

Indicators used to assess the status of biological invasions and their management in South Africa

Tsungai Zengeya, Katelyn Faulkner, John Wilson, Promise Mtileni

SANBI



Talk content

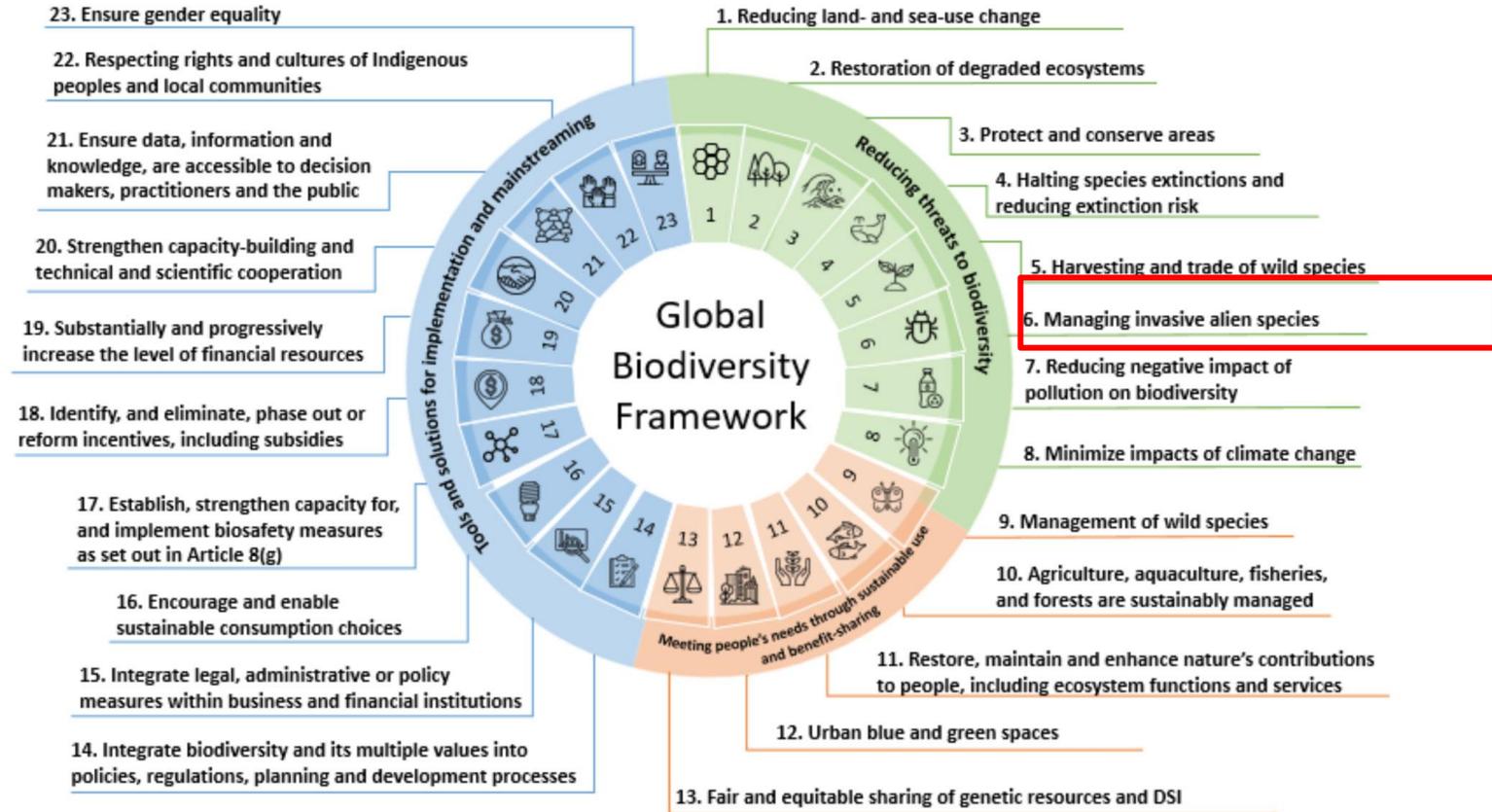
1. Mandate, rationale, and function of the report
2. Indicators used in the report
3. Link to other indicators
4. Link to B-Cubed project

Why are biological invasions a problem?



THE BIODIVERSITY PLAN
For Life on Earth

Kunming-Montreal Global Biodiversity Framework Themes and Targets

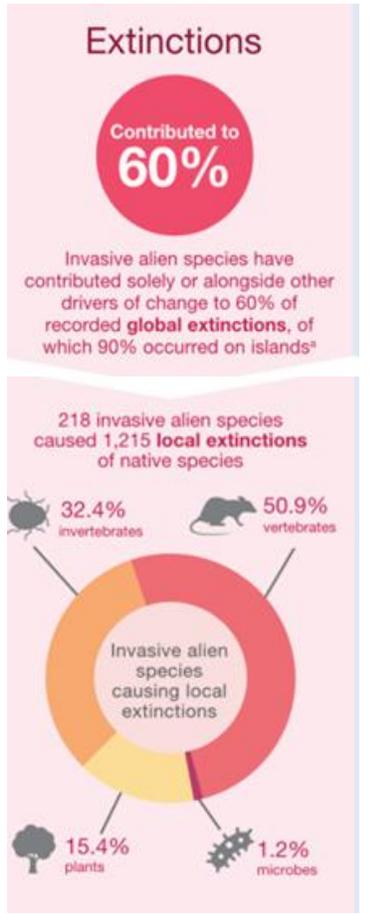
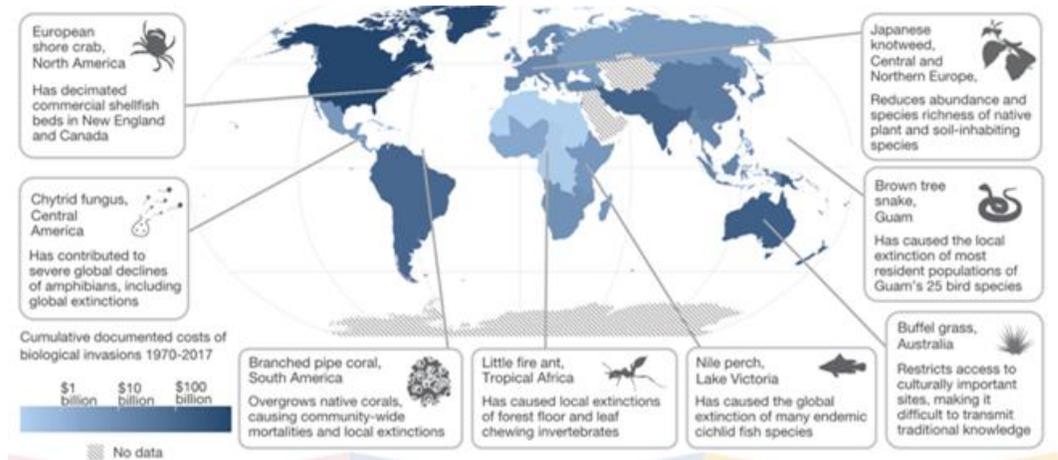
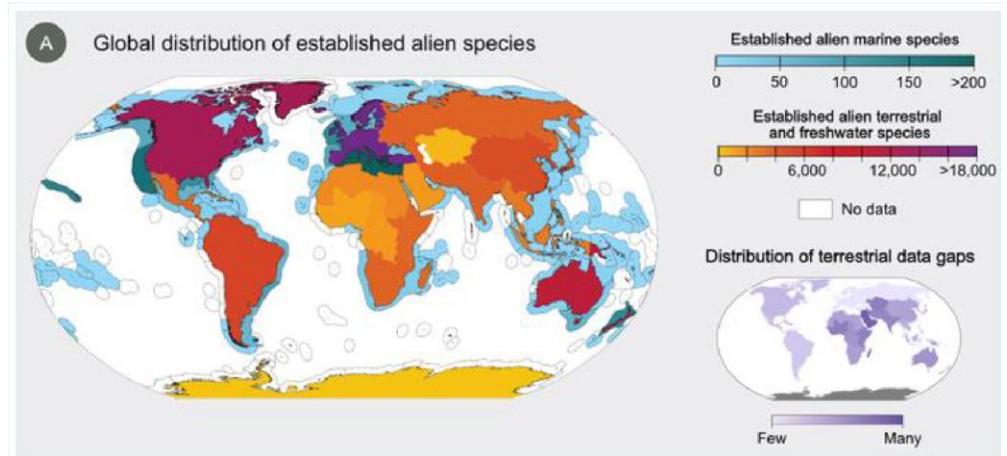
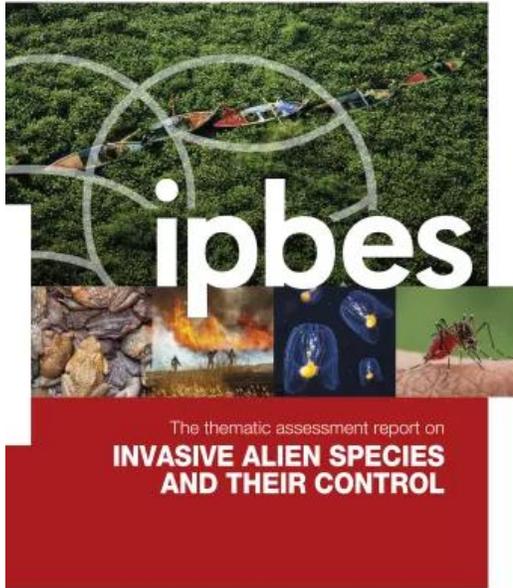


Biodiversity Building Blocks for policy

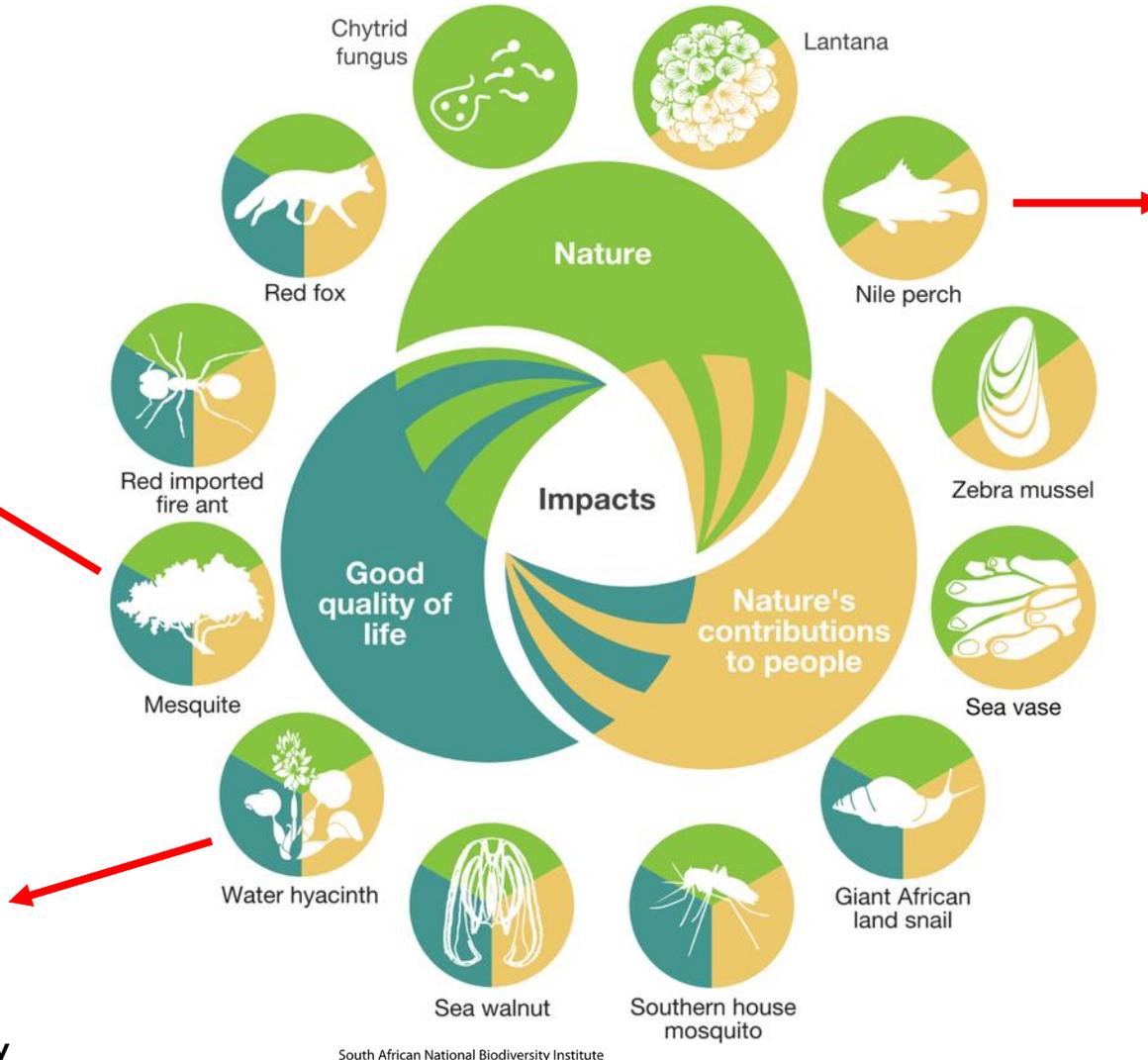


Funded by
the European Union

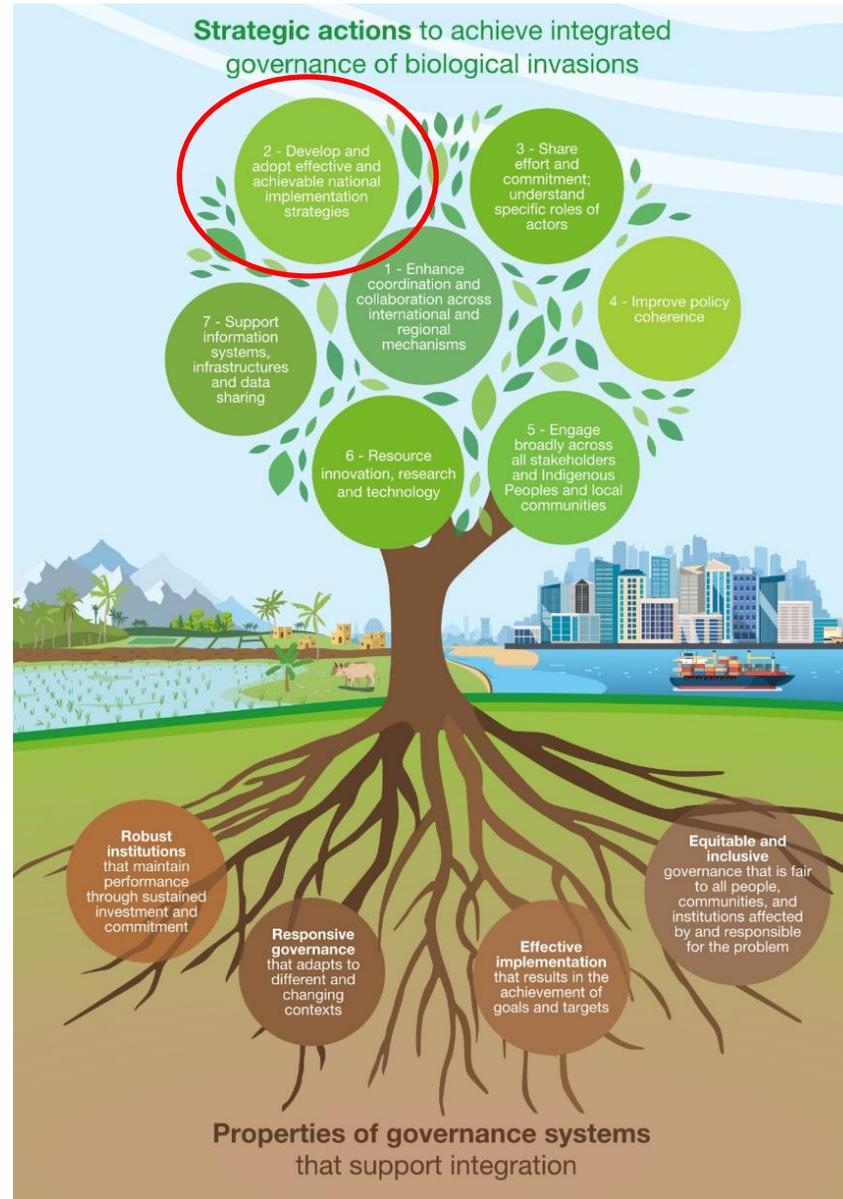
Why are biological invasions a problem?



Impacts are varied and affect different sectors of society



but can be managed with integrated governance

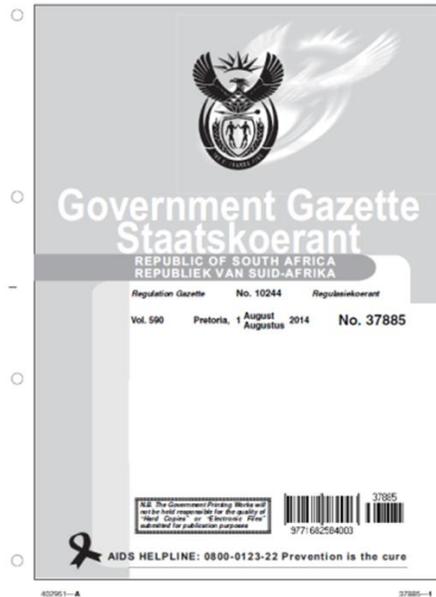


National mandate

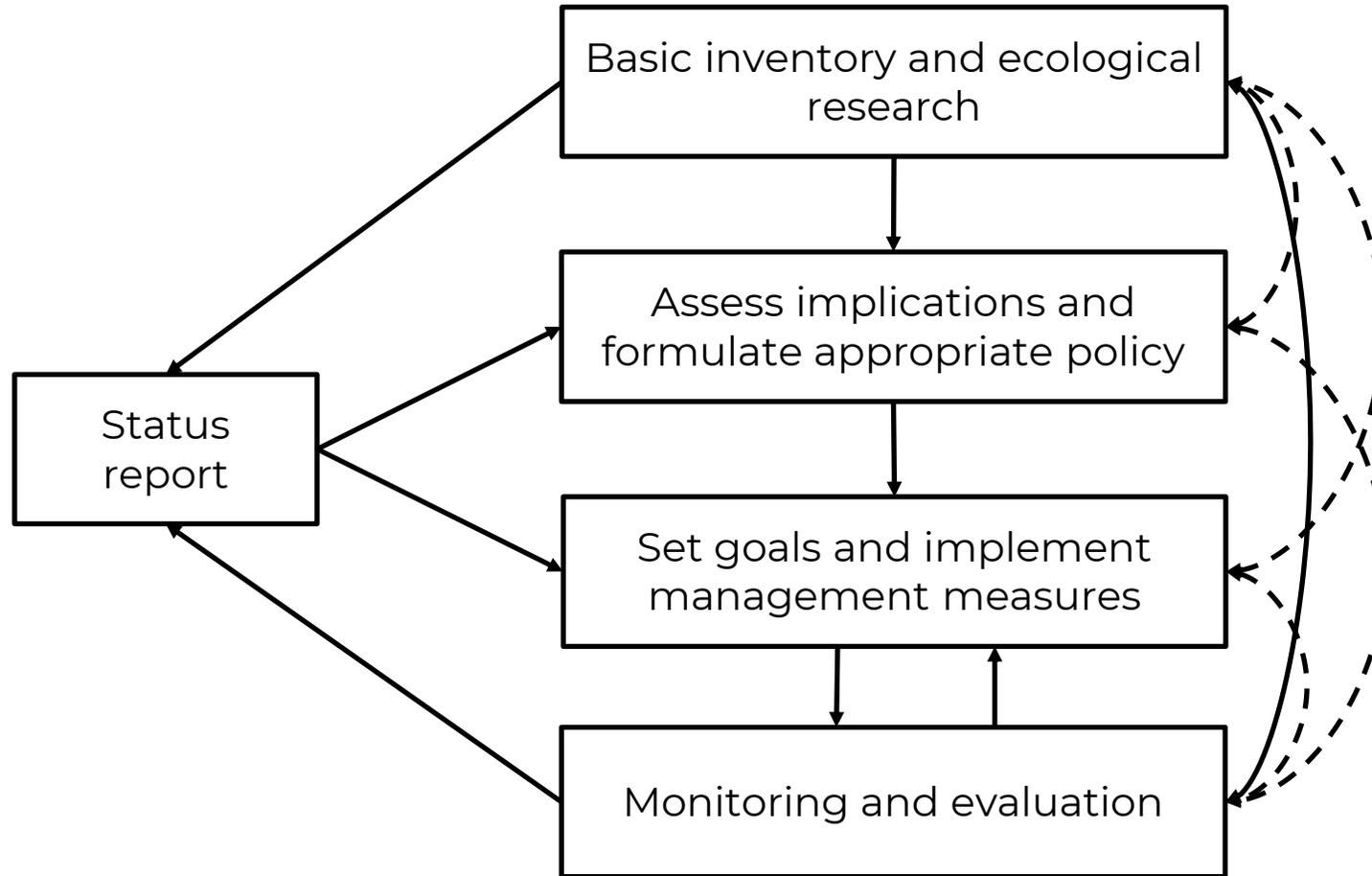


The Institute [i.e. SANBI] must submit a report on the status of listed invasive species within three years after these regulations come into effect, and every three years thereafter

The report must contain a summary and assessment of:
the status of listed invasive species; and
the effectiveness of these regulations and control measures



Why is a report needed?



Developed a suite of indicators

Received: 30 May 2018 | Accepted: 25 June 2018

DOI: 10.1111/1365-2664.13251

REVIEW

Journal of Applied Ecology 

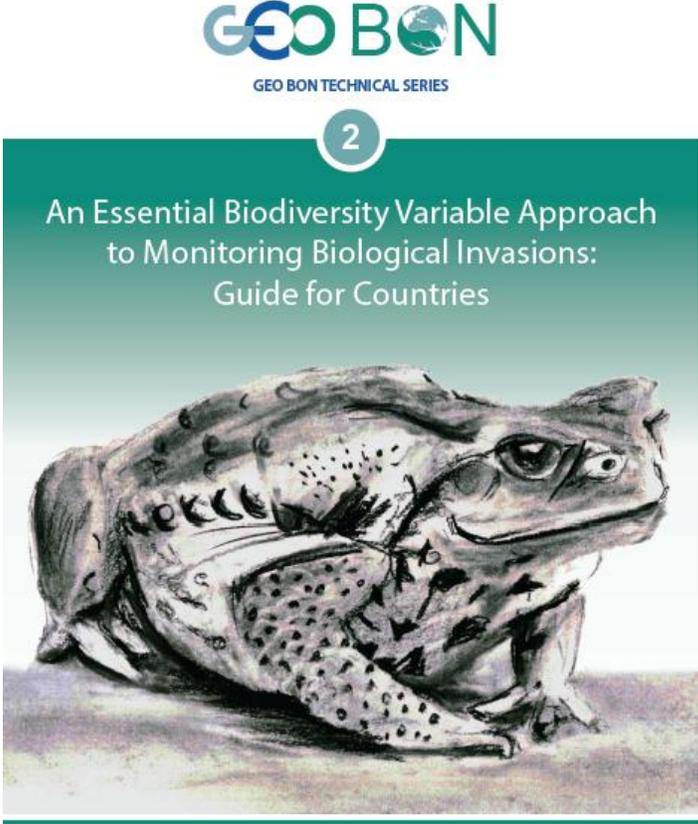
Indicators for monitoring biological invasions at a national level

John R. U. Wilson^{1,2}  | Katelyn T. Faulkner^{1,3} | Sebataolo J. Rahlao^{1,2}  |
David M. Richardson²  | Tsungai A. Zengeya^{1,3}  | Brian W. van Wilgen² 

Wilson et al. 2018, J Appl Ecol **55**: 2612-2620 <http://dx.doi.org/10.1111/1365-2664.13251>



Essential Biodiversity Variables for biological invasions



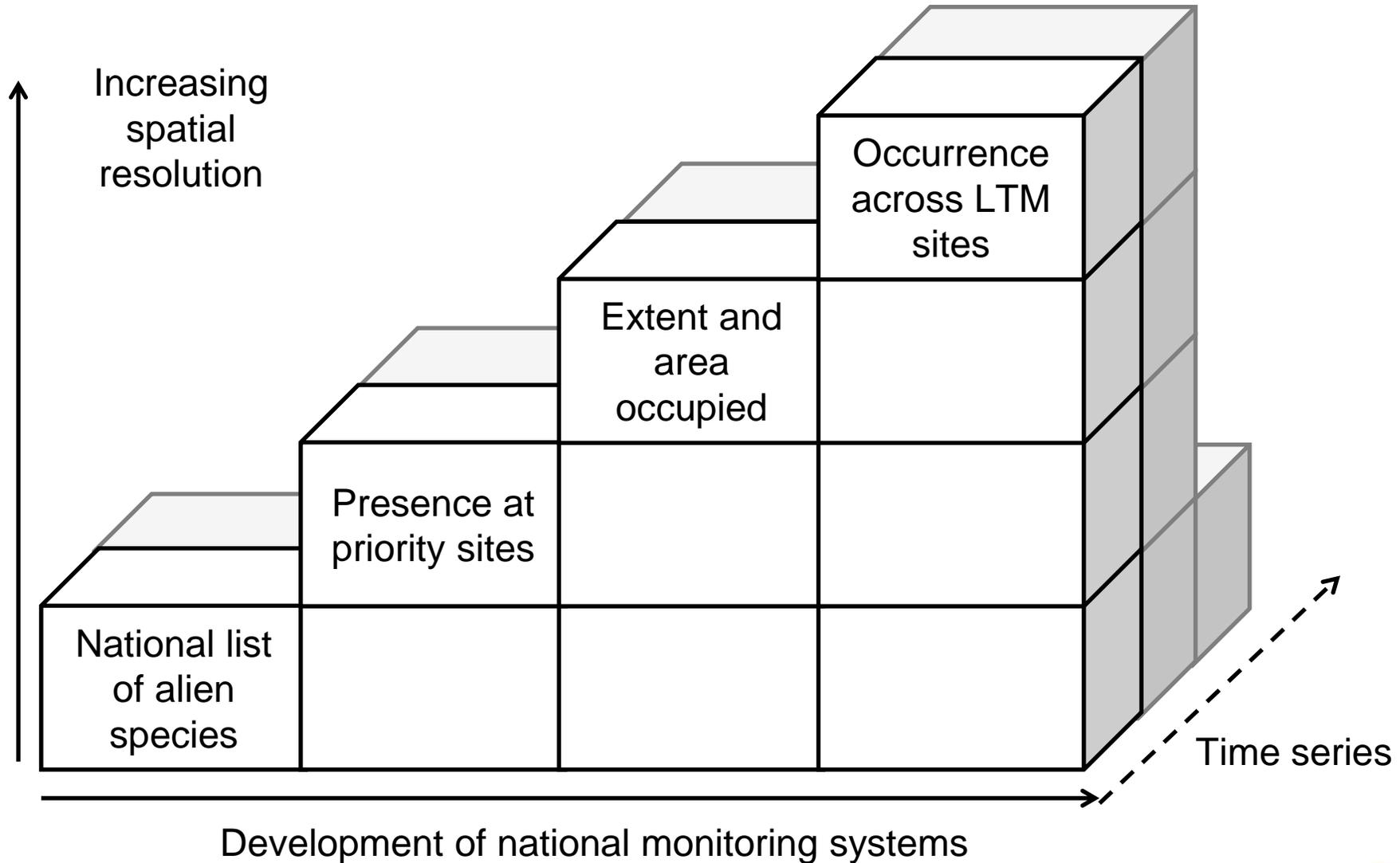
MONASH University IUCN SSC ISSG iDiv German Centre for Integration Biodiversity Research (IBiD) Halle (Saale) Leipzig

Essential Variables for Invasion Monitoring

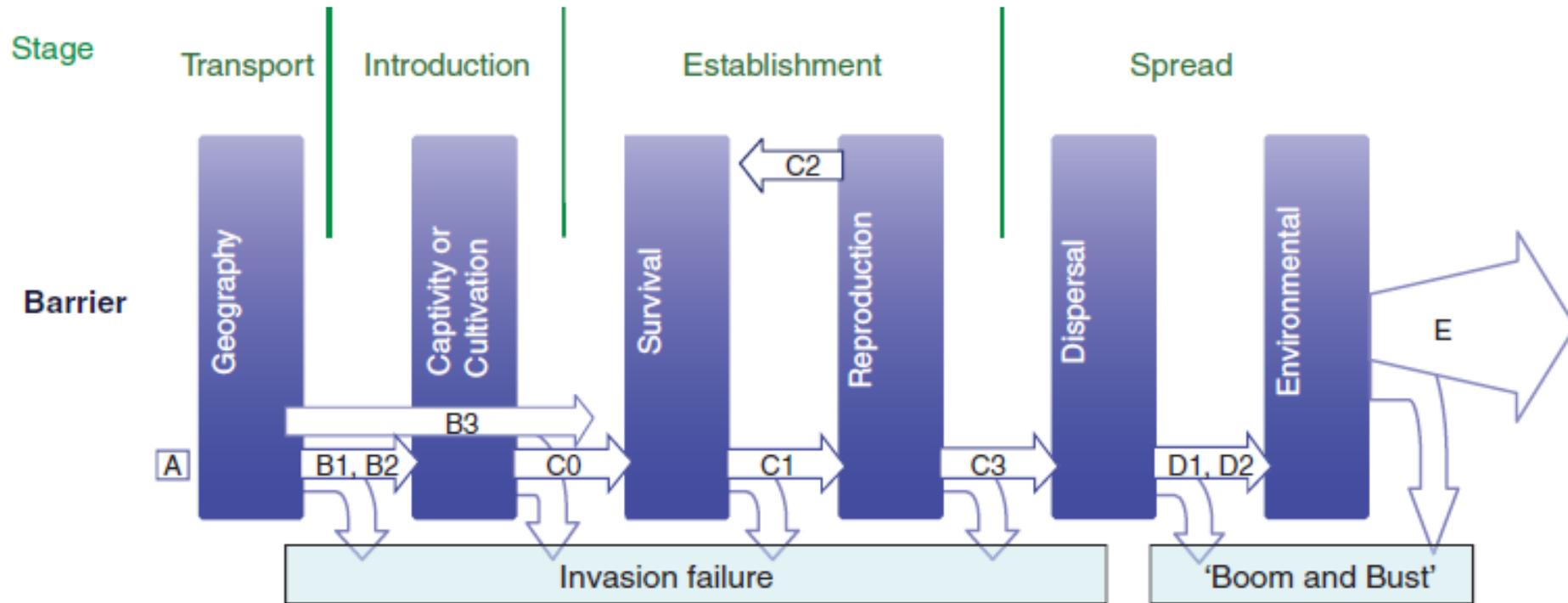


Latombe et al. 2017, Biol. Conserv. 213: 295-308 <https://doi.org/10.1016/j.biocon.2016.06.013>

Alien species occurrence



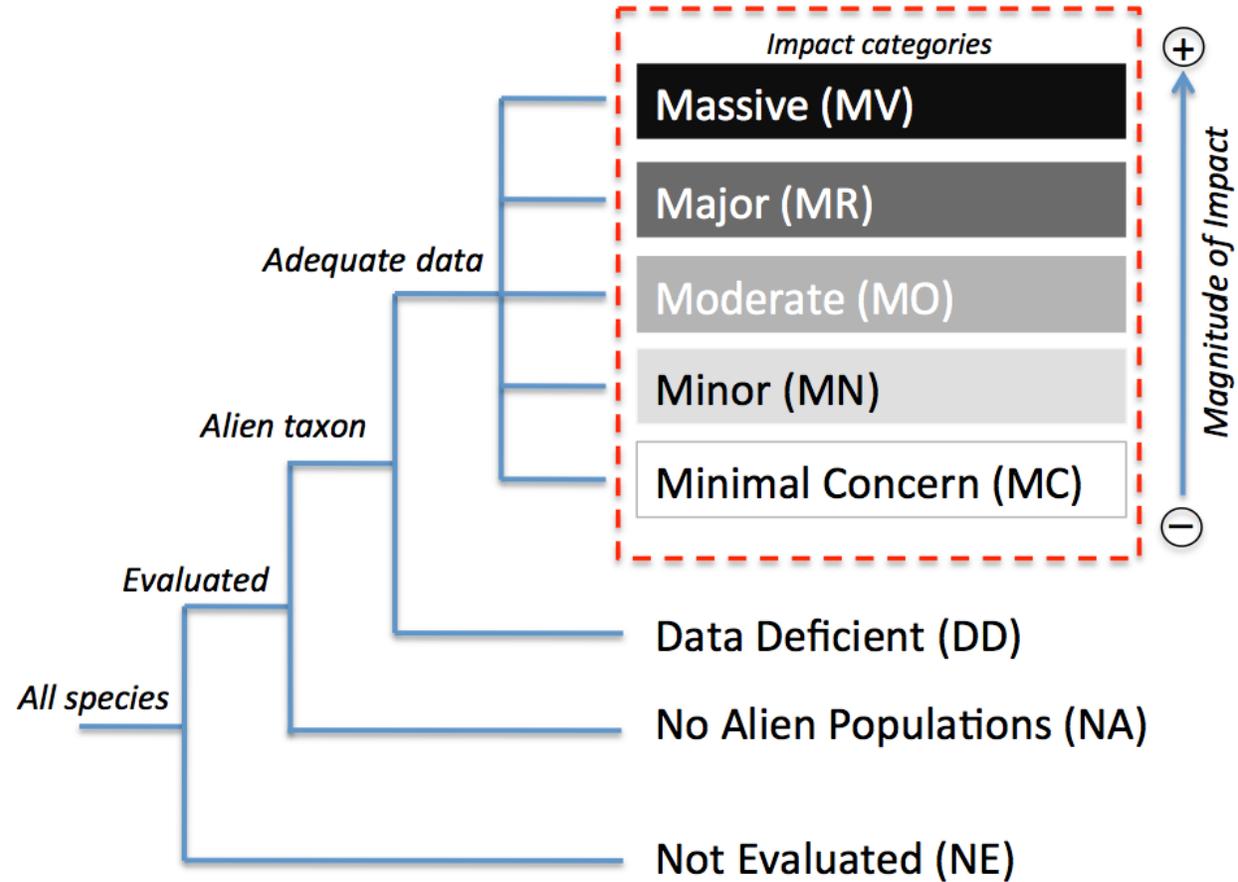
Species Alien Status—A Unified Framework



Blackburn *et al.* 2011 TREE; Wilson *et al.* 2014 Biological Invasions



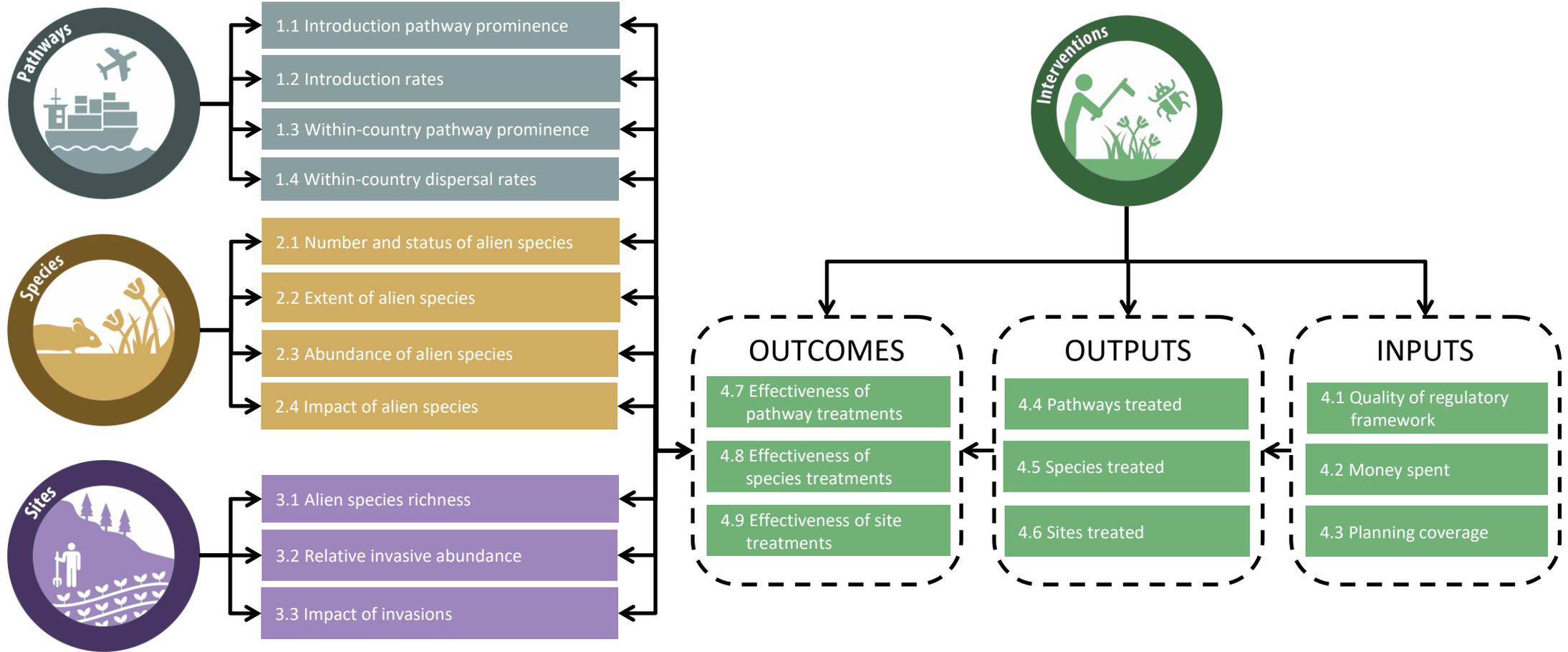
Species Impact—the EICAT and SEICAT schemes



Blackburn et al. 2014 PloS Biology; Bacher et al. 2018 Methods Ecol. Evol



Indicator framework



1. Rate of unregulated introduction of new species

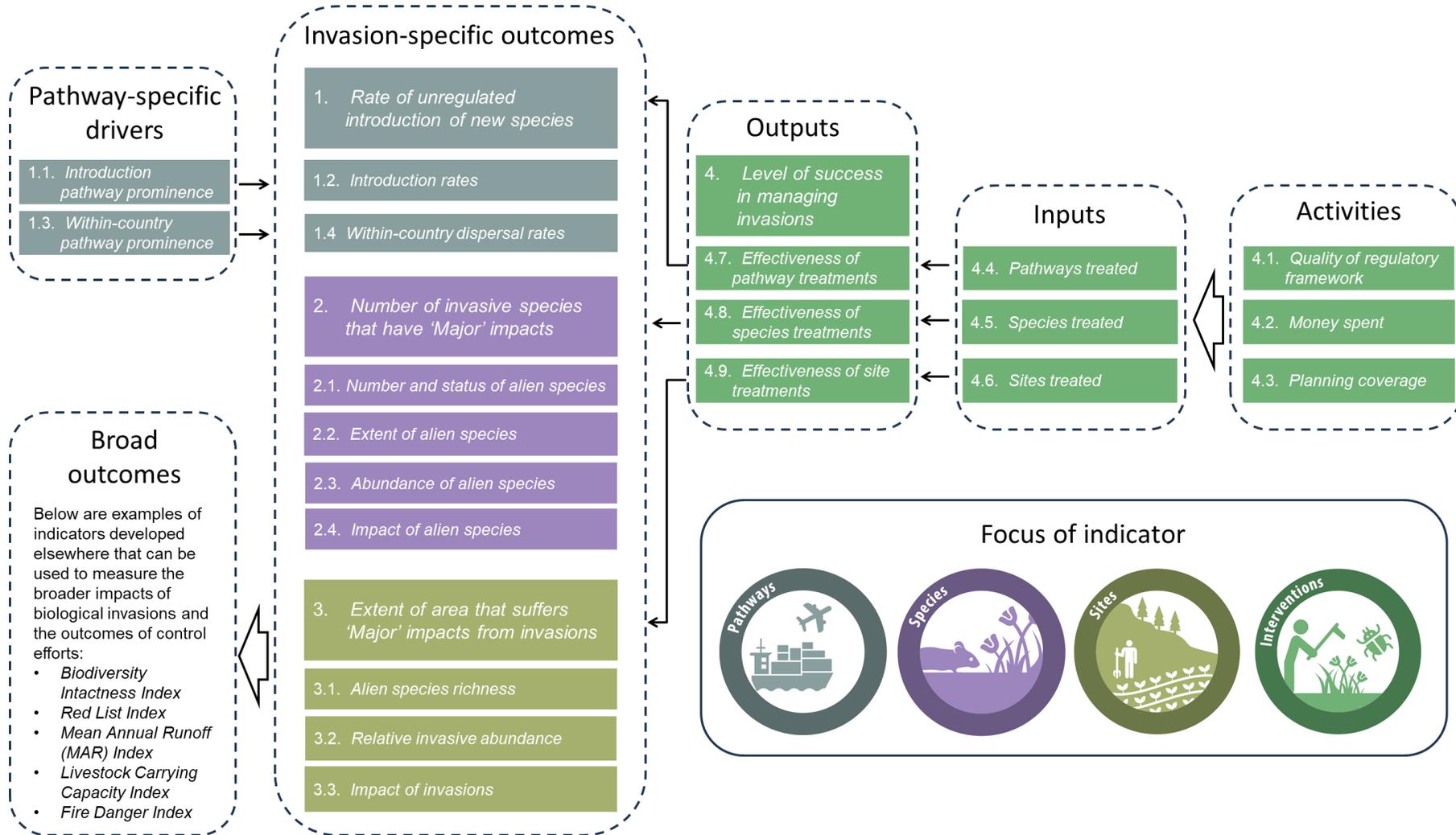
2. Number of invasive species that have 'Major' impacts

3. Extent of area that suffers 'Major' impacts from invasions

4. Level of success in managing invasions



Revisions to the indicator framework



Hierarchical metrics

Number and status of alien species

Increasing complexity
↓

2.1.1.	Number of invasive species
2.1.2.	<p>Number of alien species in one of three categories corresponding to: <i>IntroductionStatus</i></p> <ul style="list-style-type: none">• presentAsAlienNotEstablished• EstablishedNotInvasive• Invasive <p>Additional terms are available to address native-alien populations (EstablishedNotInvasive:NativeAlienPopulations, and Invasive:NativeAlienPopulations)</p>
2.1.3.	<p>Number of alien species in one of 12 categories: <i>degreeOfEstablishment</i> (adapted from Groom et al. 2019; based on Blackburn et al. 2011)</p> <p>Introduced but not established corresponds to B1–C2</p> <p>Established but not invasive corresponds to C3–D1</p> <p>Invasive corresponds to D2–E</p>



Confidence levels

Rate of introduction per pathway

High—direct evidence of the introduction pathway

Medium—species appeared when and where a single pathway was in operation and there is no other explanation

Low—pathway of introduction inferred based on traits or from other regions



Factsheets

Factsheets for indicators used to report on the status and management of biological invasions South Africa

v.20260130

These factsheets are based on the guidelines of the Biodiversity Indicators Partnership (Biodiversity Indicators Partnership, 2011), with the addition of explicit sections on how to define the confidence interval for each metric, and the properties of the indicators (see Appendix 1). A matrix showing the direct links between the indicators (i.e. where one indicator is dependent on another indicator) is shown in Appendix 2.

These indicators are used as part of the report series "The status of biological invasions and their management in South Africa". For the latest version of the report see <http://dx.doi.org/10.5281/zenodo.7414803> for general details see <http://iasreport.sanbi.org.za>

Much of the information on how the indicators are scored and how confidence levels are calculated are inherited from the metadata to the list of alien taxa for South Africa <https://doi.org/10.5281/zenodo.7433112> or from workflows associated with the national status report on biological invasions <https://doi.org/10.5281/zenodo.7433129>

There are several additional facilitating mechanisms that are vital for successful interventions, specifically: accessibility of data and information; research; organisational, infrastructure, and human capacity; and public awareness and engagement. Indicators for these are not included as they are not used for measuring outcomes or outputs of the interventions themselves.

Suggested citation for this document:

SANBI and CIB (2026) Factsheets for indicators used to report on the status and management of biological invasions in South Africa vXXXXXXX. Part of the report series "The Status of Biological Invasions and their Management in South Africa". South African National Biodiversity Institute (Kirstenbosch) and Centre for Invasion Biology (Stellenbosch) <http://dx.doi.org/10.5281/zenodo.17739011>

For enquiries contact: IAS.report.SANBI@gmail.com OR invasives@sanbi.org.za

Versions

Version	Description	Link
Not indicated on document	Paper outlining Indicators with factsheets included as supplementary material. Wilson et al. (2018) Indicators for monitoring biological invasions at a national level. Journal of Applied Ecology, 55, 2612–2620. doi: 10.1111/1365-2664.13251	http://dx.doi.org/10.1111/1365-2664.13251
20260130	Updated factsheets as part of the draft report "The Status of Biological Invasions and their Management in South Africa in 2025" sent for public comment 30 Jan–1 Mar 2026	http://dx.doi.org/10.5281/zenodo.17739011

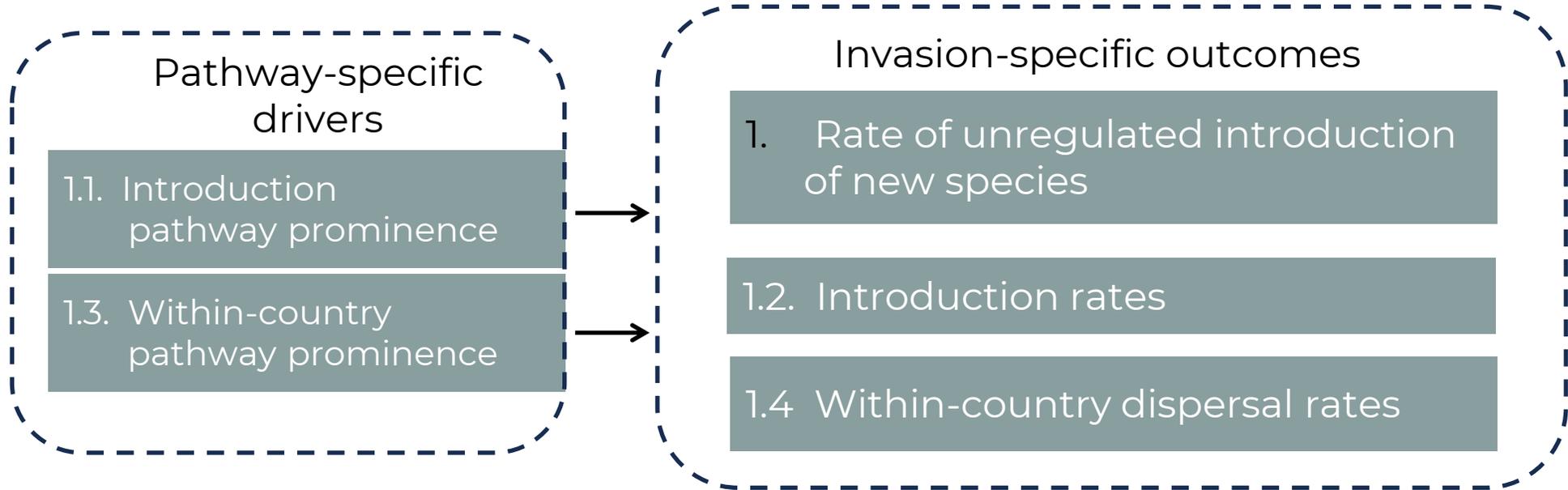


SANBI and CIB 2026, <http://dx.doi.org/10.5281/zenodo.17739011>





Pathways of introduction and dispersal





2.1 Introduction rates

Use and interpretation

Considers the introduction of new alien species to a country from another region through each introduction pathway

Depending on available data, 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 (i.e. both propagule pressure and colonisation pressure)





2.1 Introduction rates

Units in which it is expressed

-
- 1.2.1 The total number of alien species introduced through each CBD pathway sub-category over all time (CBD 2014).
-
- 1.2.2 Five categories demonstrating changes over a recent period of time (e.g., 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)
-
- 1.2.3 Number of individuals of each species introduced through the pathways and place and date of introduction
-





2.1 Introduction rates

Increasing human role ↑

Mechanism of entry	Pathway category	Pathway subcategory	Introduction rates (IR)	IR change 2020-2022
Commodity	Release	Biological control	278	↗
		Stabilisation & barriers	95	↗
		Fishery in the wild	17	→
		Hunting	34	→
		Aesthetic release	10	→
		Conservation in wild	3	→
		Release for use	9	→
		Other release	0	→
		Agriculture	113	↗
		Aquaculture	15	→
Commodity	Escape	Botanical gardens & zoos	5	→
		Pet	56	→
		Farmed animals	16	→
		Forestry	39	→
		Fur farms	1	→
		Horticulture	301	→
		Ornamental	277	↗
		Research	21	→
		Live food & live bait	2	→
		Other escape	1	→
Commodity	Contaminant	Nursery material contaminant	14	↗
		Bait contaminant	15	→
		Food contaminant	15	→
		Contaminant of animals	9	→
		Parasites of animals	36	→
		Contaminant of plants	26	→
		Parasites of plants	30	→
		Seed contaminant	40	→
		Timber trade contaminant	14	→
		Habitat material contaminant	6	→
Transport vector	Stowaway	Fishing equipment	0	→
		Container & bulk cargo	13	→
		Airplane	3	→
		Ship	26	→
		Machinery & equipment	1	→
		People & luggage	0	→
		Packing material	4	→
		Ballast water	62	→
		Hull fouling	70	→
		Land vehicles	1	→
Other stowaway	2	→		
Natural spread	Corridor	Canals & artificial waterways	0	→
		Tunnels & bridges	0	→
	Unaided	Natural dispersal	15	→





2.1 Introduction rates

Limits to usefulness and accuracy

- Difficulties associated with categorising species into the CBD pathway subcategories could lead to inaccuracies
- 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.





Species

Invasion-specific outcomes

2. Number of invasive species that have 'Major' impacts

2.1. Number and status of alien species

2.2. Extent of alien species

2.3. Abundance of alien species

2.4. Impact of alien species





2.1 Number and status of alien species

Use and interpretation

- The basis for constructing lists of alien taxa 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 alien taxa are likely to establish in future.
- Gives an indication of the effectiveness of species-focused control measures.





2.1 Number and status of alien species

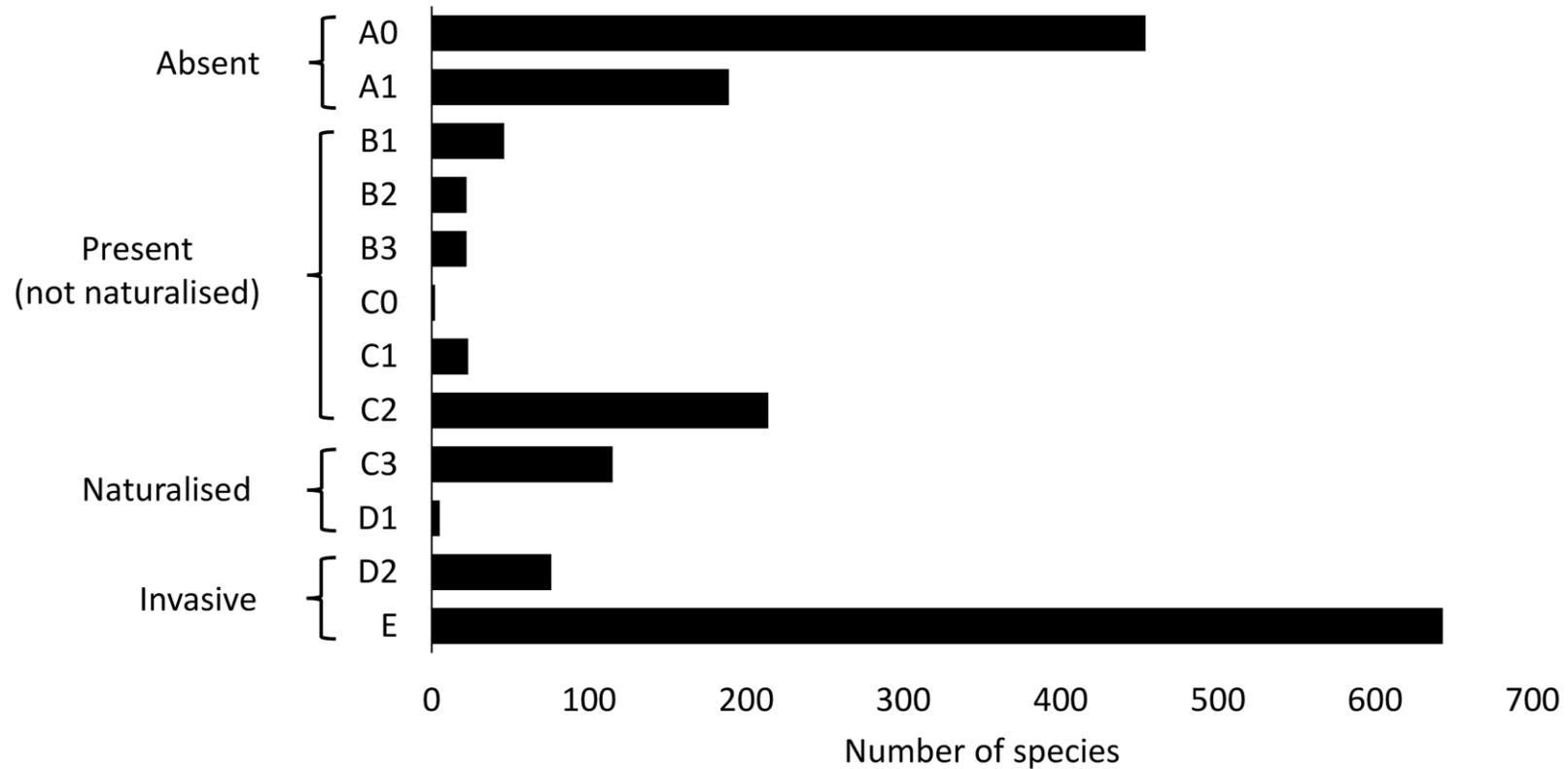
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2.1 Number and status of alien species

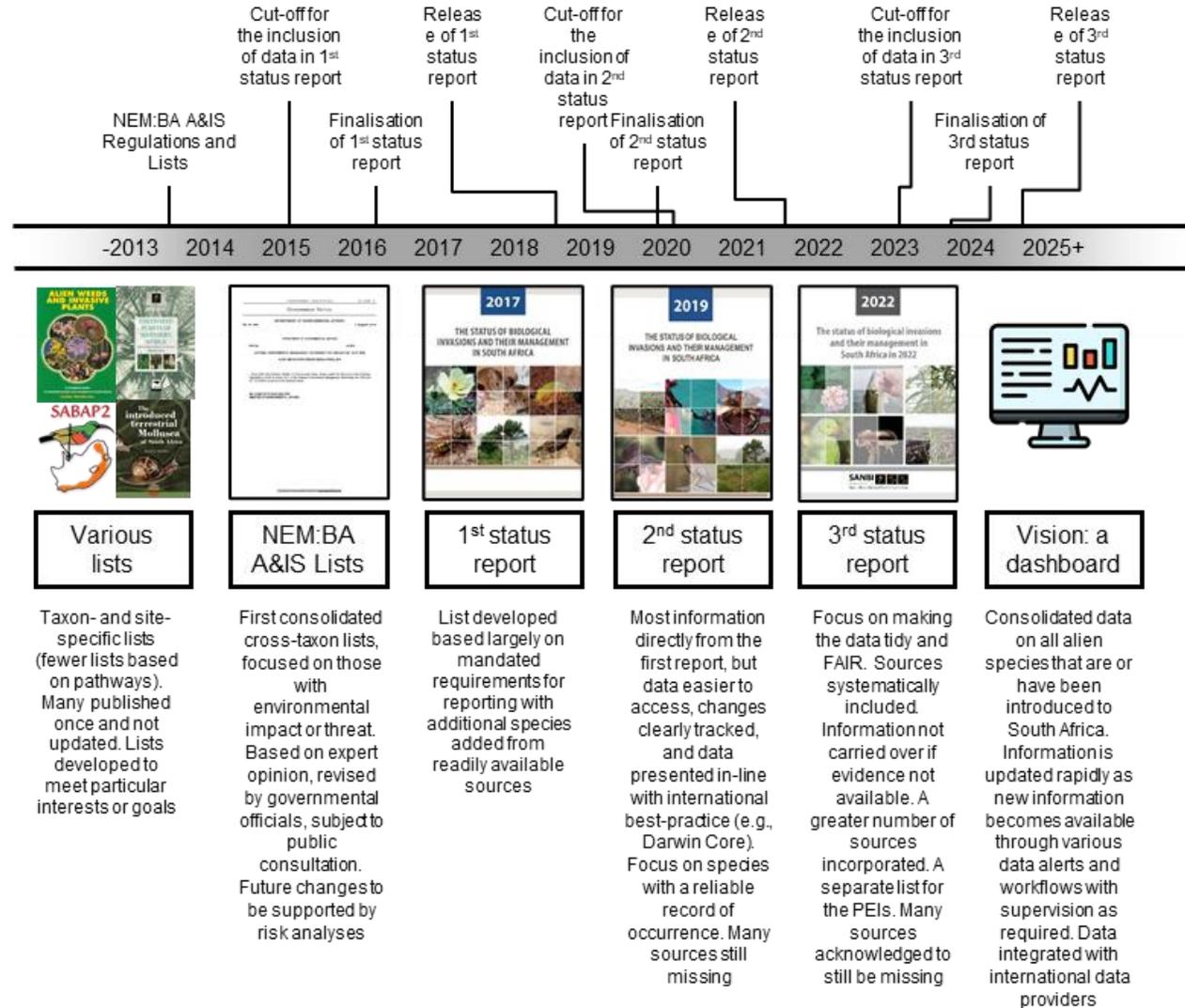


Zengeya et al. (in press). African Biodiversity & Conservation bioRxiv 2025.05.22.655507. <https://doi.org/10.1101/2025.05.22.655507>





2.1 Number and status of alien species

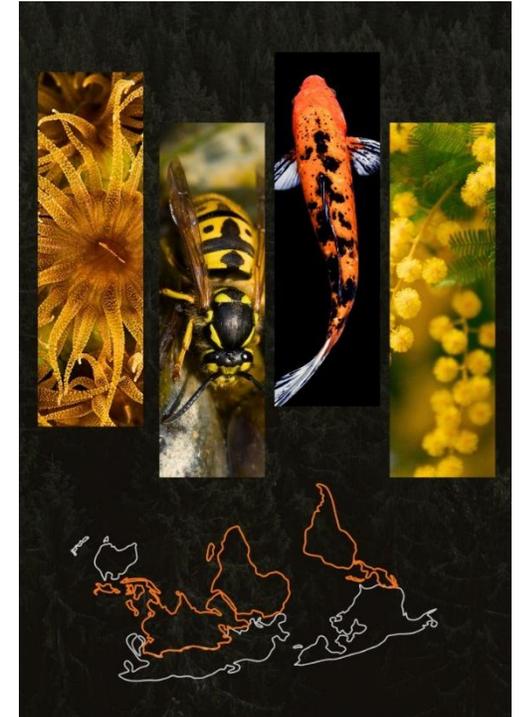


Zengeya et al. 2025. *Neobiota* 101: 203–222
<https://doi.org/10.3897/neobiota.101.162932>



Developing lists of alien taxa in the Global South: workflows, protocols, processes, and experiences

- Papers that outline workflows and protocols needed to compile lists
- Papers documenting the processes and experiences of developing lists
- Analyses of how particular issues (e.g., conflicts of interest) were addressed
- Assessments of the benefits of published lists
- Data papers with lists





Paper on the process



Special Issue papers

Editors of the special issues

Aníbal Pauchard
 Barbara Langdon
 Hanno Seebens
 John Wilson
 Katelyn T. Faulkner
 Michele de Sá Dechoum
 Shyama Pagad
 Silvía Ziller
 Tsungai Zengeya



A poster

South Africa's list

Asive Sifuba
 Brian van Wilgen
 Emily McCulloch-Jones
 John Wilson
 Katelyn Faulkner
 Laura Fernández Winzer
 Promise Mtileni
 Sabrina Kumschick
 Siya Miza-Tshangana
 Tammy Robinson
 Tsungai Zengeya
 Whitney Engelbrecht
 + lots of contributors!



Paper on the list



RSA's list of alien taxa



Metadata for the list





2.1 Number and status of alien species

Limits to usefulness and accuracy

- It can be highly sensitive to search effort and taxonomy
- Assumes an equivalency between species, e.g., one alien tree species is the same as one mite species.
- It relies on species being well-defined concepts.
- It does not encapsulate invasion at lower than the level of a whole organism, e.g., at the gene level (Petit 2004).
- There can be inconsistencies in the use of the terminology, e.g. definition of “invasive”





Sites

Invasion-specific outcomes

3. Extent of area that suffers
'Major' impacts from invasions

3.1. Alien species richness

3.2. Relative invasive abundance

3.3. Impact of invasions



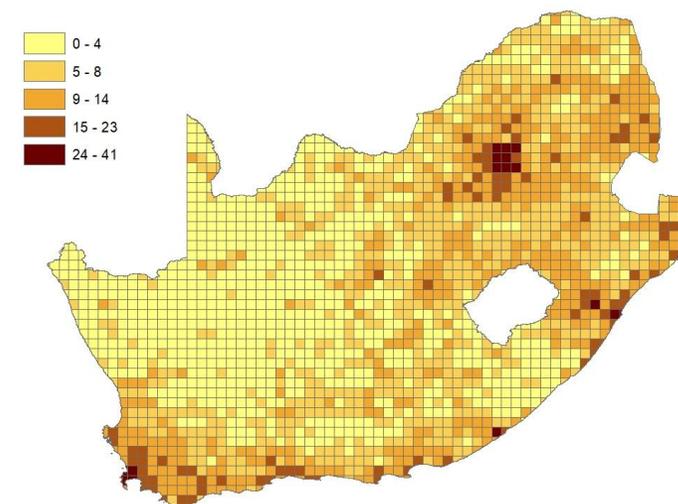


3.1 Alien species richness

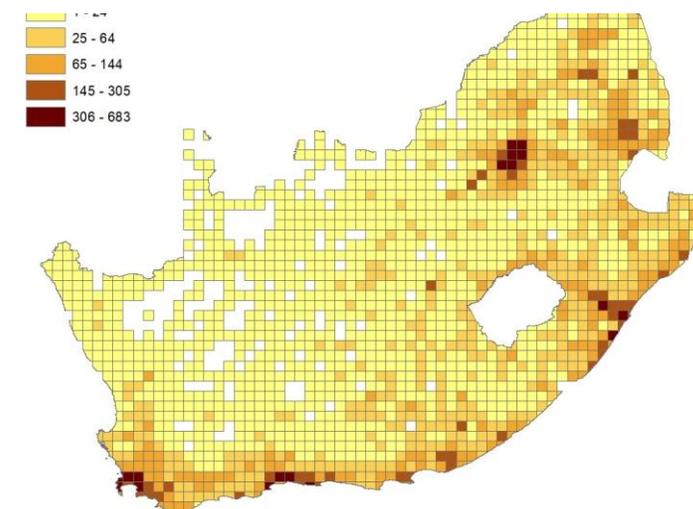
Use and interpretation

- This is an indicator of the number of alien species at a particular site.
- Higher number of invasive species indicate the number of issues addressed, while higher numbers of alien species indicate a higher risk of invasions.
- The indicator can be used at a range of scales to track invasion debt.

Alien bird species richness



Alien plant species richness

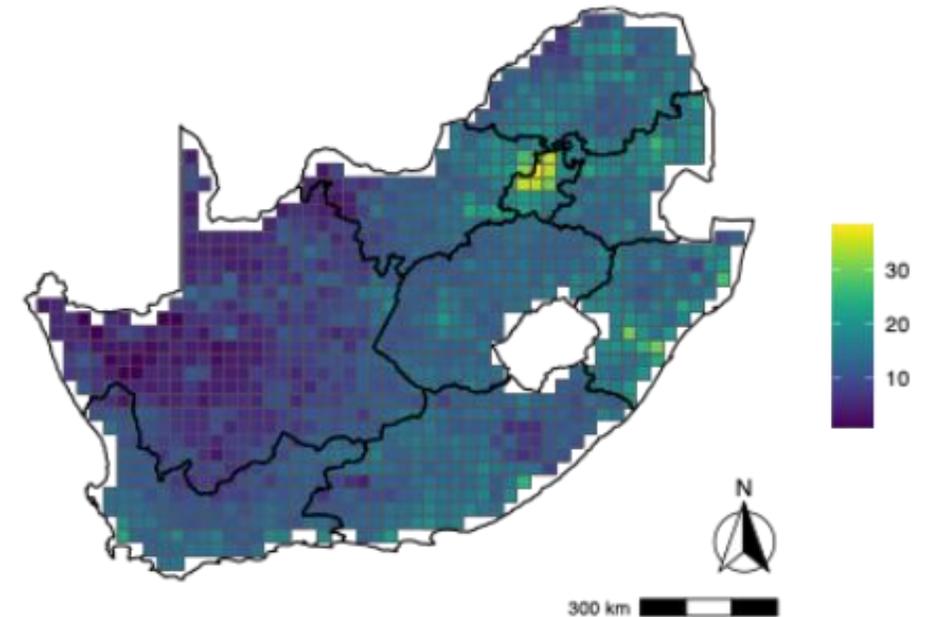




3.1 Alien species richness

Units in which it is expressed

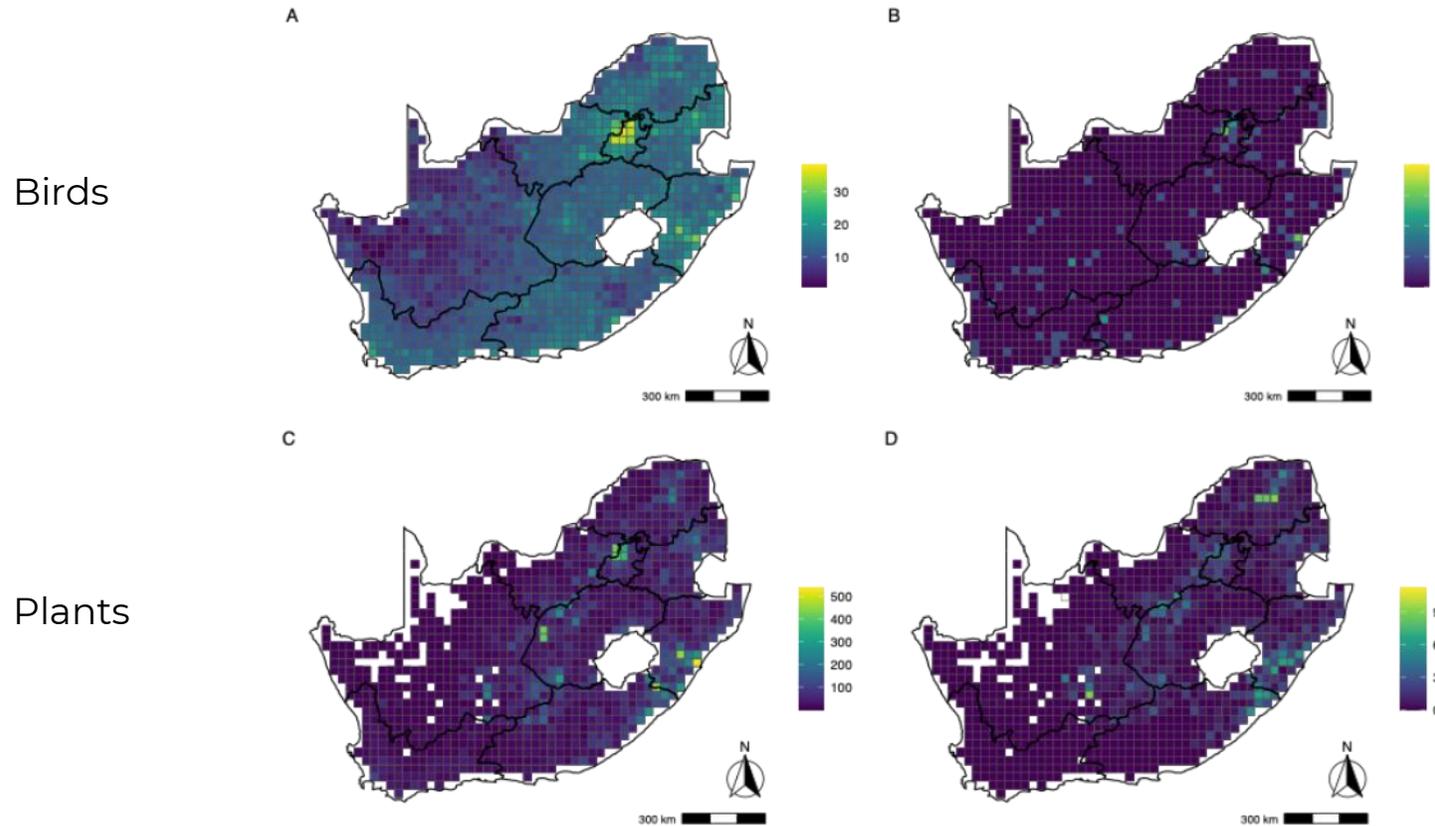
3.1.1.	The total number of invasive species per large-scale national sub-division.
3.1.2.	The total number of invasive species per finer-scale national sub-division.
3.1.3.	The number of alien species in different stages of the Unified Framework per finer-scale national sub-division





3.1 Alien species richness

Changes in alien species richness of birds and plants in South Africa between 2019 and 2022



SANBI and CIB (2026) <http://dx.doi.org/10.5281/zenodo.17697657>





3.1 Alien species richness

Limits to usefulness and accuracy

- Large sites would have to be covered on a regular basis to detect trends.
- The indicator works well for highly visible taxa (terrestrial plants, birds), but not for others.
- In some cases it is not clear if records represent invasive populations or presence within captivity or cultivation.





Outputs

4. Level of success in managing invasions

4.7. Effectiveness of pathway treatments

4.8. Effectiveness of species treatments

4.9. Effectiveness of site treatments

Inputs

4.4. Pathways treated

4.5. Species treated

4.6. Sites treated

Activities

4.1. Quality of regulatory framework

4.2. Money spent

4.3. Planning coverage





Pathway interventions

Activities:

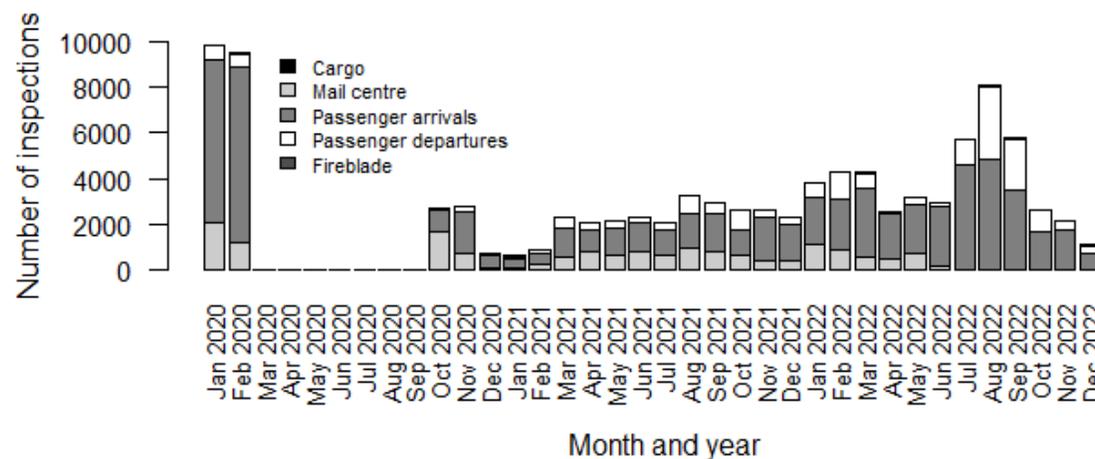
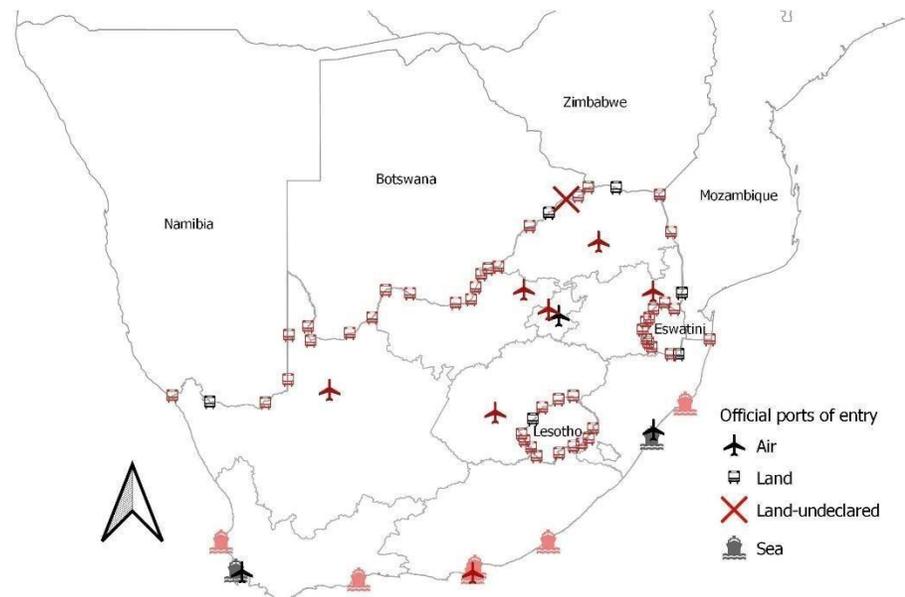
- Some plans developed for ballast water management
- Border Management Authority (BMA) established but money spent on managing pathways and border posts unclear
- Several international entry points monitored

Inputs:

- 40 of 44 pathways are managed to some extent
- Some illegal imports or luggage stowaways intercepted

Outputs:

- Unknown





Species interventions

Activities:

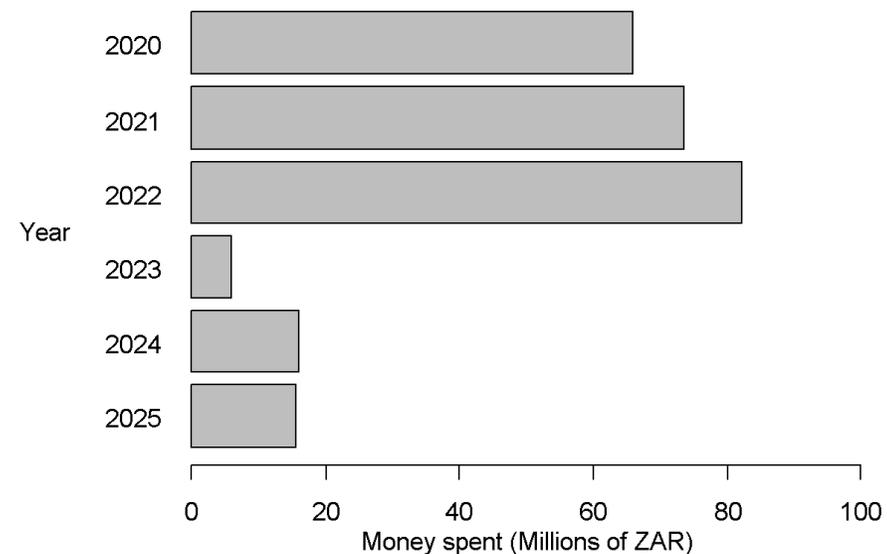
- Decline in the amount spent on biological control
- Several NGOs funded invasive plant control programs
- Some species-specific management plans have been developed, but none have been formally adopted

Inputs:

- 92 biological control agents established on 66 alien plant species

Outputs:

- 54 alien plant species under substantial or complete biological control



The amount of money spent annually on the biological control of invasive plants in South Africa





Site interventions

Activities

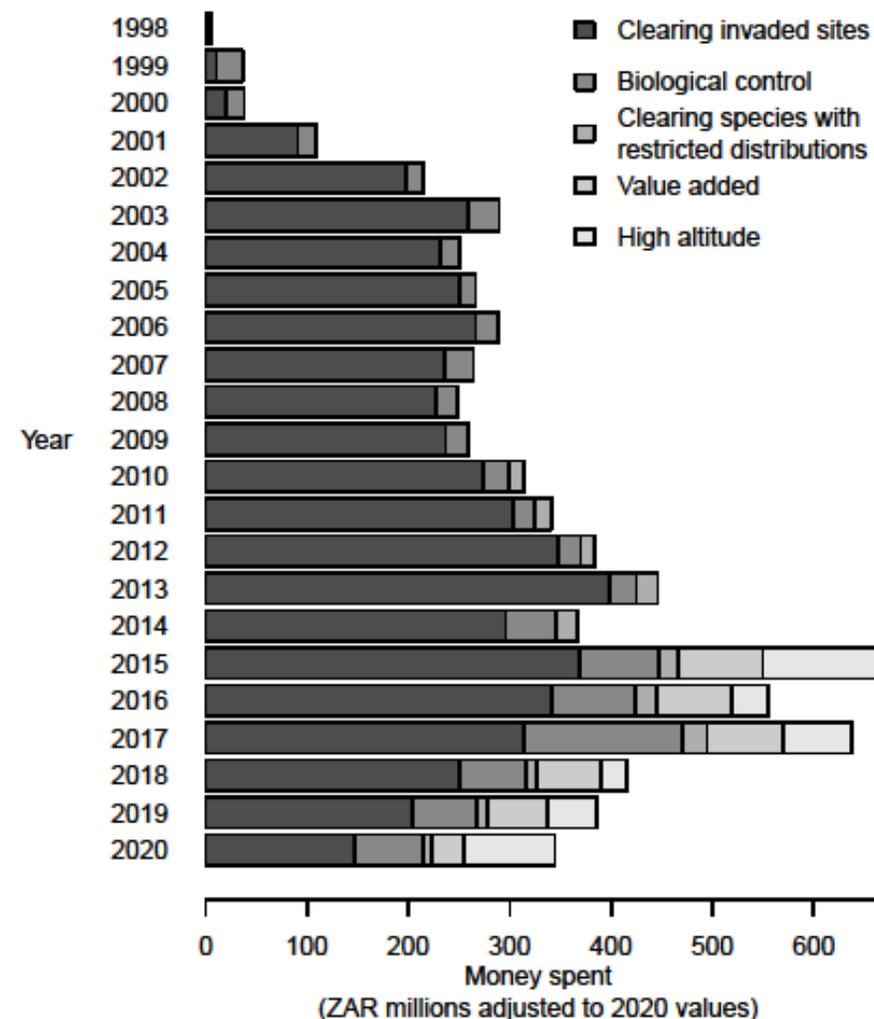
- Funding for the management of biological invasions has declined

Outputs

- 2.8 million ha cleared, 8 million ha followed up

Outputs

- Localised successes
- But continued growth in populations of all other species at a national scale
- Recovery of natural vegetation and grazing



SANBI and CIB (2026) <http://dx.doi.org/10.5281/zenodo.17697657>



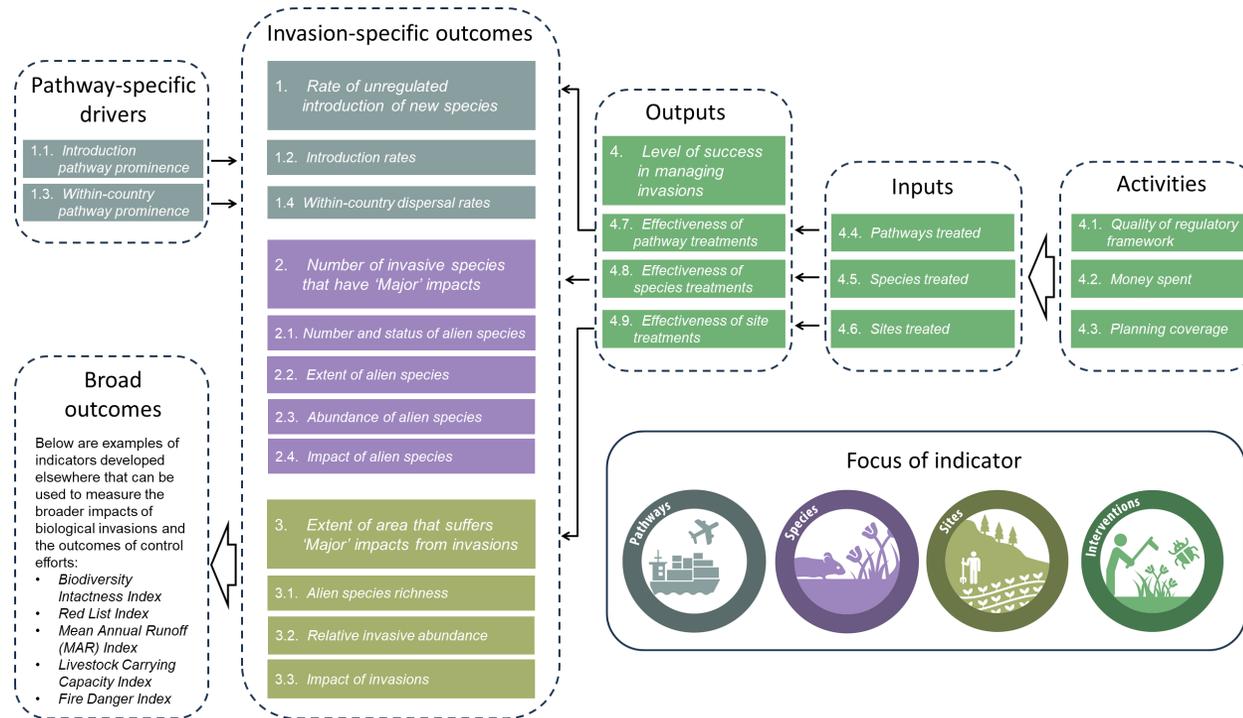
High level indicators



	Confidence	Notes
1. Rate of introduction of new unregulated species	Low	Over the last decade (2016–2025) approximately four new taxa were introduced per year either accidentally or intentionally but illegally. This is similar to previous estimates
2. Number of invasive species that have ‘Major’ impacts	Low (many taxa still need to be assessed)	National assessments using the EICAT framework show significant impacts, with 19 species having been assessed as causing ‘Major’ or ‘Massive’ impacts. Complementary assessments using risk analyses and findings from the IPBES IAS Assessment confirm these species cause widespread harm to society. However, only few taxa were assessed, there is a need for more assessments
3. Extent of area that suffers ‘Major’ impacts from invasions	Not reassessed	Biological invasions continue to cause impacts on biodiversity, ecosystem services, and human livelihoods by reducing South Africa`s water resources, degrading pasturelands, and exacerbating fire. These estimates, however, have not been recently revised.
4. Level of success in managing invasions	Not reassessed	Interventions are in place to address all facets of managing biological invasions, but funding is insufficient and declining. Despite local successes, invasions are increasing in extent and impact when assessed at a national scale.



Summary



20 indicators

4 high-level indicators

Hierarchical metrics

Confidence levels

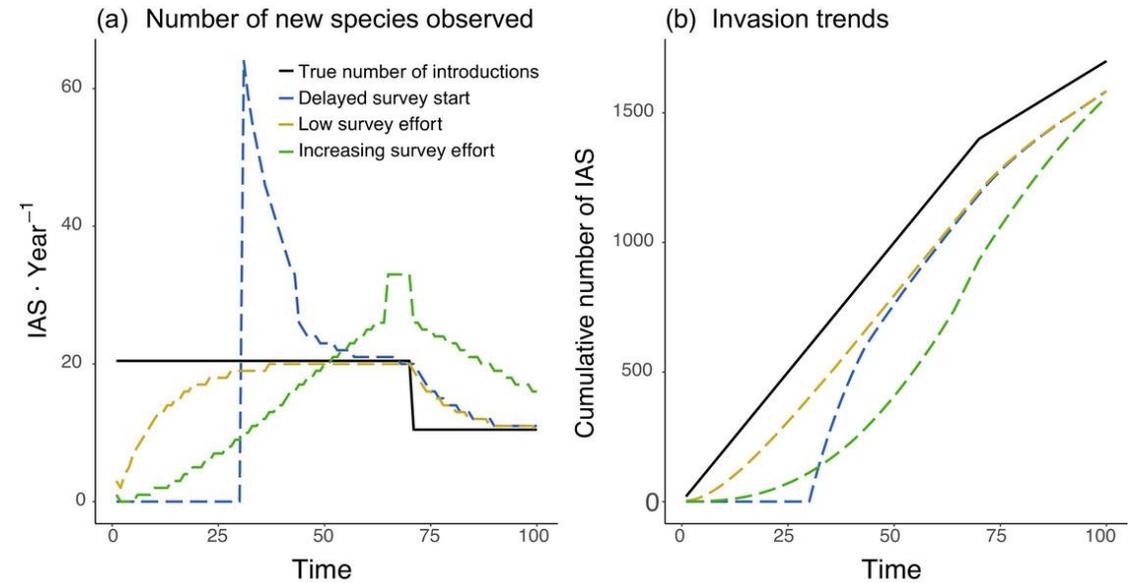
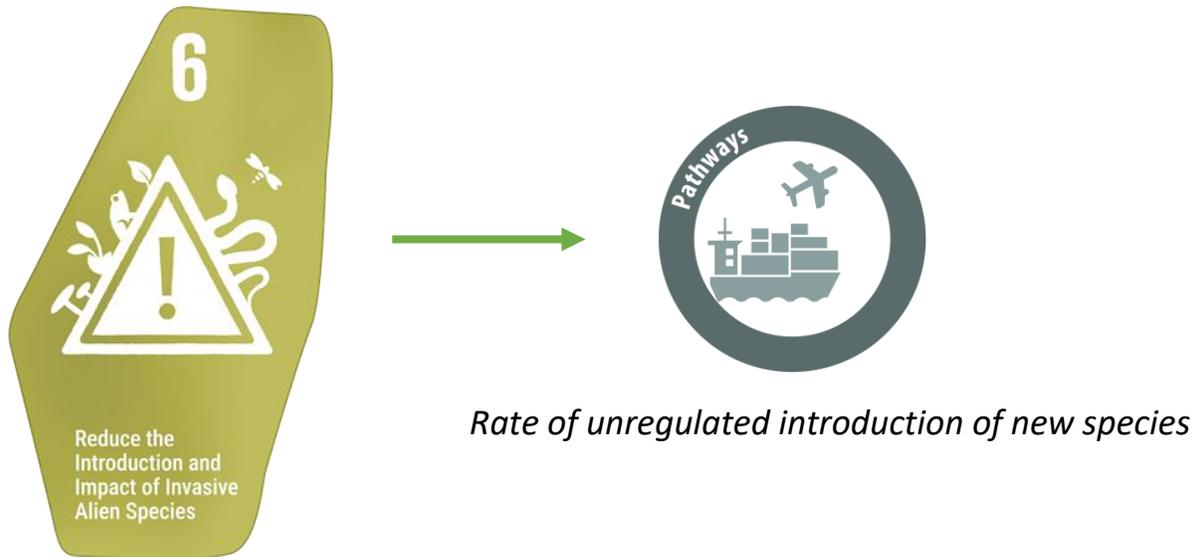
Factsheets



Link to other indicators

The Kunming-Montreal Global Biodiversity Framework Target 6 headline indicator

6.1 Rate of invasive alien species establishment

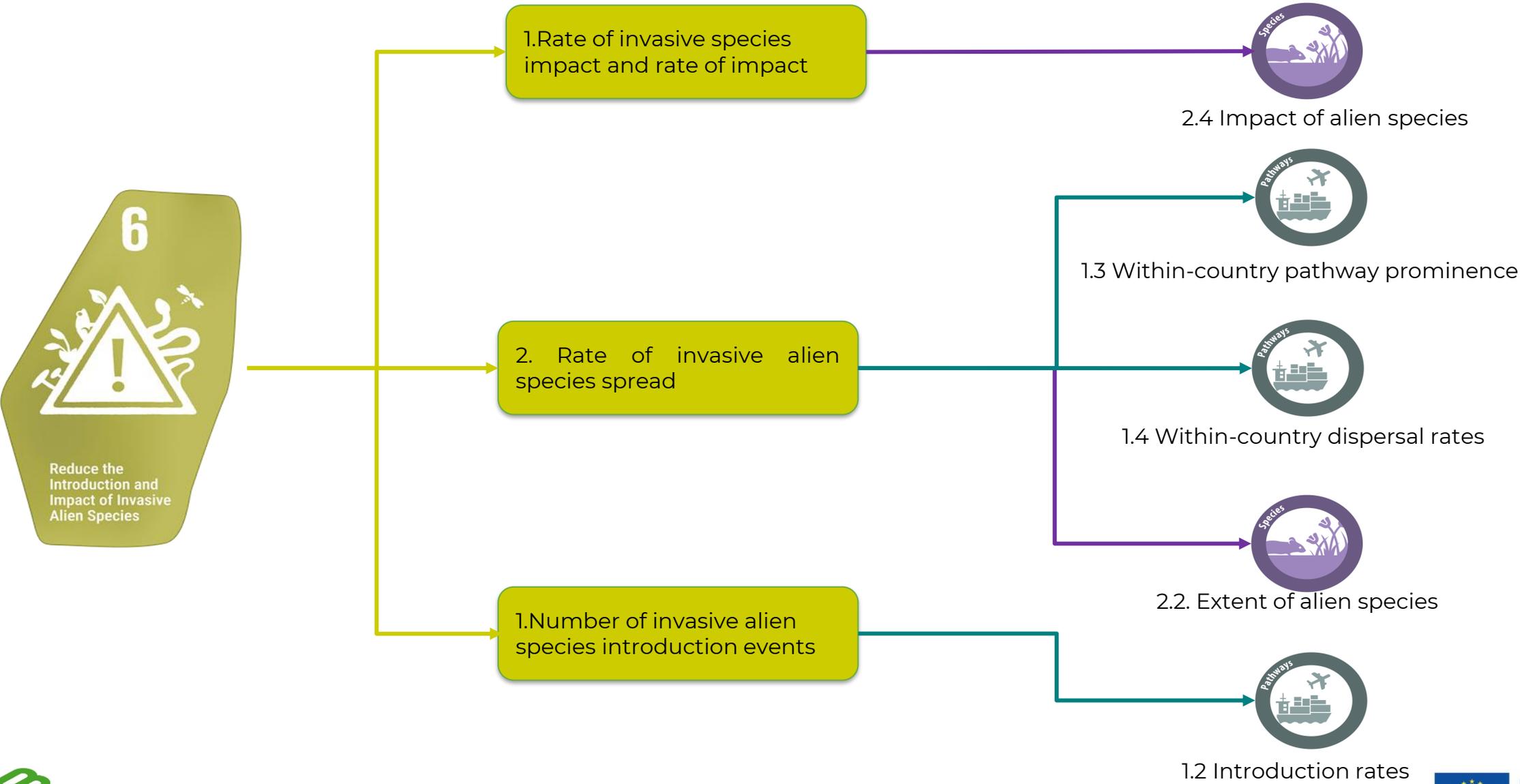


McGeoch et al. 2023, *Conservation Letters*, 16, e12981. <https://doi.org/10.1111/conl.12981>

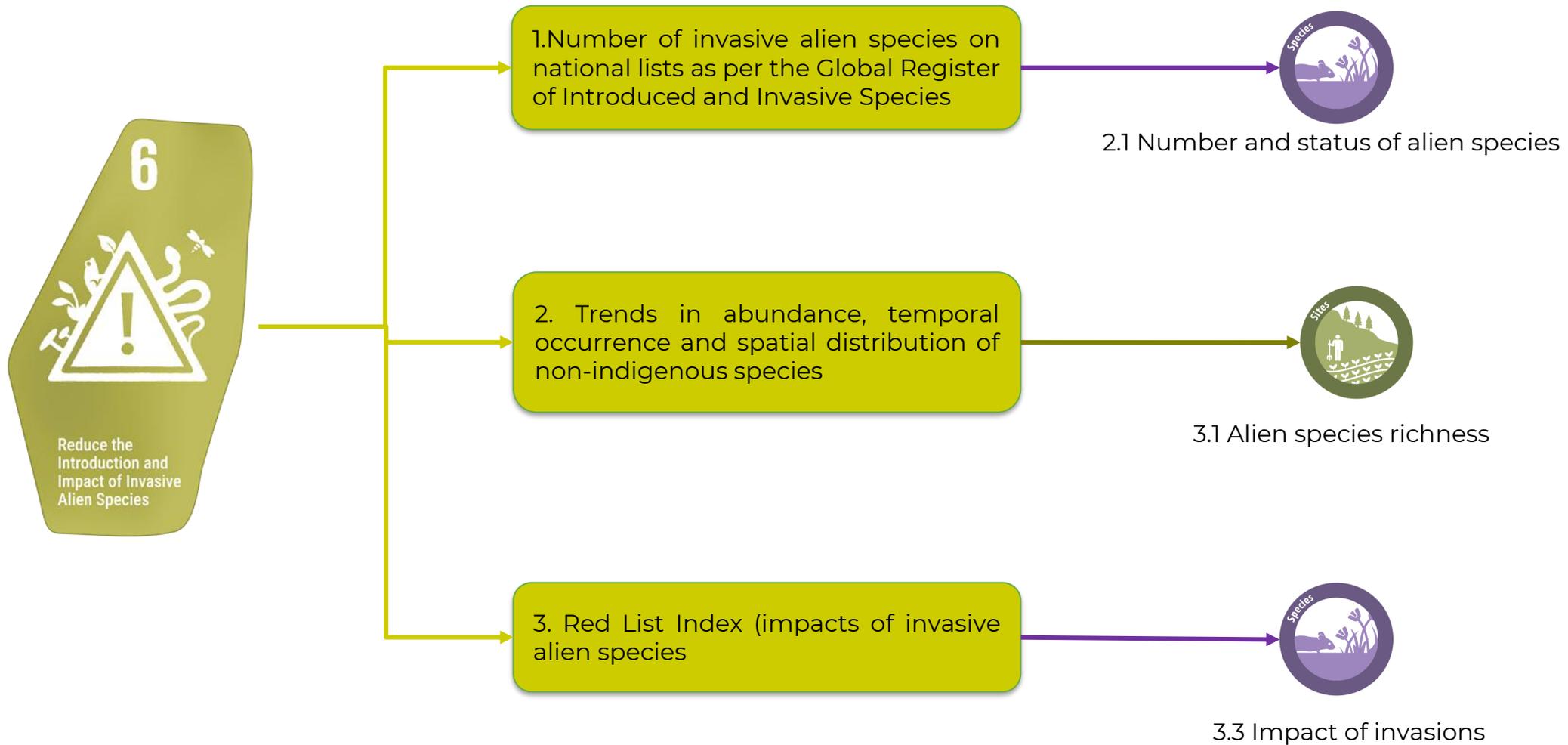
- Need to take sampling effort into account
- However, data gaps exist, and proxies of survey effort have not been routinely captured



K-MGBF Target 6 component indicators

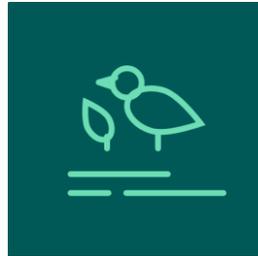


K-MGBF Target 6 complementary indicators

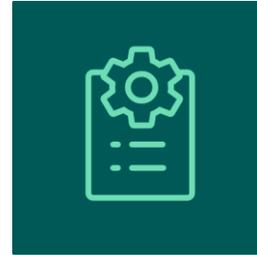


[Link to the Biodiversity Building Blocks for Policy project](#)

Case study II: Biological Invasions in South Africa



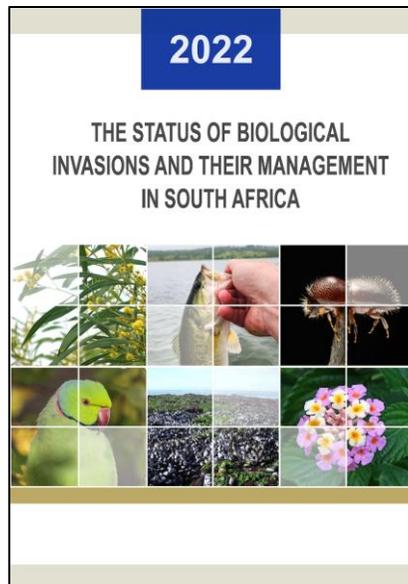
Species occurrence
cube



Automated workflows



General indicators



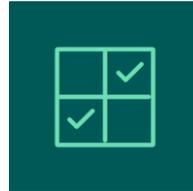
- Alignment of indicators
- Mobilization of spatial and impact data
- Assist the automation and standardization of the process
- How reports are communicated (i.e., including workflows and dashboards).



Cubes



Species occurrence cube



Suitability cube



Dissimilarity cube



Network invisibility cube

SA indicators



Number and status of alien species



Extent of alien species



Impact of alien species



Alien species richness

B Cubed indicators



General indicators



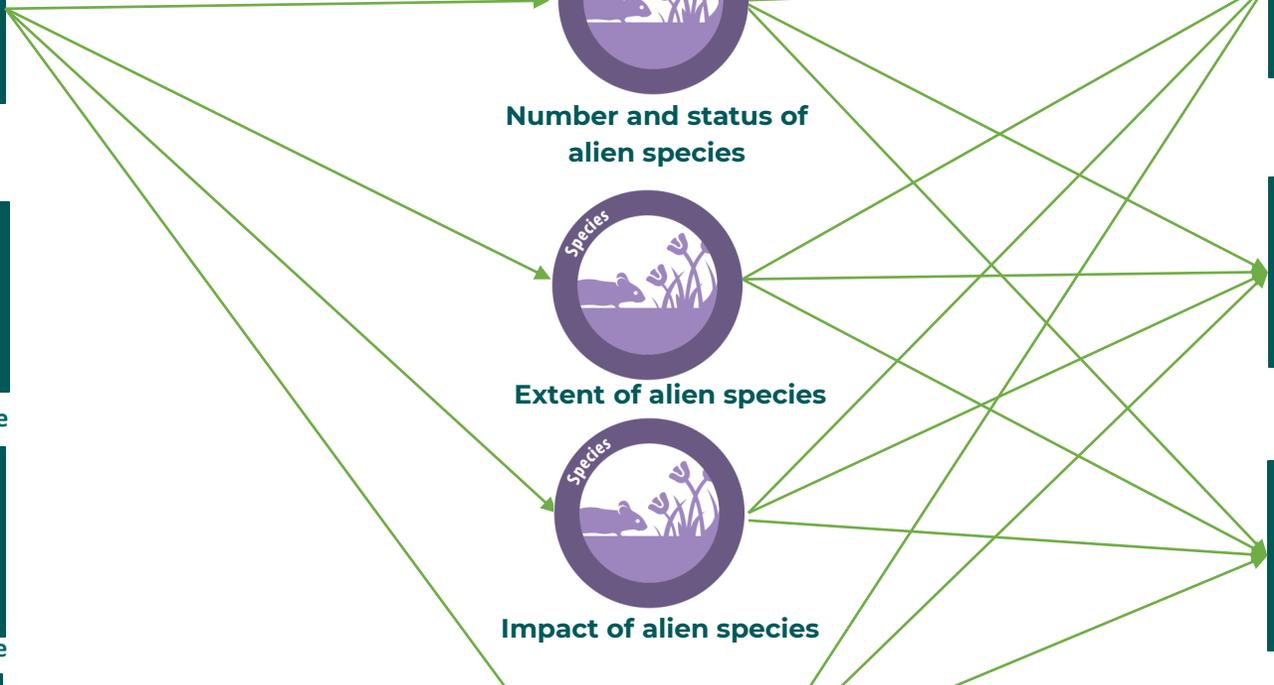
Robustness indicators



Impacts



Phylogenetic indicators



Links

For more information and links to the reports see:

<http://iasreport.sanbi.org.za>

Copies also available on: <https://zenodo.org/records/8217182>

Indicator framework: Wilson et al. (2018), Journal of Applied Ecology,

<https://doi.org/10.1111/1365-2664.13251>

Thank you!

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