (fw)	*Huso huso* (Linnaeus, 1758)	Beluga	Prohibited	A0	NE	No	0	0
244	Plant (t / fw)	*Hydrocharis morsus-ranae* L.	Frogbit	Prohibited	A0	NE	No	0	0
245	Fish (fw)	*Hydrocynus* species	African tiger fish	Prohibited	A0	NE	No	0	0
246	Plant (t / fw)	*Hydrodictyon reticulatum* (Linneus) Lagerheim	Water net	Prohibited	A0	NE	No	0	0
247	Plant (t / fw)	*Hygrophila costata* Nees	Hygrophila	Prohibited	A0	NE	No	0	0
248	Plant (t / fw)	*Hygrophila polysperma* (Roxb.) T.Anderson	Indian swamp weed	Prohibited	A0	NE	No	0	0

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249	Plant (t / fw)	*Hymenachne amplexicaulis* (Rudge) Nees	West Indian marsh grass	Prohibited	A0	NE	No	0	0
250	Plant (t / fw)	*Hypericum × inodorum* Mill.	Tall St John's wort	Prohibited	A0	NE	No	0	0
251	Plant (t / fw)	*Hypericum triquetrifolium* Turra	Tangled hypericum	Prohibited	A0	NE	No	0	0
252	Invert. (t)	*Hyphantria cunea* (Drury, 1773)	Fall webworm	Prohibited	A0	NE	No	0	0
253	Plant (t / fw)	*Hyptis capitata* Jacq.	Knobweed	Prohibited	A0	NE	No	0	0
254	Plant (t / fw)	*Hyptis pectinata* (L.) Poit.	Comb hyptis	Prohibited	A0	NE	No	0	0
255	Plant (t / fw)	*Hyptis suaveolens* (L.) Poit.	Wild spikenard	Prohibited	A0	NE	No	0	0
256	Bird	*Icterus pectoralis* (Wagler, 1829)	Spot-breasted oriole	Prohibited	A0	NE	No	0	0
257	Plant (t / fw)	*Imperata brasiliensis* Trin.	Brazilian satin-tail	Prohibited	A0	NE	No	0	0
258	Plant (t / fw)	*Imperata brevifolia* Vasey	Satin-tail	Prohibited	A0	NE	No	0	0
259	Plant (t / fw)	*Ipomoea triloba* L.	Little-bell	Prohibited	A0	NE	No	0	0
260	Plant (t / fw)	*Ischaemum rugosum* Salisb.	Murain grass	Prohibited	A0	NE	No	0	0
261	Plant (t / fw)	*Iva axillaris* Pursh.	Poverty weed	Prohibited	A0	NE	No	0	0
262	Plant (t / fw)	*Iva axillaris* subsp. *robustior* (Hook.) Bassett	Poverty weed	Prohibited	A0	NE	No	0	0
263	Fish (fw)	*Jordanella floridae* (Goode Bean, 1879)	American flagfish	Prohibited	A0	NE	No	0	0
264	Plant (t / fw)	*Juncus acutus* L.	Spiny rush	Prohibited	A0	NE	No	0	0
265	Mammal	*Kobus kob* (Erxleben, 1777)	Kob	Prohibited	A0	NE	No	0	0
266	Mammal	*Kobus leche* (Gray, 1815)	Lechwe	Prohibited	A0	NE	No	0	0
267	Mammal	*Kobus megaceros* (Fitzinger, 1855)	Nile lechwe	Prohibited	A0	NE	No	0	0
268	Invert. (t)	*Lachnopus sp.* near *campechianus*	Banana fruit-scarring beetle	Prohibited	A0	NE	No	0	0
269	Plant (t / fw)	*Lagascea mollis* Cav.	Acuate	Prohibited	A0	NE	No	0	0
270	Fish (fw)	*Lampetra* species	Lampreys	Prohibited	A0	NE	No	0	0
271	Fish (fw)	*Lates* species (Bloch, 1790)	Perch and barramundi	Prohibited	A0	NE	No	0	0
272	Fish (fw)	*Ictalurus* species	Catfish	Prohibited	A0	NE	No	0	0
273	Fish (fw)	*Idus idus* (Linnaeus, 1758)	Golden orfe	Prohibited	A0	NE	No	0	0
274	Reptile	*Leiocephalus carinatus* Gray, 1827	Northern curlytail lizard	Prohibited	A0	NE	No	0	0
275	Plant (t / fw)	*Lepidium appelianum* Al-Shehbaz	Globe-pod hoary cress	Prohibited	A0	NE	No	0	0
276	Plant (t / fw)	*Lepidium draba* subsp. *chalepense* (L.) Thell.	Lens podded hoary cress	Prohibited	A0	NE	No	0	0
277	Plant (t / fw)	*Lepidium latifolium* L.	Broadleaved pepperweed	Prohibited	A0	NE	No	0	0
278	Fish (fw)	*Lepomis* species	Sunfishes	Prohibited	A0	NE	No	0	0
279	Fish (fw)	*Leptoglanis* species	Catfishes	Prohibited	A0	NE	No	0	0
280	Fish (fw)	*Leuciscus* species	Eurasian daces	Prohibited	A0	NE	No	0	0
281	Plant (t / fw)	*Limnobium laevigatum* (Humb. & Bonpl. ex Willd.) Heine	South American spongeplant	Prohibited	A0	NE	No	0	0
282	Plant (t / fw)	*Limnobium spongia* (Bosc) Rich. ex Steud.	American spongeplant	Prohibited	A0	NE	No	0	0
283	Plant (t / fw)	*Limnocharis flava* (L.) Buchenau	Yellow burr-head	Prohibited	A0	NE	No	0	0
284	Plant (t / fw)	*Limnophila indica* (L.) Druce	Ambulia	Prohibited	A0	NE	No	0	0
285	Plant (t / fw)	*Limnophila sessiliflora* (Vahl) Blume	Asian marshweed	Prohibited	A0	NE	No	0	0
286	Fish (fw)	*Liposarcus* species	Janitor fish	Prohibited	A0	NE	No	0	0
287	Amphibian	*Lithobates catesbeianus* (Shaw, 1802)	American bullfrog	Prohibited	A0	NE	No	0	0
288	Invert. (t)	*Lobesia aeolopa* Meyrick, 1907	Tortricidae moth	Prohibited	A0	NE	No	0	0
289	Invert. (t)	*Longidorus attenuatus* Hooper, 1961	Needle nematode	Prohibited	A0	NE	No	0	0
290	Invert. (t)	*Longidorus elongatus* (De Man, 1876) Micoletzky, 1922	Needle nematode	Prohibited	A0	NE	No	0	0

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291	Fish (fw)	*Lota lota* Linnaeus, 1758)	Burbot	Prohibited	A0	NE	No	0	0
292	Fish (fw)	*Luciosoma setigerum* (Valenciennes, 1842)	Apollo sharkminnow	Prohibited	A0	NE	No	0	0
293	Plant (t / fw)	*Ludwigia peploides* (Kunth) P.H.Raven	Floating primrose-willow	Prohibited	A0	NE	No	0	0
294	Invert. (t)	*Lymantria dispar* (Linnaeus, 1758)	Asian gypsy moth	Prohibited	A0	NE	No	0	0
295	Invert. (t)	*Maconellicoccus hirsutus* Green, 1908	Pink hibiscus mealybug	Prohibited	A0	NE	No	0	0
296	Plant (t / fw)	*Malachra alceifolia* Jacq.	Malachra	Prohibited	A0	NE	No	0	0
297	Fish (fw)	*Malapterurus* species	Electric catfish	Prohibited	A0	NE	No	0	0
298	Plant (t / fw)	*Malvella leprosa* (Ortega) Krapov.	Alkali mallow	Prohibited	A0	NE	No	0	0
299	Fish (fw)	*Marcusenius* species	Elephantfish	Prohibited	A0	NE	No	0	0
300	Plant (t / fw)	*Martynia annua* L.	Devil's claw	Prohibited	A0	NE	No	0	0
301	Plant (t / fw)	*Medinilla venosa* Blume	Holdtight	Prohibited	A0	NE	No	0	0
302	Plant (t / fw)	*Melastoma malabathricum* L.	Indian-rhododendron	Prohibited	A0	NE	No	0	0
303	Plant (t / fw)	*Melastoma* species Blume	Melastoma species	Prohibited	A0	NE	No	0	0
304	Plant (t / fw)	*Menyanthes trifoliata* L.	Bog bean	Prohibited	A0	NE	No	0	0
305	Fish (fw)	*Mesobola* species	Sardines	Prohibited	A0	NE	No	0	0
306	Invert. (t)	*Metamasius callizona* (Chevrolat)	Mexican bromeliad weevil	Prohibited	A0	NE	No	0	0
307	Plant (t / fw)	*Miconia species* Ruiz & Pavón	miconia	Prohibited	A0	NE	No	0	0
308	Fish (fw)	*Micropterus* species	Black bass	Prohibited	A0	NE	No	0	0
309	Plant (t / fw)	*Mikania cordata* (Burm.f.) B.L.Rob.	Mile-a-minute	Prohibited	A0	NE	No	0	0
310	Plant (t / fw)	*Mikania micrantha* Kunth	bittervine	Prohibited	A0	NE	No	0	0
311	Plant (t / fw)	*Mikania scandens* (L.) Willd.	Climbing hempweed	Prohibited	A0	NE	No	0	0
312	Plant (t / fw)	*Mimosa diplotricha* Sauvalle	Giant sensitive-plant	Prohibited	A0	NE	No	0	0
313	Plant (t / fw)	*Miscanthus floridulus* (Labill.) Warb. ex K.Schum. & Lauterb	Giant Chinese silver grass	Prohibited	A0	NE	No	0	0
314	Fish (fw)	*Misgumus* species	Weather fish	Prohibited	A0	NE	No	0	0
315	Invert (marine)	*Mnemiopsis leidyi* A. Agassiz, 1865	Sea walnut	Prohibited	A0	NE	No	0	0
316	Bird	*Molothrus ater* (Boddaert, 1783)	Brown-headed Cowbird	Prohibited	A0	NE	No	0	0
317	Plant (t / fw)	*Monochoria hastata* (L.) Solms	Hastate-leaf-pondweed	Prohibited	A0	NE	No	0	0
318	Plant (t / fw)	*Monochoria vaginalis* (Burm.f.) C.Presl. ex Kunth	Oval-leaf pondweed	Prohibited	A0	NE	No	0	0
319	Plant (t / fw)	*Muhlenbergia schreberi* J.F.Gmel.	Nimblewill	Prohibited	A0	NE	No	0	0
320	Mammal	*Mustela erminea* Linnaeus, 1758	Short-tailed weasel	Prohibited	A0	NE	No	0	0
321	Plant (t / fw)	*Myagrum perfoliatum* L.	Muskweed	Prohibited	A0	NE	No	0	0
322	Fish (fw)	*Myleus* species	Serrasalmids	Prohibited	A0	NE	No	0	0
323	Invert. (t)	*Nacoleia octasema* (Meyrick, 1886)	Banana scab moth	Prohibited	A0	NE	No	0	0
324	Plant (t / fw)	*Najas guadalupensis* (Spreng.) Magnus	Southern naiad	Prohibited	A0	NE	No	0	0
325	Invert. (t)	*Nanidorus nanus* (Allen, 1957) Siddiqi, 1974	Stubby root nematode	Prohibited	A0	NE	No	0	0
326	Plant (t / fw)	*Nassella charruana* (Arechav.) Barkworth	Lobed needlegrass	Prohibited	A0	NE	No	0	0
327	Plant (t / fw)	*Nassella hyalina* (Nees) Barkworth	Cane needlegrass	Prohibited	A0	NE	No	0	0
328	Plant (t / fw)	*Nassella leucotricha* (Trin. & Rupr.) R.W.Pohl	Texas needlegrass	Prohibited	A0	NE	No	0	0
329	Plant (t / fw)	*Nechamandra alternifolia* (Roxb.) Thwaites	Nechamandra	Prohibited	A0	NE	No	0	0
330	Fish (fw)	*Neochanna* species	Mudfish	Prohibited	A0	NE	No	0	0
331	Fish (fw)	*Neomacheilus* species	Stone loaches	Prohibited	A0	NE	No	0	0
332	Plant (t / fw)	*Neyraudia reynaudiana* (Kunth) Keng ex A.S.Hitchc.	Burma reed	Prohibited	A0	NE	No	0	0
333	Microbe	*Nosema ceranae* (Fries *et al.*, 1996)	Kiss-of-death bacteria	Prohibited	A0	NE	No	0	0
334	Fish (fw)	*Notemigonus crysoleucas* (Mitchill, 1814)	Golden shiner	Prohibited	A0	NE	No	0	0

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335	Fish (fw)	*Notropis* species	Eastern shiner	Prohibited	A0	NE	No	0	0
336	Plant (t / fw)	*Nymphoides geminata* (R.Br.) Kuntze	Entire marshwort	Prohibited	A0	NE	No	0	0
337	Invert. (t)	*Odoiporus longicollis* Olivier, 1807	Banana pseudostem weevil	Prohibited	A0	NE	No	0	0
338	Plant (t / fw)	*Oenanthe pimpinelloides* L.	Corky-fruit water-dropwort	Prohibited	A0	NE	No	0	0
339	Invert. (t)	*Oligonychus biharensi* (Hirst)	Spider mite	Prohibited	A0	NE	No	0	0
340	Invert. (t)	*Oligonychus punicae* (Hirst, 1926)	Avocado brown mite	Prohibited	A0	NE	No	0	0
341	Invert. (t)	*Oligonychus yothersi* (McGregor)	Avocado red mite	Prohibited	A0	NE	No	0	0
342	Fish (fw)	*Oncorhynchus* species,	Trout and Salmon species	Prohibited	A0	NE	No	0	0
343	Plant (t / fw)	*Ononis alopecuroides* L.	Foxtail restharrow	Prohibited	A0	NE	No	0	0
344	Plant (t / fw)	*Onopordum acaulon* L.	Stemless thistle	Prohibited	A0	NE	No	0	0
345	Plant (t / fw)	*Onopordum illyricum* L.	Illyrian thistle	Prohibited	A0	NE	No	0	0
346	Plant (t / fw)	*Onopordum tauricum* Willd.	Taurean thistle	Prohibited	A0	NE	No	0	0
347	Fish (fw)	*Ophicephalus* species	Snakehead	Prohibited	A0	NE	No	0	0
348	Fish (fw)	*Opsaridium* species	Barilius	Prohibited	A0	NE	No	0	0
349	Plant (t / fw)	*Opuntia* species	Prickly pears	Prohibited	A0	NE	No	0	0
350	Invert (fw)	*Orconectes limosus* (Rafinesque, 1817)	North American spiny cheek crayfish	Prohibited	A0	NE	Yes	0	0
351	Invert (fw)	*Orconectes rusticus* (Girard, 1852)	Rusty crayfish	Prohibited	A0	NE	Yes	0	0
352	Fish (fw)	*Oreochromis* species	Tilapias	Prohibited	A0	NE	No	0	0
353	Plant (t / fw)	*Orobanche cooperi* (A.Gray) A.Heller	Cooper's broomrape	Prohibited	A0	NE	No	0	0
354	Invert. (t)	*Oryctes rhinoceros* (Linnaeus, 1758)	Asiatic rhinoceros beetle	Prohibited	A0	NE	No	0	0
355	Mammal	*Oryx beisa* Rüppell, 1835	Beisa oryx	Prohibited	A0	NE	No	0	0
356	Plant (t / fw)	*Oryza rufipogon* Griff.	Perennial wild red rice	Prohibited	A0	NE	No	0	0
357	Fish (fw)	*Oryzias* species	Rice fish	Prohibited	A0	NE	No	0	0
358	Fish (fw)	*Osmerus eperlanus* (Linnaeus, 1758)	Smelt	Prohibited	A0	NE	No	0	0
359	Amphibian	*Osteopilus septentrionalis* (Duméril & Bibron, 1841)	Cuban tree-frog	Prohibited	A0	NE	No	0	0
360	Invert (marine)	*Ostrea edulis* Linnaeus, 1758	European flat oyster	3	A0	Negligible	No	0	0
361	Plant (t / fw)	*Ottefia alismoides* (L.) Pers.	Duck-lettuce	Prohibited	A0	NE	No	0	0
362	Plant (t / fw)	*Oxyspora paniculata* (D.Don) DC.	Bristletips	Prohibited	A0	NE	No	0	0
363	Bird	*Oxyura leucocephala* (Scopoli, 1769)	White-headed duck	Prohibited	A0	NE	No	0	0
364	Invert (fw)	*Pacifastacus leniusculus* (Dana, 1852)	North American signal crayfish	Prohibited	A0	NE	Yes	0	0
365	Plant (t / fw)	*Paederia cruddasiana* Prain	Sewer vine	Prohibited	A0	NE	No	0	0
366	Plant (t / fw)	*Paederia foetida* L.	Skunk vine	Prohibited	A0	NE	No	0	0
367	Microbe	*Paenibacillus larvae* (Ash, 1994)	American foulbrood bacteria	Prohibited	A0	NE	No	0	0
368	Plant (t / fw)	*Panicum antidotale* Retz	Blue panic grass	Prohibited	A0	NE	No	0	0
369	Fish (fw)	*Paragalaxias* species	Paragalaxias	Prohibited	A0	NE	No	0	0
370	Invert. (t)	*Paratachardina pseudolobata* Kondo & Gullan	Lobate lac scale	Prohibited	A0	NE	No	0	0
371	Invert. (t)	*Paratrichodorus pachydermus* (Seinhorst, 1954)	Stubby root nematode	Prohibited	A0	NE	No	0	0
372	Invert. (t)	*Paratrichodorus tunisiensis* (Siddiqi, 1963)	Stubby root nematode	Prohibited	A0	NE	No	0	0
373	Invert. (t)	*Paratylenchus bukowinensis* Micholetzky, 1922 -Goodey, 1963	Pin nematode	Prohibited	A0	NE	No	0	0

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374	Plant (t / fw)	*Parietaria judaica* L.	Wall pellitory	Prohibited	A0	NE	No	0	0
375	Bird	*Passer hispaniolensis* (Temminck, 1820)	Spanish sparrow	Prohibited	A0	NE	Yes	0	0
376	Bird	*Passer montanus* (Linnaeus, 1758)	Eurasian tree sparrow	Prohibited	A0	NE	Yes	0	0
377	Plant (t / fw)	*Passiflora bicornis* Mill.	Wingleaf passionfruit	Prohibited	A0	NE	No	0	0
378	Amphibian	*Pelophylax* species (unidentified)	Edible frog	1b	A0	Severe	No	0	0
379	Invert (marine)	*Penaeus monodon* Fabricius, 1798	Giant tiger prawn	2	A0	Negligible	Yes	0	0
380	Plant (t / fw)	*Pennisetum alopecuroides* (L.) Spreng.	Chinese pennisetum	Prohibited	A0	NE	No	0	0
381	Plant (t / fw)	*Pennisetum pedicellatum* Trin.	Kyasuwa-grass	Prohibited	A0	NE	No	0	0
382	Plant (t / fw)	*Pennisetum polystachion* (L.) Schult.	Mission grass	Prohibited	A0	NE	No	0	0
383	Fish (fw)	*Perca* species	Perch	Prohibited	A0	NE	No	0	0
384	Fish (fw)	*Percina* species	Roughbelly darters	Prohibited	A0	NE	No	0	0
385	Bird	*Perdix perdix* (Linnaeus, 1758)	Grey partridge	Prohibited	A0	NE	Yes	0	0
386	Plant (t / fw)	*Pereskia* species not in South Africa	Rose cacti	Prohibited	A0	NE	No	0	0
387	Plant (t / fw)	*Persicaria perfoliata* (L.) H.Gross	Devil's tail tearthumb	Prohibited	A0	NE	No	0	0
388	Plant (t / fw)	*Persicaria wallichii* Greuter & Burdet	Himalayan knotweed	Prohibited	A0	NE	No	0	0
389	Fish (fw)	*Petrocephalus* species	Mormyrid	Prohibited	A0	NE	No	0	0
390	Fish (fw)	*Petromyzon marinus* Linnaeus, 1758	Sea lamprey	Prohibited	A0	NE	No	0	0
391	Fish (fw)	*Phoxinus* species	Minnow	Prohibited	A0	NE	No	0	0
392	Plant (t / fw)	*Physalis longifolia* Nutt.	Long-leaf ground-cherry	Prohibited	A0	NE	No	0	0
393	Microbe	*Phytophthora ramorum* Werres *et al.*, 2001	Sudden oak death pathogen	Prohibited	A0	NE	No	0	0
394	Plant (t / fw)	*Picnomon acarna* (L.) Cass.	Soldier thistle	Prohibited	A0	NE	No	0	0
395	Plant (t / fw)	*Piper aduncum*	Spiked pepper	Prohibited	A0	NE	No	0	0
396	Invert. (t)	*Planococcoides njalensis* (Laing)	West African cocoa mealybug	Prohibited	A0	NE	No	0	0
397	Invert. (t)	*Planococcus litchi* Cox, 1989	Mealybug	Prohibited	A0	NE	No	0	0
398	Invert. (t)	*Planococcus minor* Maskell 1897	Passionvine mealybug	Prohibited	A0	NE	No	0	0
399	Invert. (t)	*Planotortix excessana* (Walker)	Leafroller moth	Prohibited	A0	NE	No	0	0
400	Microbe	*Plasmodium relictum* (Grassi & Feletti, 1891)	Avian malariapathogen	Prohibited	A0	NE	No	0	0
401	Invert. (t)	*Platydemus manokwari* de Beauchamp, 1963	Flatworm (Turbellaria)	Prohibited	A0	NE	No	0	0
402	Invert. (t)	*Platynota stultana* Walsingham (1884–1965)	Omnivorous leafroller	Prohibited	A0	NE	No	0	0
403	Fish (fw)	*Plecostomus* species	Pleco	Prohibited	A0	NE	No	0	0
404	Reptile	*Podarcis* species	True and Italian wall lizards	Prohibited	A0	NE	No	0	0
405	Fish (fw)	*Pogonopoma* species	Armored catfish	Prohibited	A0	NE	No	0	0
406	Fish (fw)	*Pomoxis* species	Crappies	Prohibited	A0	NE	No	0	0
407	Plant (t / fw)	*Pontederia rotundifolia* L.f.	Tropical pickerel-weed	Prohibited	A0	NE	No	0	0
408	Invert (fw)	*Potamocorbula amurensis* (Schrenck, 1861)	Asian clam	Prohibited	A0	NE	No	0	0
409	Invert (marine)	*Potamocorbula amurensis* (Schrenck, 1861)	Asian clam	Prohibited	A0	NE	No	0	0
410	Plant (t / fw)	*Potamogeton perfoliatus* L.	Clasped pondweed	Prohibited	A0	NE	No	0	0
411	Invert. (t)	*Proeulia auraria* (Clarke, 1949)	Chilean fruit leafroller	Prohibited	A0	NE	No	0	0
412	Invert. (t)	*Proeulia chrysopteris* (Butler, 1883	Grapevine leaf-rolling tortricid	Prohibited	A0	NE	No	0	0
413	Plant (t / fw)	*Prosopis alpataco* Phil.	Mesquite	Prohibited	A0	NE	No	0	0
414	Plant (t / fw)	*Prosopis argentina* Burkart	Algarobilla	Prohibited	A0	NE	No	0	0

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415	Plant (t / fw)	*Prosopis burkartii* O.Muniz	Mesquite	Prohibited	A0	NE	No	0	0
416	Plant (t / fw)	*Prosopis caldenia* Burkart	Mesquite	Prohibited	A0	NE	No	0	0
417	Plant (t / fw)	*Prosopis calingastana* Burkart	Mesquite	Prohibited	A0	NE	No	0	0
418	Plant (t / fw)	*Prosopis campestris* Griseb.	Mesquite	Prohibited	A0	NE	No	0	0
419	Plant (t / fw)	*Prosopis castellanosii* Burkart	Mesquite	Prohibited	A0	NE	No	0	0
420	Plant (t / fw)	*Prosopis denudans* Benth.	Mesquite	Prohibited	A0	NE	No	0	0
421	Plant (t / fw)	*Prosopis elata* (Burkart) Burkart	Mesquite	Prohibited	A0	NE	No	0	0
422	Plant (t / fw)	*Prosopis farcta* (Banks & Sol.) J.F.Macbr.	Syrian mesquite	Prohibited	A0	NE	No	0	0
423	Plant (t / fw)	*Prosopis ferox* Griseb.	Mesquite	Prohibited	A0	NE	No	0	0
424	Plant (t / fw)	*Prosopis fiebrigii* Harms	Mesquite	Prohibited	A0	NE	No	0	0
425	Plant (t / fw)	*Prosopis hassleri* Harms	Mesquite	Prohibited	A0	NE	No	0	0
426	Plant (t / fw)	*Prosopis humilis* Hook.	Mesquite	Prohibited	A0	NE	No	0	0
427	Plant (t / fw)	*Prosopis kuntzei* Harms	Mesquite	Prohibited	A0	NE	No	0	0
428	Plant (t / fw)	*Prosopis palmeri* S.Watson	Mesquite	Prohibited	A0	NE	No	0	0
429	Plant (t / fw)	*Prosopis reptans* Benth.	Tornillo	Prohibited	A0	NE	No	0	0
430	Plant (t / fw)	*Prosopis rojasiana* Burkart	Mesquite	Prohibited	A0	NE	No	0	0
431	Plant (t / fw)	*Prosopis ruizlealii* Burkart	Mesquite	Prohibited	A0	NE	No	0	0
432	Plant (t / fw)	*Prosopis ruscifolia* Griseb.	Mesquite	Prohibited	A0	NE	No	0	0
433	Plant (t / fw)	*Prosopis sericantha* Gillies ex Hook. & Arn.	Mesquite	Prohibited	A0	NE	No	0	0
434	Plant (t / fw)	*Prosopis strombulifera* (Lam.) Benth.	Argentine screwbean	Prohibited	A0	NE	No	0	0
435	Plant (t / fw)	*Prosopis torquata* (Cav. ex Lag.) DC.	Mesquite	Prohibited	A0	NE	No	0	0
436	Fish (fw)	*Protopterus* species	African Lung fish	Prohibited	A0	NE	No	0	0
437	Invert. (t)	*Pseudococcus comstocki* Kuwana, 1902	Comstock mealybug	Prohibited	A0	NE	No	0	0
438	Invert. (t)	*Pseudococcus cryptus* Hempel	Citriculus mealybug	Prohibited	A0	NE	No	0	0
439	Invert. (t)	*Pseudococcus elisae* Borchsenius, 1947	Banana mealybug	Prohibited	A0	NE	No	0	0
440	Invert. (t)	*Pseudococcus jackbeardsleyi* Gimpel and Miller, 1996	Jack Beardsley mealybug	Prohibited	A0	NE	No	0	0
441	Fish (fw)	*Pseudocrenilabrus* species	Mouthbrooder	Prohibited	A0	NE	No	0	0
442	Fish (fw)	*Pseudorasbora* species	Whiptail sturgeon	Prohibited	A0	NE	No	0	0
443	Fish (fw)	*Pseudorinelepis* species	Catfish	Prohibited	A0	NE	No	0	0
444	Fish (marine)	*Pterois volitans* (Linnaeus, 1758)	Pacific red lionfish	Prohibited	A1	NE	No	0	0
445	Fish (fw)	*Pterygoplichthys* species	Janitor fish	Prohibited	A0	NE	No	0	0
446	Plant (t / fw)	*Pueraria phaseoloides* (Roxb.) Benth.	Tropical kudzu	Prohibited	A0	NE	No	0	0
447	Fish (fw)	*Pungitius* species	Stickleback	Prohibited	A0	NE	No	0	0
448	Fish (fw)	*Pygocentrus* species	Piranha	Prohibited	A0	NE	No	0	0
449	Fish (fw)	*Pygosteus* species	Stickleback	Prohibited	A0	NE	No	0	0
450	Reptile	*Python molurus* (Linnaeus, 1758)	Indian rock python	Prohibited	NA	NE	No	0	0
451	Reptile	*Python sebae* (Gmelin, 1788)	African rock python	Prohibited	A0	Some	No	0	0
452	Plant (t / fw)	*Ranunculus acris* L.	Giant buttercup	Prohibited	A0	NE	No	0	0
453	Plant (t / fw)	*Ranunculus sceleratus* L.	Celery-leaf buttercup	Prohibited	A0	NE	No	0	0
454	Invert. (t)	*Rastrococcus iceryoides* (Green, 1908).	Mango mealybug	Prohibited	A0	NE	No	0	0
455	Invert. (t)	*Rastrococcus invadens* Williams	Fruit tree mealybug	Prohibited	A0	NE	No	0	0
456	Invert. (t)	*Rastrococcus mangiferae* (Green, 1896)	Mango shield scale	Prohibited	A0	NE	No	0	0
457	Invert. (t)	*Rastrococcus spinosus* (Robinson)	Philippine mango mealybug	Prohibited	A0	NE	No	0	0
458	Mammal	*Rattus exulans* (Peale, 1848)	Polynesian rat	Prohibited	A0	NE	No	0	0

	HIGH LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	IMPACT STATUS	RISK ASS. COMPLETED	PERMITS GRANTED	PERMITS REFUSED
459	Mammal	*Redunca redunca* (Pallas, 1767)	Bohor reedbuck	Prohibited	A0	NE	No	0	0
460	Plant (t / fw)	*Reseda phyteuma* L.	Rampion mignonette	Prohibited	A0	NE	No	0	0
461	Plant (t / fw)	*Reynoutria × bohemica* Chrtek & Chrtková.	Japanese knotweed hybrid	Prohibited	A0	NE	No	0	0
462	Invert. (t)	*Rhadinaphelenchus cocophilus* (Cobb, 1919) Goodey, 1960	Red ring disease nematode	Prohibited	A0	NE	No	0	0
463	Fish (fw)	*Rhamdia* species	Three-barbeled catfish	Prohibited	A0	NE	No	0	0
464	Amphibian	*Rhinella marina* (Linnaeus, 1758	Cane toad	Prohibited	A0	NE	No	0	0
465	Fish (fw)	*Rhinelepis* species	Catfish	Prohibited	A0	NE	No	0	0
466	Fish (fw)	*Rhinichthys atratulus* (Hermann, 1804)	Black-nose dace	Prohibited	A0	NE	No	0	0
467	Fish (fw)	*Rhinichthys obtusus* (Agassiz, 1854)	Western black-nose dace	Prohibited	A0	NE	No	0	0
468	Invert. (t)	*Rhipiphorothrips cruentatus* Hood, 1919	Grapevine thrips	Prohibited	A0	NE	No	0	0
469	Fish (fw)	*Rhodeus* species	Bitterlings	Prohibited	A0	NE	No	0	0
470	Fish (fw)	*Rooseveltiella* species	Piranha	Prohibited	A0	NE	No	0	0
471	Plant (t / fw)	*Rorippa austriaca* (Crantz) Besser	Austrian field cress	Prohibited	A0	NE	No	0	0
472	Plant (t / fw)	*Rorippa sylvestris* (L.) Besser	Creeping yellow field cress	Prohibited	A0	NE	No	0	0
473	Plant (t / fw)	*Rubrivena polystachya* (Wall. ex Meisn.) M. Král	Himalayan knotweed						
474	Plant (t / fw)	*Rubus anglocandicans* A.Newton	Blackberry	Prohibited	A0	NE	No	0	0
475	Plant (t / fw)	*Rubus argutus* Link	Prickly Florida blackberry	Prohibited	A0	NE	No	0	0
476	Plant (t / fw)	*Rubus moluccanus* L.	Wild blackberry	Prohibited	A0	NE	No	0	0
477	Plant (t / fw)	*Rubus sieboldii* Blume	Molucca raspberry	Prohibited	A0	NE	No	0	0
478	Fish (fw)	*Rutilus* species	Roach	Prohibited	A0	NE	No	0	0
479	Plant (t / fw)	*Saccharum spontaneum* L.	Wild sugarcane	Prohibited	A0	NE	No	0	0
480	Plant (t / fw)	*Sagittaria montevidensis* Cham. & Schltdl.	Giant arrowhead	Prohibited	A0	NE	No	0	0
481	Fish (fw)	*Salmo* species, 1758)	Trout and salmon	Prohibited	A0	NE	No	0	0
482	Plant (t / fw)	*Salsola collina* Pall.	Spineless Russian thistle	Prohibited	A0	NE	No	0	0
483	Plant (t / fw)	*Salsola paulsenii* Litv.	Barbwire Russian thistle	Prohibited	A0	NE	No	0	0
484	Plant (t / fw)	*Salsola vermiculata* L.	Wormleaf salsola	Prohibited	A0	NE	No	0	0
485	Fish (fw)	*Salvelinus* species	Char	Prohibited	A0	NE	No	0	0
486	Plant (t / fw)	*Salvia aethiopis* L.	Mediterranean sage	Prohibited	A0	NE	No	0	0
487	Plant (t / fw)	*Salvia virgata* Jacq.	Meadow sage	Prohibited	A0	NE	No	0	0
488	Plant (t / fw)	*Salvinia auriculata* Aubl.	Eared watermoss	Prohibited	A0	NE	No	0	0
489	Plant (t / fw)	*Salvinia biloba* Raddi	Giant salvinia	Prohibited	A0	NE	No	0	0
490	Plant (t / fw)	*Salvinia herzogii* de la Sota	Giant salvinia	Prohibited	A0	NE	No	0	0
491	Plant (marine)	*Sargassum muticum* (Yendo) Fensholt	Strangle weed	Prohibited	A0	NE	No	0	0
492	Fish (fw)	*Sargochromis* species	Cichlid	Prohibited	A0	NE	No	0	0
493	Fish (fw)	*Sarotherodon* species	Tilapia	Prohibited	A0	NE	No	0	0
494	Fish (fw)	*Schilbe* species	Butter catfish	Prohibited	A0	NE	No	0	0
495	Plant (t / fw)	*Sclerolaena birchii* (F.Muell.) Domin	Galvanised burr	Prohibited	A0	NE	No	0	0
496	Plant (t / fw)	*Scolymus hispanicus* L.	Golden thistle	Prohibited	A0	NE	No	0	0
497	Plant (t / fw)	*Scolymus maculatus* L.	Spotted golden thistle	Prohibited	A0	NE	No	0	0
498	Invert. (t)	*Scutellonema bradys* (Steiner & LeHew, 1933) Andrássy, 1958	Yam nematode	Prohibited	A0	NE	No	0	0
499	Plant (t / fw)	*Senecio jacobaea* L.	St James' ragwort	Prohibited	A0	NE	No	0	0

	HIGH LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	IMPACT STATUS	RISK ASS. COMPLETED	PERMITS GRANTED	PERMITS REFUSED
500	Plant (t / fw)	*Senecio squalidus* L.	Oxford ragwort	Prohibited	A0	NE	No	0	0
501	Plant (t / fw)	*Senna tora* (L.) Roxb.	Java bean, Sicklepod senna	Prohibited	A0	NE	No	0	0
502	Fish (fw)	*Serrasalmus* species	Piranha	Prohibited	A0	NE	No	0	0
503	Plant (t / fw)	*Setaria faberi* Herrm.	Chinese foxtail	Prohibited	A0	NE	No	0	0
504	Plant (t / fw)	*Setaria palmifolia* (J.Koenig) Stapf	Palm grass	Prohibited	A0	NE	No	0	0
505	Fish (fw)	*Silurus glanis* (Linnaeus, 1758)	European/Wels/Waller catfish	Prohibited	A0	NE	No	0	0
506	Plant (t / fw)	*Solanum carolinense* L.	Horse nettle	Prohibited	A0	NE	No	0	0
507	Plant (t / fw)	*Solanum dimidiatum* Raf.	Torrey's nightshade	Prohibited	A0	NE	No	0	0
508	Plant (t / fw)	*Solanum lanceolatum* Cav.	Lance-leaf nightshade	Prohibited	A0	NE	No	0	0
509	Plant (t / fw)	*Solanum marginatum* L.f.	White-margined nightshade	Prohibited	A0	NE	No	0	0
510	Plant (t / fw)	*Solanum robustum* H.Wendl	Silver-leaf nightshade	Prohibited	A0	NE	No	0	0
511	Plant (t / fw)	*Solanum tampicense* Dunal	Wetland nightshade	Prohibited	A0	NE	No	0	0
512	Invert. (t)	*Solenopsis invicta* Buren, 1972	Red imported fire ant (RIFA)	Prohibited	A0	NE	No	0	0
513	Plant (t / fw)	*Sonchus arvensis* L.	Perennial sow thistle	Prohibited	A0	NE	No	0	0
514	Plant (t / fw)	*Sorghum* hybrid 'Silk'	Silk forage sorghum	Prohibited	A0	NE	No	0	0
515	Plant (t / fw)	*Sorghum* x *almum* Parodi	Columbus grass	Prohibited	A0	NE	No	0	0
516	Plant (t / fw)	*Sparganium erectum* L.	Exotic bur-reed	Prohibited	A0	NE	No	0	0
517	Plant (t / fw)	*Spermacoce alata* Aubl.	Borreria, Buttonweed	Prohibited	A0	NE	No	0	0
518	Plant (t / fw)	*Sphaerophysa salsula* (Pall.) DC.	Austrian peaweed	Prohibited	A0	NE	No	0	0
519	Invert. (t)	*Spodoptera litura* (Fabricius, 1775)	Oriental leafworm moth	Prohibited	A0	NE	No	0	0
520	Plant (t / fw)	*Sporobolus indicus* (L.) R.Br.	Giant Parramatta grass	Prohibited	A0	NE	No	0	0
521	Invert. (t)	*Stemochetus frigidus* (Fabricius, 1787)	Mango pulp weevil	Prohibited	A0	NE	No	0	0
522	Plant (t / fw)	*Stipa brachychaeta* Godr.	Puna grass	Prohibited	A0	NE	No	0	0
523	Plant (t / fw)	*Stratiotes aloides* L.	Water-aloe	Prohibited	A0	NE	No	0	0
524	Bird	*Streptopelia picturata* (Temminck, 1813)	Madagascar (Malagasy) turtle-dove	Prohibited	A0	NE	No	0	0
525	Bird	*Struthio camelus molybdophanes* Reichenow, 1883	Somali ostrich	Prohibited	A0	NE	No	0	0
526	Mammal	*Suncus murinus* (Linnaeus, 1766)	Asian house shrew	Prohibited	A0	NE	No	0	0
527	Plant (t / fw)	*Symphytum asperum* Lepech.	Prickly comfrey, Rough comfrey	Prohibited	A0	NE	No	0	0
528	Plant (t / fw)	*Taeniatherum caput-medusae* (L.) Nevski	Medusa-head	Prohibited	A0	NE	No	0	0
529	Reptile	*Tarentola mauritanica* (Linnaeus, 1758)	Common wall gecko	Prohibited	A0	NE	No	0	0
530	Invert. (t)	*Tetranychus desertorum* Banks, 1900	Desert spider mite	Prohibited	A0	NE	No	0	0
531	Invert. (t)	*Tetranychus mexicanus* (McGregor)	Spider mite	Prohibited	A0	NE	No	0	0
532	Invert. (t)	*Tetranychus piercei* McGregor 1950	Banana spider mite	Prohibited	A0	NE	No	0	0
533	Invert (marine)	*Tetrapygus niger* (Molina, 1782)	Black sea-urchin	1a	A1	Some	No	0	0
534	Invert. (t)	*Thecla basilides* (Geyer)	Pineapple borer	Prohibited	A0	NE	No	0	0
535	Invert. (t)	*Thecla legota* Hewitson, 1877	Thecla moth	Prohibited	A0	NE	No	0	0
536	Plant (t / fw)	*Themeda quadrivalvis* (L.) Kuntze	Grader grass	Prohibited	A0	NE	No	0	0
537	Plant (t / fw)	*Themeda villosa* (Poir.) A.Camus	Lyon's grass	Prohibited	A0	NE	No	0	0

	HIGH LEVEL GROUPING	SPECIES	COMMON NAME	LEGAL STATUS	INTRODUCTION STATUS	IMPACT STATUS	RISK ASS. COMPLETED	PERMITS GRANTED	PERMITS REFUSED
538	Invert. (t)	*Thrips hawaiiensis* (Morgan, 1913)	Banana flower thrips	Prohibited	A0	NE	No	0	0
539	Invert. (t)	*Thrips palmi* Karny, 1925	Melon thrips	Prohibited	A0	NE	No	0	0
540	Plant (t / fw)	*Thunbergia annua* Hochst.	Thunbergia	Prohibited	A0	NE	No	0	0
541	Plant (t / fw)	*Thunbergia fragrans* Roxb.	White thunbergia	Prohibited	A0	NE	No	0	0
542	Fish (fw)	*Thymallus thymallus* (Linnaeus, 1758)	Grayling	Prohibited	A0	NE	No	0	0
543	Fish (fw)	*Tilapia* species	Tilapias	Prohibited	A0	NE	No	0	0
544	Invert. (t)	*Tmolus echion* (Linnaeus, 1767)	Red-spotted hairstreak	Prohibited	A0	NE	No	0	0
545	Invert. (t)	*Toxotrypana curvicauda* Gerstaecker	Papaya fruit fly	Prohibited	A0	NE	No	0	0
546	Plant (t / fw)	*Tribulus cistoides* L.	Caltrop	Prohibited	A0	NE	No	0	0
547	Invert. (t)	*Trichodorus primitivus* (De Man, 1876) Micol. 1922	Stubby root nematode	Prohibited	A0	NE	No	0	0
548	Invert. (t)	*Trichodorus similis* Seinhorst 1963	Stubby root nematode	Prohibited	A0	NE	No	0	0
549	Invert. (t)	*Trichodorus viruliferus* Hooper 1963	Stubby root nematode	Prohibited	A0	NE	No	0	0
550	Mammal	*Trichosurus vulpecula* (Kerr, 1792)	Common Brushtail possum	Prohibited	A0	NE	No	0	0
551	Amphibian	*Triturus carnifex* (Laurenti, 1768)	Italian crested newt	1b	A0	Negligible	No	0	0
552	Plant (t / fw)	*Triumfetta semitriloba* Jacq.	Sacramento bur	Prohibited	A0	NE	No	0	0
553	Invert. (t)	*Tuckerella pavoniformis* (Ewing)	Tuckerellid mite	Prohibited	A0	NE	No	0	0
554	Bird	*Turdus merula* Linnaeus, 1758	Common/Eurasian Blackbird	Prohibited	A0	NE	Yes	0	0
555	Bird	*Turdus philomelos* C.L. Brehm, 1831	Song thrush	Prohibited	A0	NE	Yes	0	0
556	Invert. (t)	*Unaspis citri* Comstock,	Citrus snow scale	Prohibited	A0	NE	No	0	0
557	Plant (marine)	*Undaria pinnatifida* (Harvey) Suringar	Asian kelp	1b	A0	NE	No	0	0
558	Plant (t / fw)	*Vallisneria gigantea* Graebn.	Eelgrass	Prohibited	A0	NE	No	0	0
559	Invert (marine)	*Venerupis phillippinarum* (A. Adams and Reeve, 1850).	Manila clam	Prohibited	A0	NE	No	0	0
560	Invert. (t)	*Vespa velutina* Lepeletier, 1836	Asian predatory wasp	Prohibited	A0	NE	No	0	0
561	Invert. (t)	*Vespula vulgaris* (Linnaeus, 1758)	Common wasp	Prohibited	A0	NE	No	0	0
562	Invert. (t)	*Vinsonia stellifera* (Westwood, 1871)	Stellate scale	Prohibited	A0	NE	No	0	0
563	Plant (t / fw)	*Viscum album* L.	European mistletoe	Prohibited	A0	NE	No	0	0
564	Mammal	*Vulpes vulpes* (Linnaeus, 1758	Red fox	Prohibited	A0	NE	No	0	0
565	Invert. (t)	*Wasmannia auropunctata* (Roger, 1863)	Cocoa tree-ant	Prohibited	A0	NE	No	0	0
566	Invert. (t)	*Xylosandrus compactus* (Eichhoff)	Ambrosia beetle	Prohibited	A0	NE	No	0	0
567	Invert. (t)	*Xylosandrus mutilates* (Blandford	Camphor shoot beetle	Prohibited	A0	NE	No	0	0
568	Bird	*Zenaida asiatica* (Linnaeus, 1758)	White-winged dove	Prohibited	A0	NE	Yes	0	0
569	Plant (t / fw)	*Zizania latifolia* (Griseb.) Turcz. ex Stapf	Manchurian wild rice	Prohibited	A0	NE	No	0	0
570	Plant (t / fw)	*Zygophyllum fabago* Linnaeus	Syrian bean-caper	Prohibited	A0	NE	No	0	0

LIST 3 List of alien species that do not occur in South Africa, and are not listed as prohibited, but for which a risk assessment has been completed.

For a description of the entries to different columns, see the descriptive notes at the start of list 1. In all cases a risk assessment has been performed, but given the taxa are not in South Africa, the impact status is not evaluated. *Note *Tuta absoluta* is in South Africa (Visser *et al.*, 2017a), and will be added to List 1 in future reports.

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME
1	Bird	*Acanthis flammea* (Linnaeus, 1758)	Common Redpoll
2	Reptile	*Acrochordus granulatus* (Schneider, 1799)	Little file snake
3	Reptile	*Ahaetulla prasina* (Boie, 1827)	Asian vine snake
4	Reptile	*Boiga nigriceps* (Günther, 1863)	Black-headed cat snake
5	Invert. (t)	*Bombus terrestris* (Linnaeus, 1758)	Buff-tailed bumblebee
6	Reptile	*Brochocela jubata* (A.M.C. Duméril & Bibron, 1837)	Maned forest lizard
7	Reptile	*Candoia carinata* (Schneider, 1801)	Pacific ground boa
8	Reptile	*Crotalus* species (unidentified)	Rattlesnakes
9	Plant (t / fw)	*Cyathea australis* (R.Br.) Domin	Rough Tree Fern
10	Plant (t / fw)	*Cyathea cooperi* (Hook. ex F.Muell.) Domin, 1929	Australian tree fern
11	Reptile	*Dasia olivacea* Gray, 1839	Olive Dasia
12	Reptile	*Draco lineatus* Daudini 1802	Flying lizards
13	Invert. (t)	*Drosophila suzukii* (Matsumura, 1931)	Spotted wing drosophila
14	Bird	*Estrilda coerulescens* (Vieillot, 1817)	Lavender waxbill
15	Bird	*Estrilda melpoda* (Vieillot, 1817)	Orange-cheeked waxbill
16	Bird	*Estrilda troglodytes* (Lichtenstein, 1823)	Black-rumped waxbill
17	Bird	*Francolinus francolinus* (Linnaeus, 1766)	Black francolin
18	Reptile	*Gehyra vorax* Gray, 1834	Halmahera giant gecko
19	Reptile	*Gekko vittatus* Houttuyn, 1782	Lined gecko
20	Reptile	*Gonocephalus chamaeleontinus* (Laurenti, 1768)	Chameleon forest dragon
21	Plant (t / fw)	*Grateloupia longifolia* Kylin (1938)	No common name found
22	Bird	*Haemorhous mexicanus* (Müller, 1776)	House Finch
23	Fish (marine)	*Hippocampus whitei* Bleeker, 1855	New Holland seahorse
24	Reptile	*Hydrosaurus weberi* Barbour, 1911	Weber's sailfin lizard
25	Fish (fw)	*Hypostomus* species (unidentified)	NA
26	Invert. (marine)	*Jasus paulensis* (Heller, 1862)	St Paul rock lobster
27	Plant (t / fw)	*Kalanchoe prolifera* (Bowie ex Hook.) Raym.-Hamet	Blooming Boxes
28	Fish (fw)	*Lates calcarifer* (Bloch, 1790)	Barramundi

	HIGH-LEVEL GROUPING	SPECIES	COMMON NAME
29	Plant (t / fw)	*Morus nigra* L.	Black mulberry
30	Invert. (fw)	*Neocaridina davidi* Kubo, 1938	Red/Cherry shrimp
31	Bird	*Netta rufina* (Pallas, 1773)	Red-crested pochard
32	Fish (fw)	*Oncorhynchus kisutch* (Walbaum, 1792)	Silver salmon
33	Fish (fw)	*Oncorhynchus tshawytscha* (Walbaum, 1792)	Chinook salmon
34	Mammal	*Ovis ammon* (Linnaeus, 1758)	Mouflon
35	Fish (fw)	*Pangasianodon hypophthalmus* (Sauvage, 1878)	Striped catfish
36	Plant (t / fw)	*Pereskia bleo* (Kunth) DC.	Rose cactus, leaf cactus)
37	Plant (t / fw)	*Philodendron hederaceum* (Jacq.) Schott	Vilevine
38	Reptile	*Physignathus temporalis* Boulenger 1885	Striped water dragon lizard
39	Reptile	*Protobothrops mangshanensis* (Zhao, 1990)	Mangshan pit viper
40	Reptile	*Ptychozoon kuhli* Stejneger, 1902	Common flying gecko
41	Plant (t / fw)	*Syzygium cordatum* Hochst. ex Krauss	Water berry
42	Bird	*Tadorna tadorna* (Linnaeus, 1758)	Common shelduck
43	Mammal	*Taurotragus derbianus* (Gray, 1847)	Giant eland
44	Reptile	*Tiliqua scincoides* (White, 1790)	Blue-tongued lizards
45	Reptile	*Tribolontus gracilis* De Rooij, 1909	Red-Eyed crocodile skink
46	Reptile	*Tribolontus novaeguineae* (Schlegel, 1834)	Spiny skink
47	Invert. (t)	*Tuta absoluta* (Meyrick, 1917)*	Tomato leafminer
48	Bird	*Uraeginthus bengalus* (Linnaeus, 1766)	Red-checked cordon-bleu
49	Reptile	*Varanus beaccari* (Doria, 1874)	Black tree monitor
50	Reptile	*Varanus reisingeri* Eidenmüller & Wicker, 2005	Yellow tree monitor
51	Reptile	*Varanus rudicollis* (Gray, 1845)	Roughneck monitor lizard
52	Reptile	*Varanus yuwonoi* Harvey & Barker, 1998	No common name found

APPENDIX 4

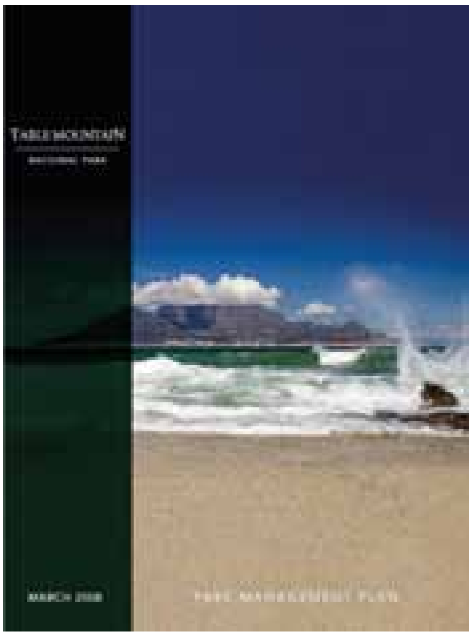
AREA MANAGEMENT PLANS (TERMED "INVASIVE SPECIES MONITORING, CONTROL AND ERADICATION PLANS" IN THE REGULATIONS).

This appendix provides details of all the area management plans submitted to the Department of Environmental Affairs in terms of the 2014 Alien and Invasive Species Regulations, as of 31 March 2017. The adequacy of each plan was assessed using criteria set out in the guidelines for control plans (www.environment.gov.za/sites/default/files/legislations/nemba_invasivespecies_controlguideline.pdf). Plans were required to include the following:

- A detailed list and description of any listed invasive species occurring on the relevant land.
- A description of the part of land that is infested with such listed invasive species.
- An assessment of the extent of such infestation.
- A review of the efficacy of previous control and eradication measures.
- A description of the measures to monitor, control and eradicate the listed invasive species.
- Measurable indicators of progress and success, and indications of when the control plan is to be completed.

The degree to which each of these requirements was met was assessed for each of the submitted plans, using the proposed indicator 15. *Planning coverage* (see Appendix 1). Each plan was placed into one of three categorises, as follows:

- **Adequate**: all of the above criteria from the guidelines were addressed and are of adequate standard;
- **Partially adequate**: most of the required criteria (> 50%) were addressed, and are of adequate standard; or
- **Inadequate**: most of the required criteria (≤ 50%) were not addressed in the control plan.



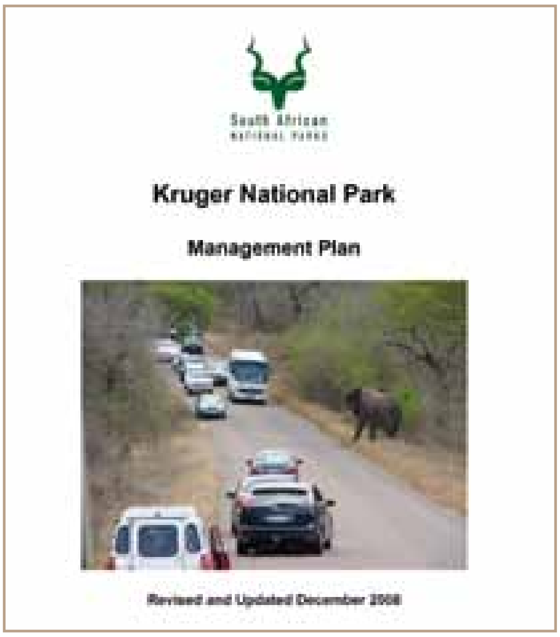


TABLE A4.1. Area management plans submitted to the Department of Environmental Affairs in terms of the 2014 A&IS Regulations (termed "Invasive species monitoring, control and eradication plans" in the regulations) and the South African National Biodiversity Institute. It has been assumed that universities are organs of state in South Africa.

SUBMITTING AGENCY	LOCATION	AREA (HECTARES UNLESS STATED OTHERWISE)	AREA CATEGORY	ADEQUACY OF PLAN						
				DETAILED LIST OF SPECIES	DESCRIPTION OF LAND INVADED	EXTENT OF INVASION	REVIEW OF PREVIOUS CONTROL	DESCRIPTION OF CONTROL MEASURES	INCLUSION OF INDICATORS	OVERALL ADEQUACY
South African National Roads Agency (SANRAL)	All national roads	21 945 km of road network	Organ of state	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate
Breede Valley Municipality	Breede Valley Municipality	299 500	Municipality	Inadequate	Inadequate	Inadequate	Adequate	Inadequate	Inadequate	Inadequate
Langeberg Municipality	Langeberg Municipality	451 800	Municipality	Inadequate	Adequate	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate
Eskom	Koeberg Nature Reserve	2 667.48	Organ of state	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Partially adequate	Inadequate
N3 Toll Concession	N3 Toll Road	1 600 km of road	Organ of state	Partially adequate	Inadequate	Inadequate	Inadequate	Partially adequate	Inadequate	Inadequate
Overberg District Municipality	Overberg District Municipality	1 224 100	Municipality	Partially adequate	Inadequate	Inadequate	Inadequate	Inadequate	Partially adequate	Inadequate
Hessequa Municipality	Hessequa Municipality	Not available	Municipality	Inadequate	Adequate	Partially adequate	Inadequate	Partially adequate	Inadequate	Partially adequate
Airports Company South Africa	King Shaka International Airport	2 060	Organ of state	Inadequate	Inadequate	Inadequate	Inadequate	Partially adequate	Partially adequate	Inadequate
Drakenstein Municipality	Paarl Mountain Nature Reserve	2 038	Protected area	Adequate	Inadequate	Partially adequate	Inadequate	Partially adequate	Inadequate	Partially adequate
City of Cape Town	Blaauwberg Nature Reserve	1 452	Protected area	Partially adequate	Inadequate	Partially adequate	Adequate	Adequate	Inadequate	Partially adequate
	Cape Town Parks	372	Protected areas	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate
	Dassenberg Coastal Catchment Programme	30 000	Protected area	Inadequate	Adequate	Partially adequate	Inadequate	Partially adequate	Inadequate	Partially adequate
	False Bay Nature Reserve	1 957	Protected area	Partially adequate	Adequate	Partially adequate	Inadequate	Partially adequate	Inadequate	Partially adequate
	City of Cape Town residential units	1 136	Housing land parcels	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate
	Hout Bay Llandudno suburbs	141	Residential areas	Inadequate	Adequate	Partially adequate	Inadequate	Inadequate	Inadequate	Inadequate
	Kenilworth Racecourse Conservation Area	45	Protected area	Partially adequate	Adequate	Partially adequate	Partially adequate	Partially adequate	Partially adequate	Adequate
	Macassar Dune Nature Reserve	910	Protected area	Partially adequate	Adequate	Inadequate	Inadequate	Inadequate	Partially adequate	Partially adequate
	Table Bay Nature Reserve	956	Protected area	Inadequate	Adequate	Partially adequate	Partially adequate	Inadequate	Partially adequate	Partially adequate
	Wemmershoek Dam catchment area	2 486	Municipality	Inadequate	Adequate	Adequate	Inadequate	Inadequate	Adequate	Partially adequate

SUBMITTING AGENCY	LOCATION	AREA (HECTARES UNLESS STATED OTHERWISE)	AREA CATEGORY	ADEQUACY OF PLAN						
				DETAILED LIST OF SPECIES	DESCRIPTION OF LAND INVADED	EXTENT OF INVASION	REVIEW OF PREVIOUS CONTROL	DESCRIPTION OF CONTROL MEASURES	INCLUSION OF INDICATORS	OVERALL ADEQUACY
Fancourt South Africa	Fancourt Hotel and Estate George	Not available	Private land	Inadequate	Inadequate	Inadequate	Partially adequate	Partially adequate	Adequate	Partially adequate
Arabella Country Estate	House of Arabella hotel and residential plots and Golf course	113	Private land	Inadequate	Adequate	Inadequate	Partially adequate	Adequate	Adequate	Partially adequate
The Alien SWAT Team (Pty) Ltd and Charlotte Jefferey	Erf 4211 9 Mount Street Grahamstown	1	Private land	Partially adequate	Inadequate	Partially adequate	Partially adequate	Inadequate	Inadequate	Partially adequate
Stellenbosch University	Stellenbosch University Campus	447	Organ of state	Inadequate	Adequate	Partially adequate	Inadequate	Adequate	Partially adequate	Partially adequate
Kana Environmental Consultants	Portion 1 of farm Schuinspad No. 375.	Not available	Private land	Inadequate	Inadequate	Inadequate	Partially adequate	Inadequate	Inadequate	Inadequate
Cape Environmental Assessment Practitioners	Portion 1 of Farm 210 Saffraan Rivier, Oudtshoorn	52	Private land	Inadequate	Adequate	Inadequate	Partially adequate	Inadequate	Inadequate	Inadequate
Transnet	Transnet freight railways	861.51 km of rail network	Organ of state	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Partially adequate	Inadequate
Bitou/Eden Municipality	Bitou/Eden Municipality	99 200	Municipality	Inadequate	Inadequate	Inadequate	Inadequate	Partially adequate	Partially adequate	Inadequate
COEGA Industrial development zone and port	Port Elizabeth	11 362	Organ of state	Adequate	Inadequate	Inadequate	Partially adequate	Inadequate	Inadequate	Inadequate
eThekwini Municipality	eThekwini Municipality	75 000	Municipality	Inadequate	Inadequate	Inadequate	Inadequate	Adequate	Partially adequate	Inadequate

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