

Economic costs of invasive rodents worldwide: the tip of the iceberg



Christophe Diagne, L. Ballesteros-Mejia, T. Bodey, R. N. Cuthbert,
J. Fantle-Lepczyk, E. Angulo, G. Dobigny & and F. Courchamp

Invasive alien rodents: a major problem worldwide

Global Invasive Species Database: <http://www.iucngisd.org/gisd/>

Global Register of Introduced and Invasive Species: <http://www.griis.org/>

48 *species (currently) recorded*



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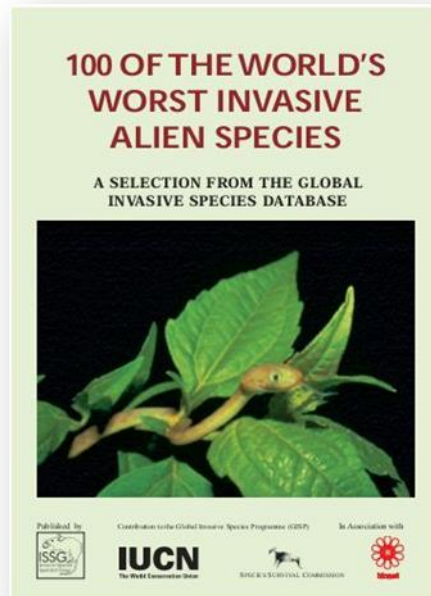


Black rat (*Rattus rattus*)

Grey squirrel (*Sciurus carolinensis*)

House mouse (*Mus musculus*)

Coypu (*Myocastor coypus*)





biodiversity and ecosystems

e.g. Russel et al. 2020 *Biol Inv*
Sainsbury et al. 2020 *Cons Sci Prac*

- decline of native biota (plants, birds, invertebrates, mammals,...)
- disruption to ecosystem functioning



Invasive alien rodents: a major problem worldwide



biodiversity and
ecosystems

- ~ 60 known zoonotic pathogens
- ~ 400 million human cases every year



public health



e.g. Han et al. 2015 *PNAS*
Meerburg et al. 2009 *Crit Rev Microbiol*

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public health



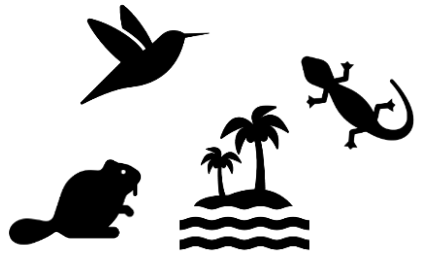
e.g. Garba et al. 2014 *Plos One*
Colombe et al. 2019 *WHO Report*



human well-being

- up to 25% of house fires of unknown origin (USA)
- markers of low-social status and unsanitary conditions

Invasive alien rodents: a major problem worldwide



biodiversity and
ecosystems



public health

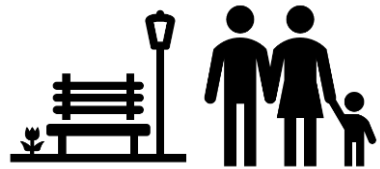


e.g. Singleton et al. 2005 *Biol J Linn Soc*
Dossou et al. 2020 *Biotech Agron Soc Environ*

- damage to food stocks and crops
- economic losses to industries



socio-economic activities



human well-being

Invasive alien rodents: a major problem worldwide



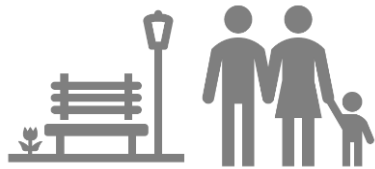
biodiversity and
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public health



discrepancy between tremendous
impacts and insufficient control efforts?



human well-being



socio-economic activities

Invasive alien rodents: why studying their monetary impacts?

Difficult measure & demonstration of impacts

Difficult anticipation of system evolution

Lack of general rules

Local scale interests

Lack of knowledge on many systems

Multifaceted threat



Alerting

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Currency: a common and understandable metrics



Economic costs

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Economic costs



Damage and losses



Management expenditures

Bradshaw et al. 2016 *Sci Rep*
Courchamp et al. 2017 *TREE*

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Damage and losses



Management expenditures



improve public communication and compel policymakers

Bradshaw et al. 2016 *Sci Rep*
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Diagne et al. 2020 *NeoBiota*

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Damage and losses



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improve public communication and compel policymakers



support efficient and cost-effective **decision-making**

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Economic costs



Damage and losses



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support efficient and cost-effective **decision-making**



increase prioritization in the global environmental agenda

Bradshaw et al. 2016 *Sci Rep*
Courchamp et al. 2017 *TREE*
Diagne et al. 2020 *NeoBiota*

Economic and Environmental Impacts of Harmful Non-Indigenous Species in Southeast Asia

Le T. P. Nghiem¹, Tarek Soliman¹, Darren C. J. Yeo¹, Hugh T. W. Tan¹, Theodore A. Evans¹, John D. Mumford², Reuben P. Keller³, Richard H. A. Baker⁴, Richard T. Corlett⁵, Luis R. Carrasco^{1*}

~ US\$ **1.9 billion** per year

Management of rodents in crops: the Pied Piper and his orchestra

Herwig Leirs

University of Antwerp, Department of Biology, Groenenborgerlaan 171, B-2020 Antwerpen, BELGIUM; and
Danish Pest Infestation Laboratory, Skovbrynet 14, DK-2800 Kgs. Lyngby, DENMARK
Email: herwig.leirs@ua.ac.be

~ US\$ **45 million** per year



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harmonize available information
& identify knowledge gaps

prioritize actions & coordinate
responses at relevant scales



First global synthesis of the documented economic costs of invasive alien rodents



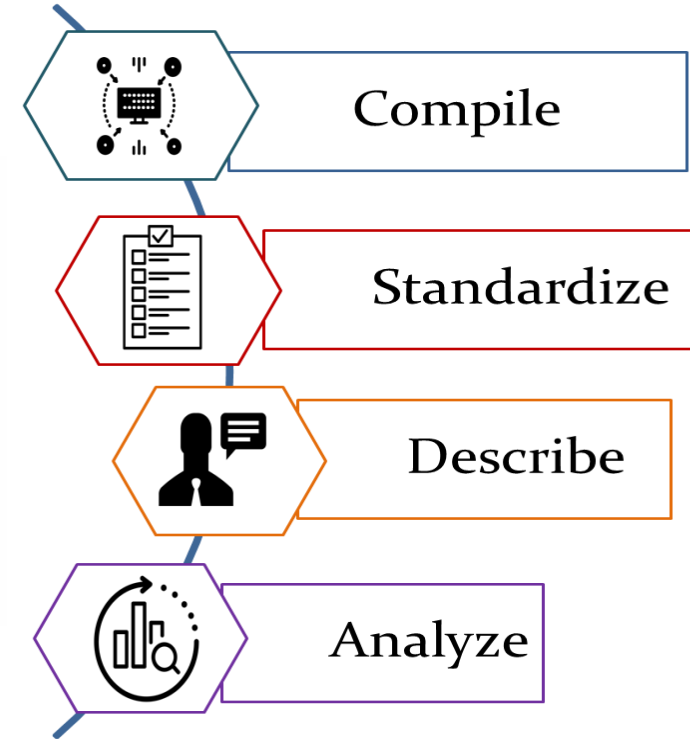
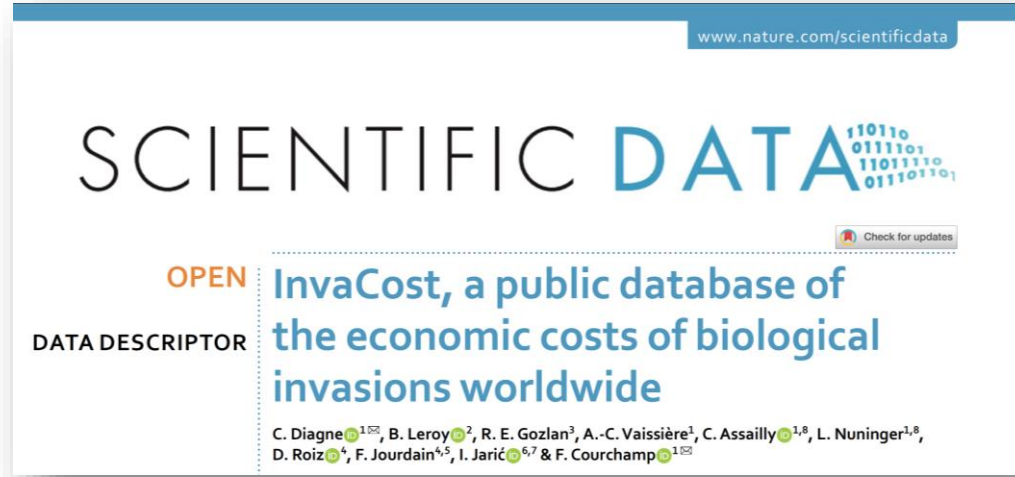
Total/annual cost to human society over time?

Damage versus management?

Distribution across space and taxa?

Research and management implications?

The InvaCost database as an original resource



collaborative



**publicly
accessible**



**'living'
(regularly updated)**

Version 4.0: <https://invacost.fr/>

- **13,123** cost entries (US\$)
- **750+** taxa

- **90+** countries
- **~2200** sources

65 descriptive fields



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Reference
title, authors,
publication year, etc.



Column_name	Definition
<i>Cost_ID</i>	Unique identifier for the cost entry
<i>Repository</i>	Literature engine (Web of Science (WoS), Google Scholar (GS), Google search engine (Go)) or original source (Targeted collection (TC)) from
<i>Reference_ID</i>	Identifier for the reference where the cost entry is reported. As much as possible, this is the original source where the cost was first provided
<i>Reference_title</i>	Title of the reference where the cost entry is reported
<i>Authors</i>	Authors of the reference where the cost entry is reported
<i>Abstract</i>	If existing/accessible, the abstract of the reference where the cost entry is reported
<i>Publication_year</i>	Year of publication of the reference where the cost entry is reported
<i>Language</i>	Main language used in the original reference reporting the cost entry
<i>Type_of_material</i>	Type of reference analyzed (i.e. scientific peer-reviewed article or grey literature); for grey literature, the exact nature of the reference was
<i>Previous_materials</i>	If any, the list of successive materials checked before reaching the original reference providing the cost entry
<i>Availability</i>	The accessibility of the original reference as a searchable document (yes/no)

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Taxonomy (GBIF*)
from kingdom to species,
vernacular name, etc.

<i>Kingdom</i>	Taxonomic kingdom of the invasive species associated with the cost entry
<i>Phylum</i>	Taxonomic phylum of the invasive species associated with the cost entry
<i>Class</i>	Taxonomic class of the invasive species associated with the cost entry
<i>Order</i>	Taxonomic order of the invasive species associated with the cost entry
<i>Family</i>	Taxonomic family of the invasive species associated with the cost entry
<i>Genus</i>	Taxonomic genus of the invasive species associated with the cost entry
<i>Species</i>	Taxonomic species of the invasive species associated with the cost entry
<i>Sub-species</i>	Taxonomic sub-species of the invasive species associated with the cost entry
<i>Common_name</i>	Non-scientific (or vernacular) name(s) provided in the original reference, or by the International Union for Conservation of Nature (IUCN) v

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Study
spatial scale, time
range, location, etc.

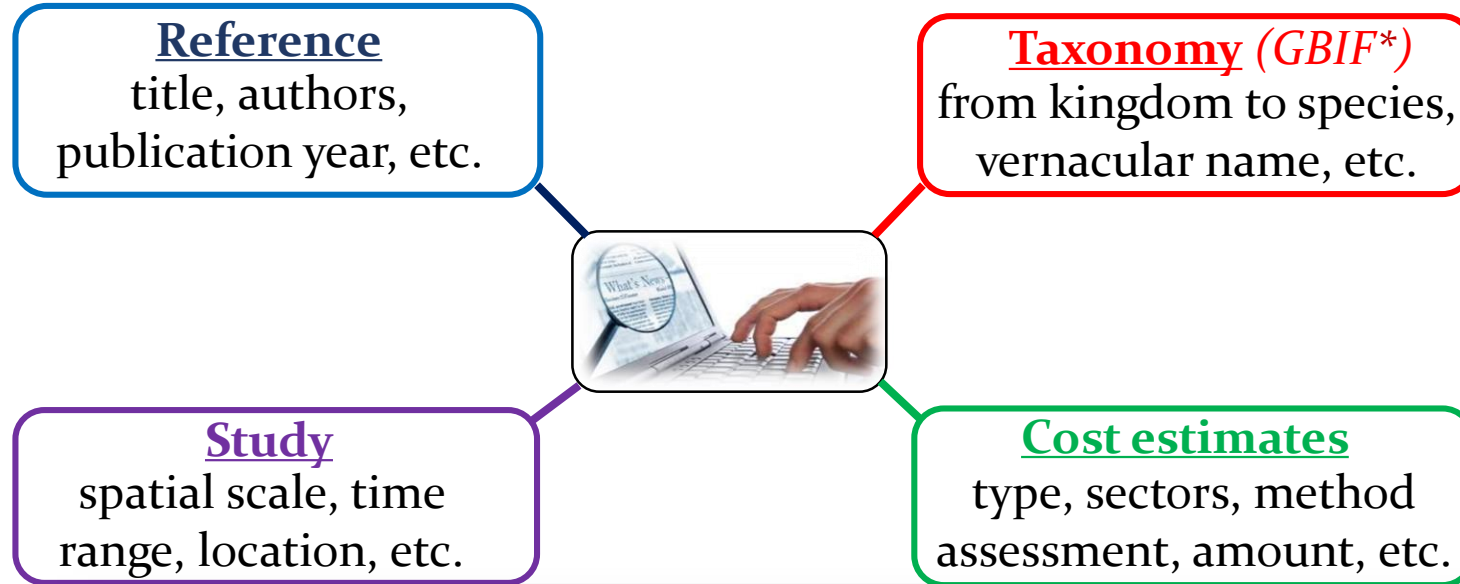
<i>Environment</i>	Type of environment (aquatic, terrestrial, semi-aquatic, diverse/unspecified) where the cost estimate occurred
<i>Environment_IAS</i>	Type of environment where the invasive species lives, independently of where the cost occurred: aquatic (species with a close association with water)
<i>Habitat</i>	The type of habitat where the cost occurred (1 .Forests: closed vegetation dominated by deciduous or evergreen trees; 2 .Open forests: woody vegetation with scattered trees)
<i>Habitat_verbatim</i>	Copy from the original reference of the sentence/paragraph indicating the habitat typology of the studied area
<i>Island</i>	Assessment of the geographical area where the cost occurred as an island (Y) or not (N); NA is used when the information is not clearly provided
<i>ProtectedArea</i>	Assessment of the geographical area where the cost occurred as a protected area (Y) or not (N); NA is used if the area comprises both protected and non-protected areas
<i>Geographic_region</i>	Geographical region(s) where the cost occurred (Africa, Antarctic-Subantarctic, Asia, Central America, Europe, North America, Oceania, South America)
<i>Official_country</i>	Country where the cost occurred; sometimes, this is not congruent with the geographic region as some territories (e.g., overseas areas) are not included in the region
<i>State Province Administrative_area</i>	The second level of geographic division (state, province or territory) for the official country where the cost occurred
<i>Location</i>	When provided, the precise location (e.g., city, area) where the cost estimate occurred
<i>Spatial_scale</i>	Order of magnitude of the extent, size of the land/water area where the costs incurred. Options include: global (worldwide-scale), intercontinental (intercontinental-scale), continental (continental-scale), regional (regional-scale), local (local-scale)
<i>Period_of_estimation</i>	If provided, the exact period of time covered by the cost, otherwise the raw formulation provided in the reference analyzed (e.g. late 90s, c. 2000)
<i>Time_range</i>	Two options: period if the cost is given for a period exceeding a year; or year if the cost is given yearly or for a period up to one year
<i>Probable_starting_year_&_Probable_ending_year</i>	Year range in which the cost is known or assumed to have occurred. When not explicitly provided by the authors, we mentioned unspecified
<i>Probable_starting_year_adjusted_&_Probable_ending_year_adjusted</i>	<i>Probable starting year</i> and <i>Probable ending year</i> columns where the cells with unspecified information are replaced, as much as possible, by the most probable year range
<i>Occurrence</i>	Status of the cost estimate as potentially ongoing (if the cost can be expected to continue over time) or one-time (if the cost was deemed to have occurred only once)

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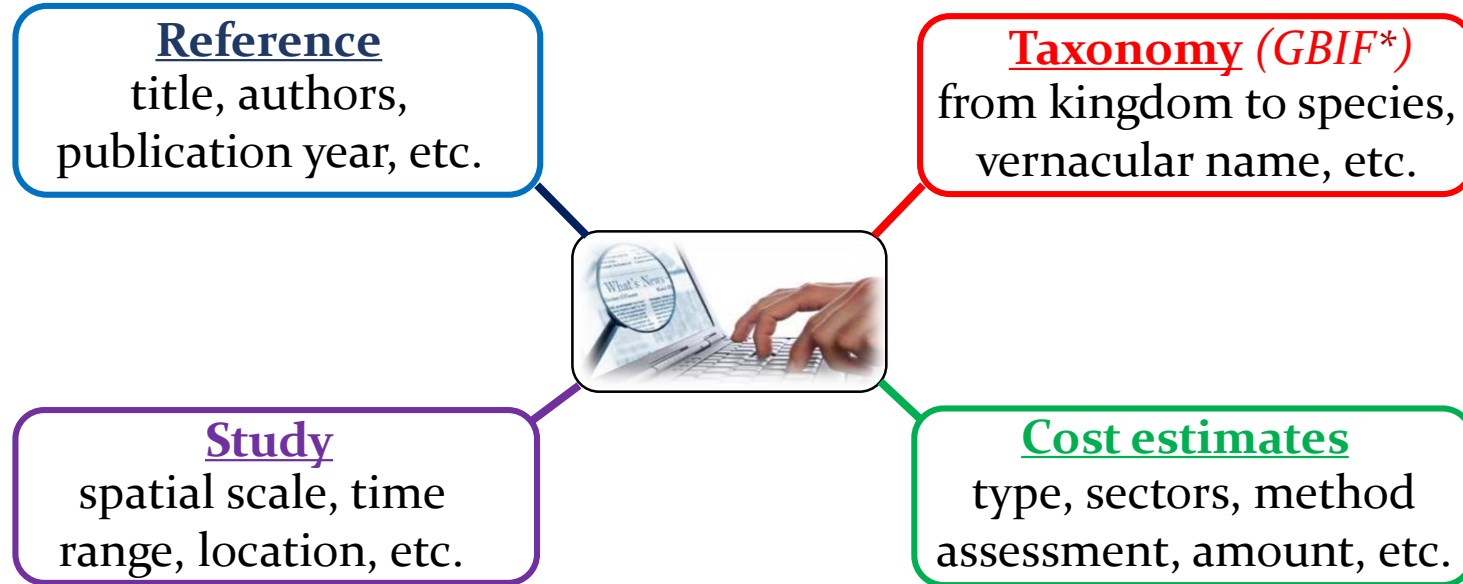
<i>Implementation</i>	This states — at the time of the estimation — whether the reported cost was actually observed (i.e., cost actually incurred) or potential (i.e., cost not yet incurred)
<i>Acquisition_method</i>	Method used to obtain the cost estimate: report/estimation directly obtained or derived (using inference methods) from field-based information
<i>Impacted_sector</i>	Sector impacted by the cost estimate in our socio-ecosystems: Agriculture (considered at its broadest sense, food and other useful products) or Other
<i>Type_of_cost</i>	Damage and losses incurred by an invasion (e.g. damage-loss, damage repair, medical care, crop losses) or means dedicated to understanding the invasion
<i>Type_of_cost_merged</i>	Categories of the <i>Type of cost</i> column reassigned into damage (economic losses due to direct and/or indirect impacts of invaders, such as crop losses, damage to infrastructure, etc.) or other (means dedicated to understanding the invasion)
<i>Management_type</i>	Pre-invasion management (monetary investments for preventing successful invasions in an area - including quarantine or border inspection) or Post-invasion management (monetary investments for managing the invasion)
<i>Method_reliability</i>	Assessment of the methodological approach used for cost estimation as of (i) high reliability if either provided by officially pre-assessed methods or (ii) low reliability if not
<i>Method_reliability_refined</i>	Assessment of the methodological approach used for cost estimation as of high or low reliability based on the evaluation of the estimation method
<i>Method_reliability_refined_Explanation</i>	Detailed explanation why a particular methodological approach used for cost estimation was deemed as of high or low reliability based on the evaluation of the estimation method
<i>Method_reliability_refined_Expert_Name</i>	Complete name and contact details of the expert who had deemed the reliability of the cost entry
<i>Benefit_values</i>	Mention (if any) of the benefit value in the analyzed material (yes/no); the figure was not recorded or described as being out of the scope of the study
<i>Details</i>	When necessary, narrative elements deemed important either to understand the cost estimate or to support choices made for completing the cost entry

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‘**invacost**’ package
(Leroy et al. 2020 *BioRxiv*)



InvaCost 3.0

9,823 entries

1605 references

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Rodentia subset

362 cost entries

102 references



Rodents

→ only entries with 'Rodentia' in the "Order" column

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Rodentia subset

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102 references



Rodents

→ only entries with 'Rodentia' in the "Order" column

Suitable subset

349 entries

88 references



Complete

→ potential duplicates/overlaps are removed

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9,823 entries

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102 references



Rodents

→ only entries with 'Rodentia' in the "Order" column

Suitable subset

349 entries

88 references



Complete

→ potential duplicates/overlaps are removed

Expanded subset

718 entries

88 references



Annualized

→ cost entries are homogenized on an annual basis

InvaCost 3.0

9,823 entries

1605 references

Rodentia subset

362 cost entries

102 references



Rodents

→ only entries with 'Rodentia' in the "Order" column

Suitable subset

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Complete

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718 entries

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Annualized

→ cost entries are homogenized on an annual basis

Final subset

426 entries (1930-2018)

58 references

12 taxa



Highly reliable
& observed

→ only the most robust data are kept for analyses

3 main insights today



Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

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Christophe DIAGNE (✉ chrisdiagne89@hotmail.fr)

Universite Paris-Sud <https://orcid.org/0000-0002-6406-1270>

Liliana Ballesteros-Mejia

Universite Paris-Saclay

Thomas Bodey

University of Aberdeen

Ross Cuthbert

GEOMAR: Helmholtz-Zentrum für Ozeanforschung Kiel

Jean Fantle-Lepczyk

Auburn University

Elena Angulo

Universite Paris-Saclay

Gauthier Dobigny

Institut de recherche pour le developpement

Franck Courchamp

Centre National de la Recherche Scientifique

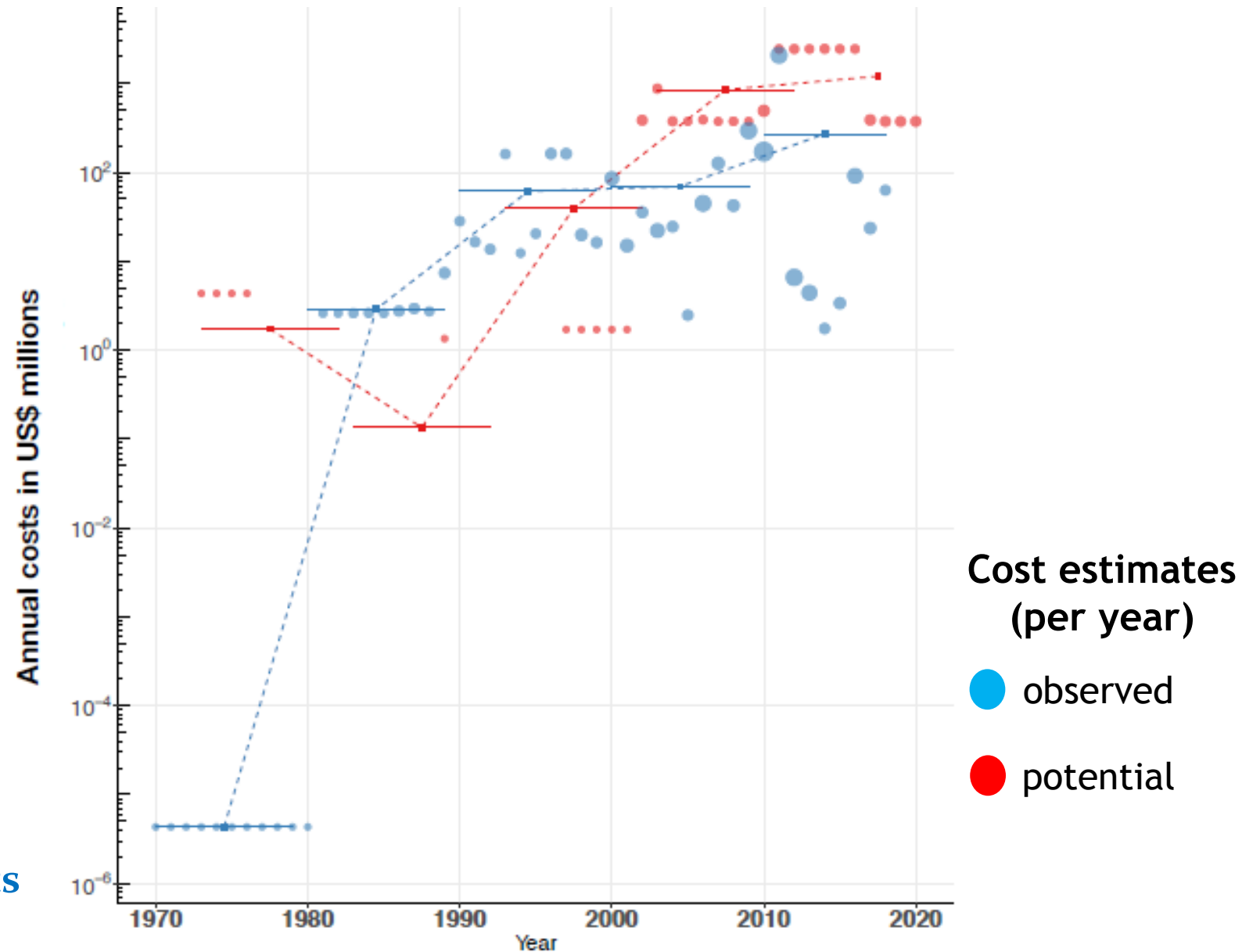
But more in our
preprint!!!

Insight 1: tremendous and increasing costs

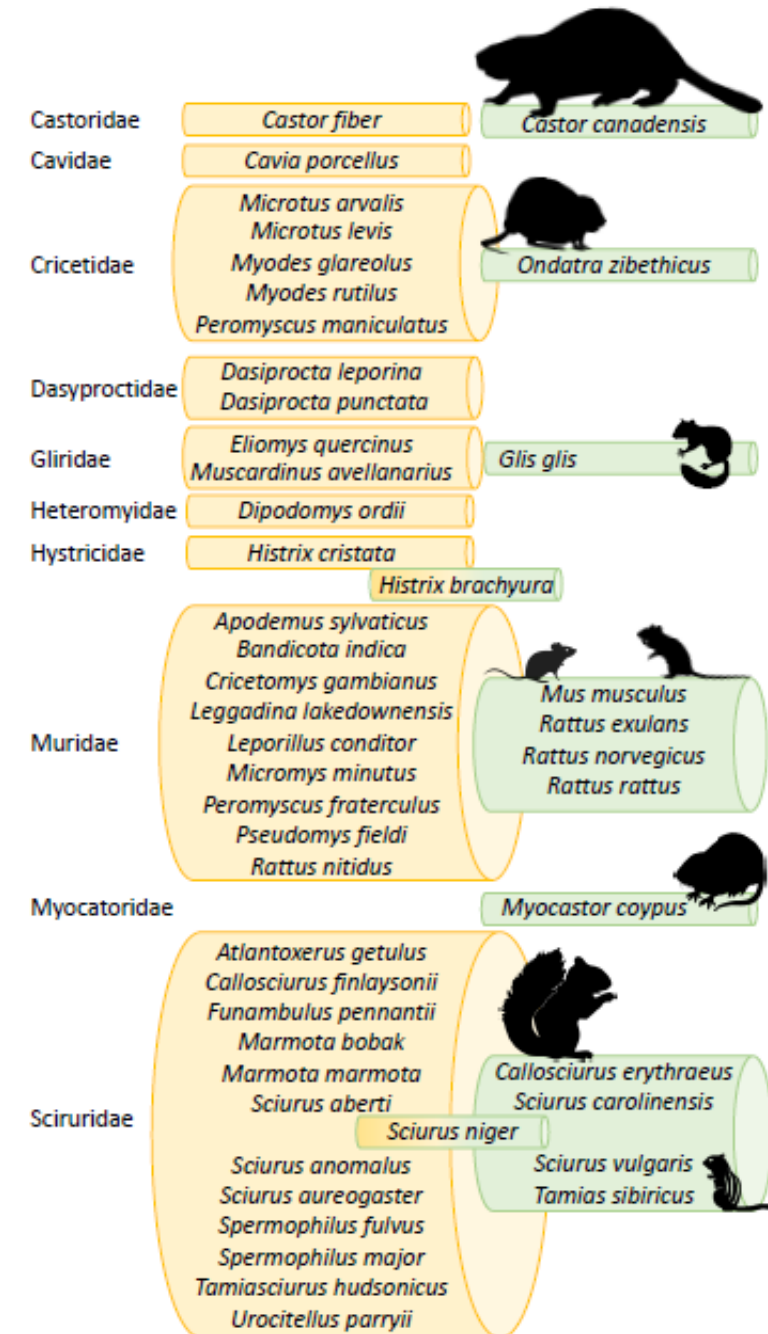


US\$ 3.28 billion
between 1930 and 2018

**Increasing invasion
opportunities,
detections and reports**

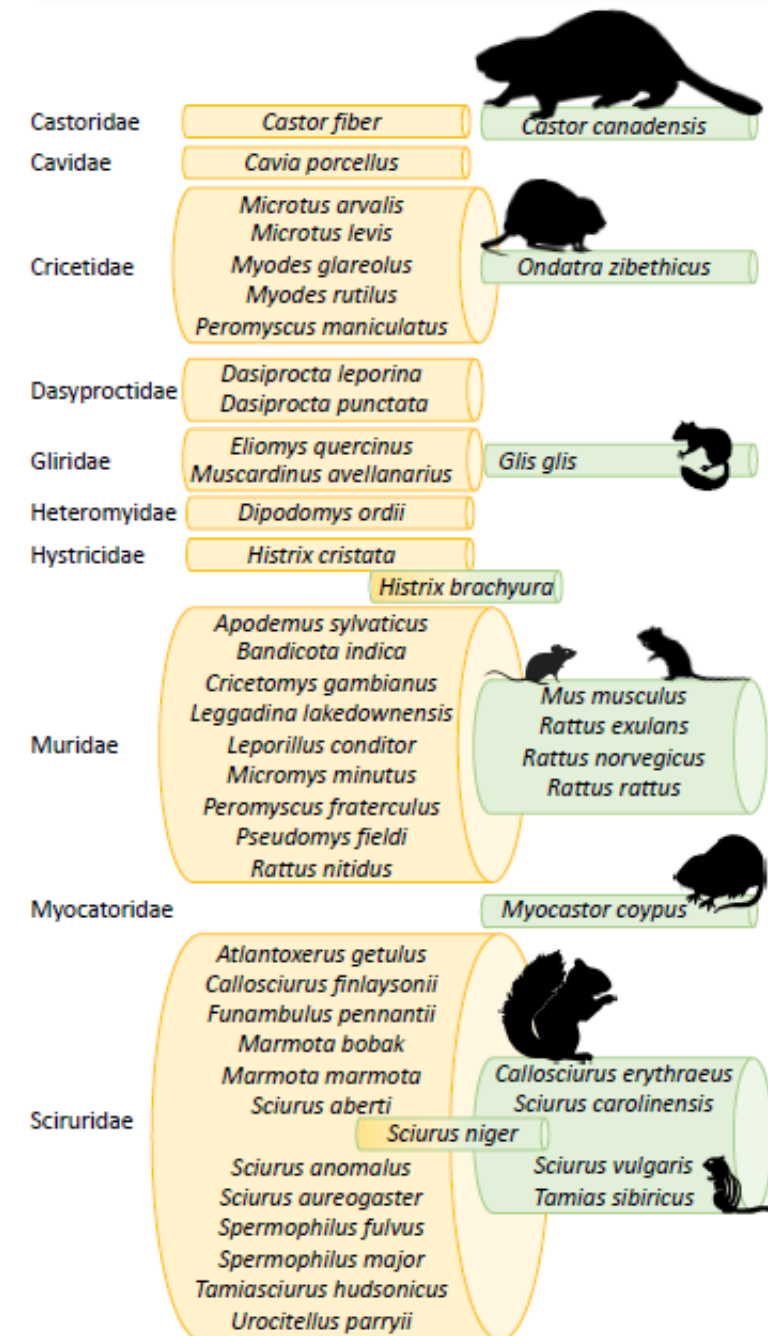


Insight 2: uneven and biased distribution of costs



Only **12** species (out of **48!**)
with recorded costs

Insight 2: uneven and biased distribution of costs



Only **12** species (out of **48!**)
with recorded costs



Ondatra zibethicus (US\$ 378.1 million; n = 18 cost entries)



undefined rats *Rattus spp.* (US\$ 329.3 million; n = 82)



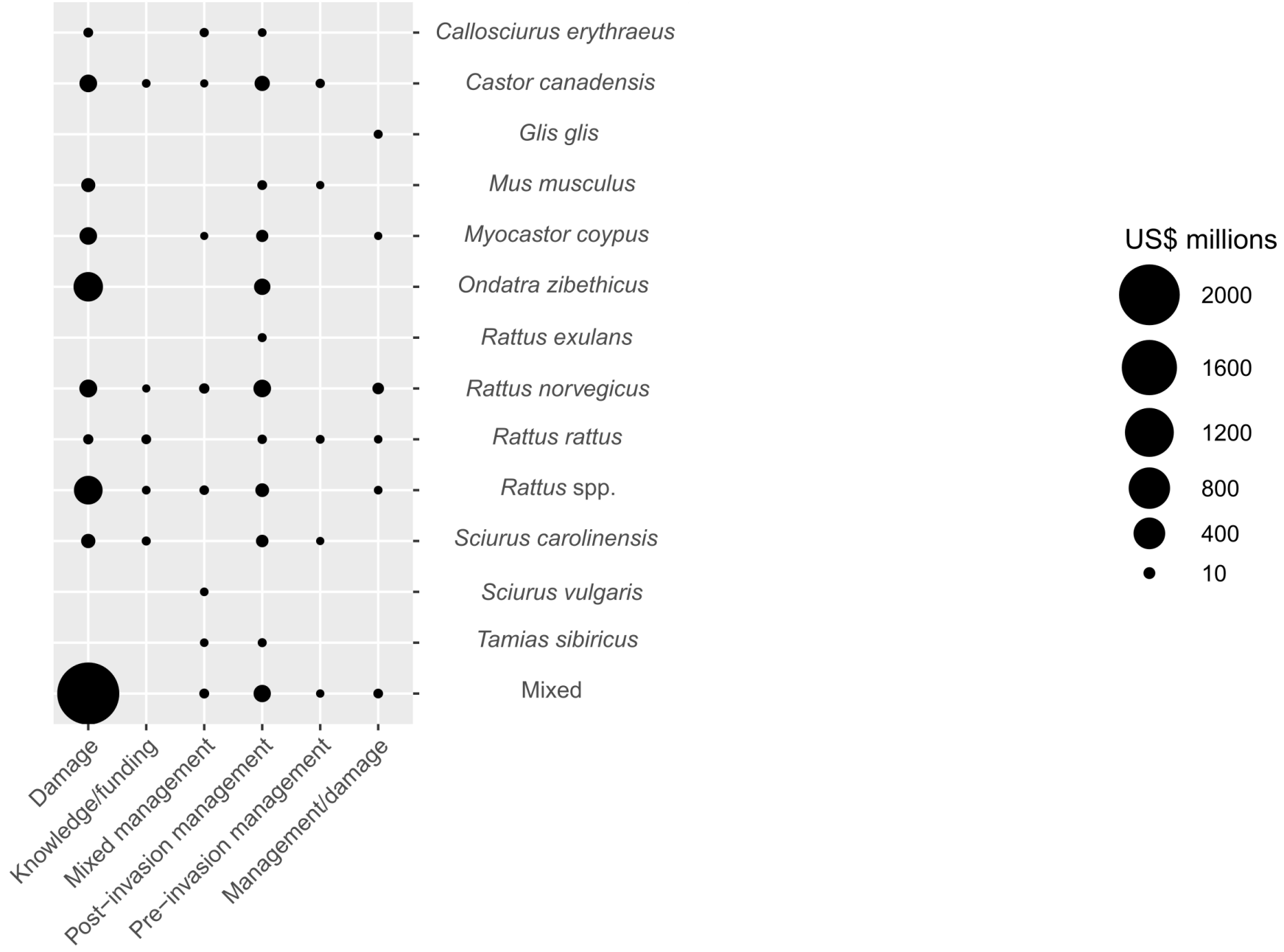
Rattus norvegicus (US\$ 145.8 million; n = 29)



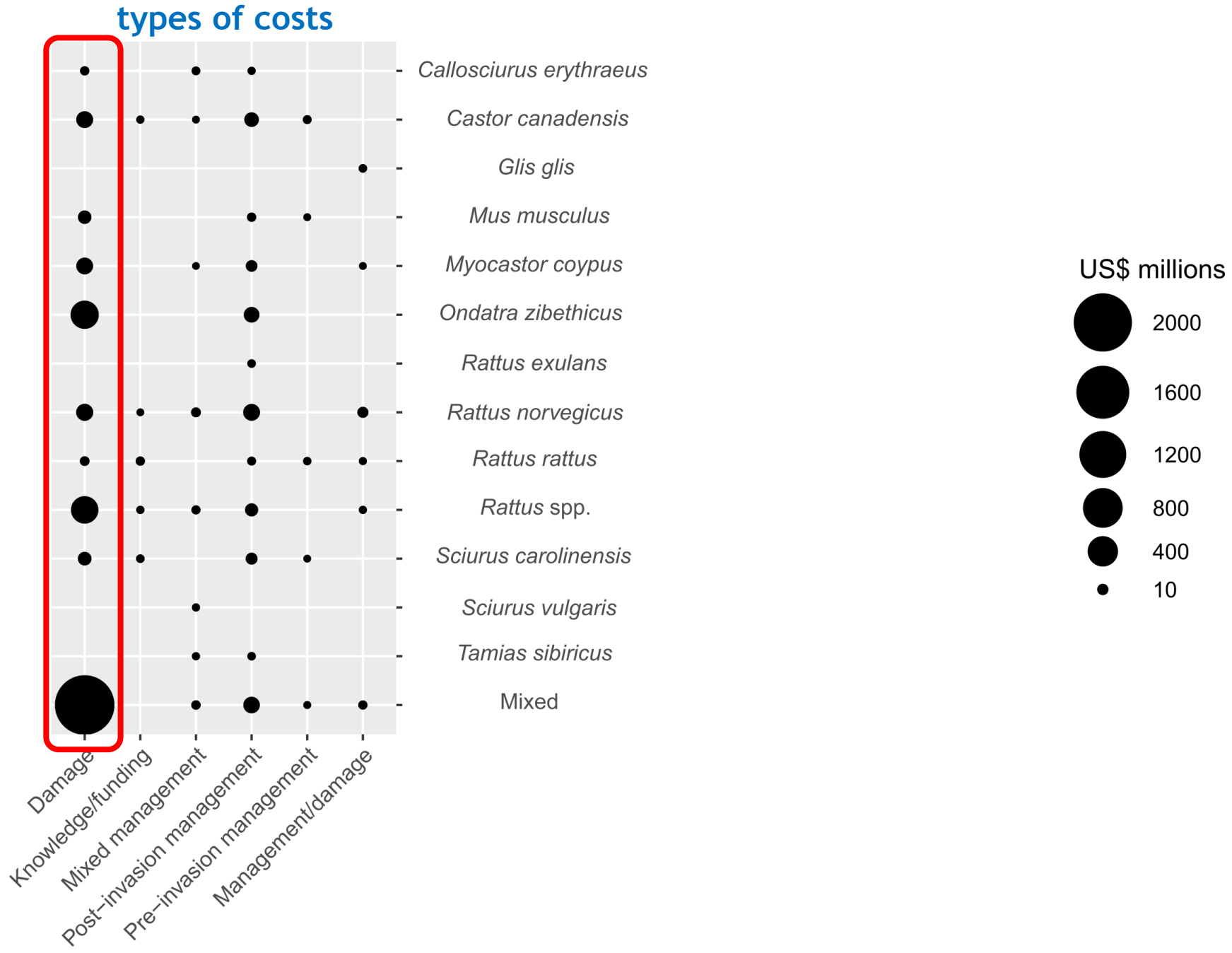
Castor canadensis (US\$ 103.9 million; n = 15).

Insight 2: uneven and biased distribution of costs

types of costs



Insight 2: uneven and biased distribution of costs

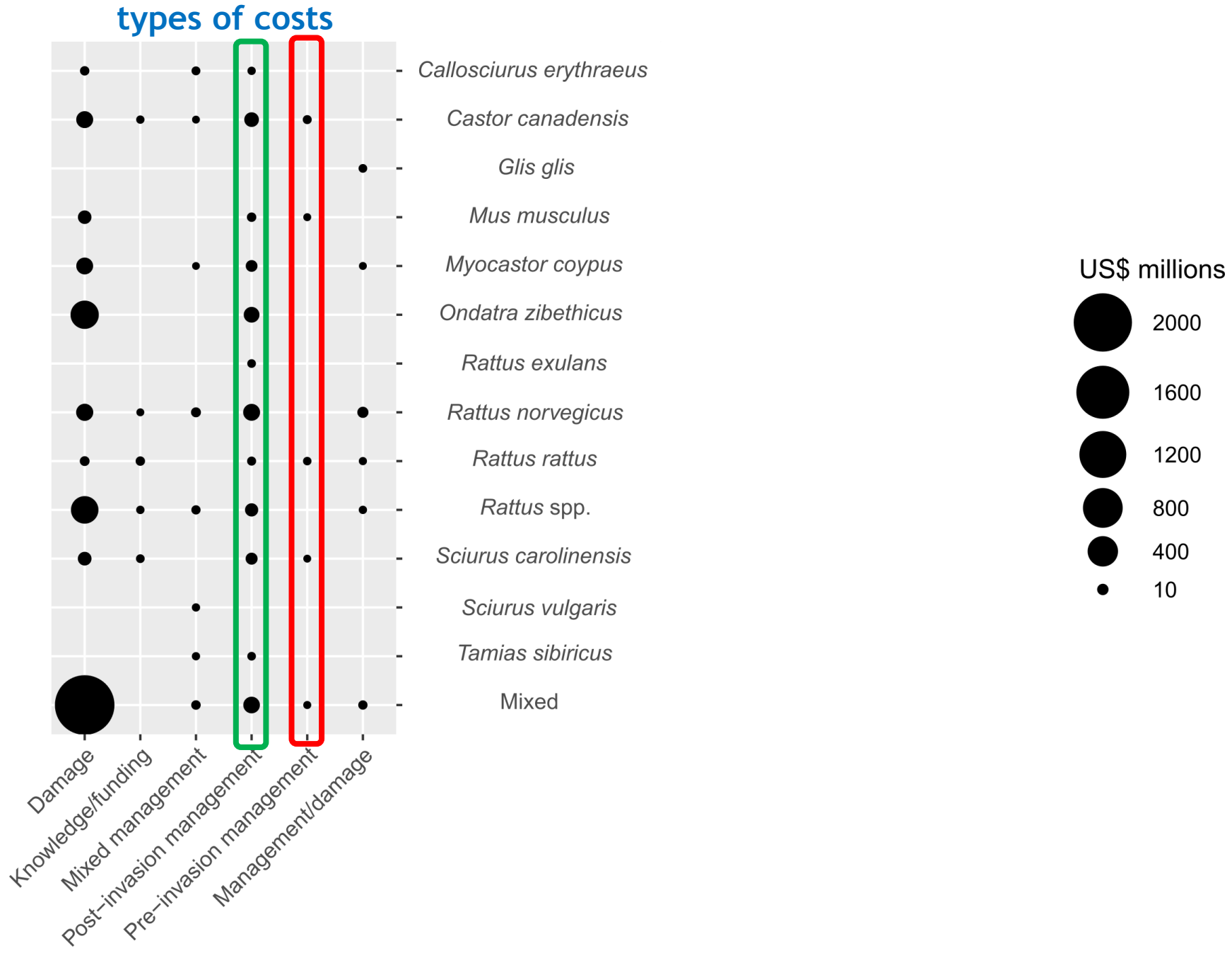


Insight 2: uneven and biased distribution of costs

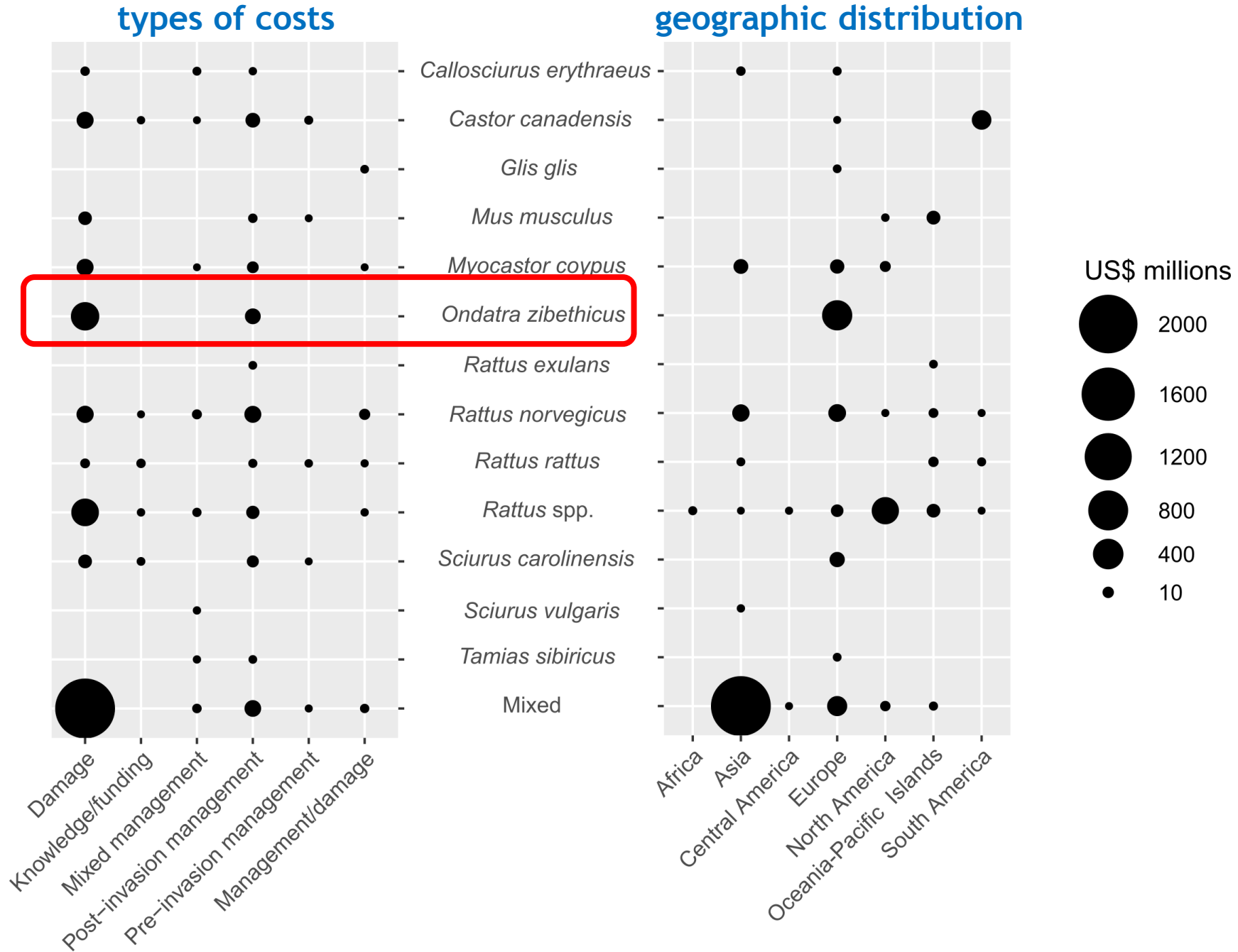
types of costs



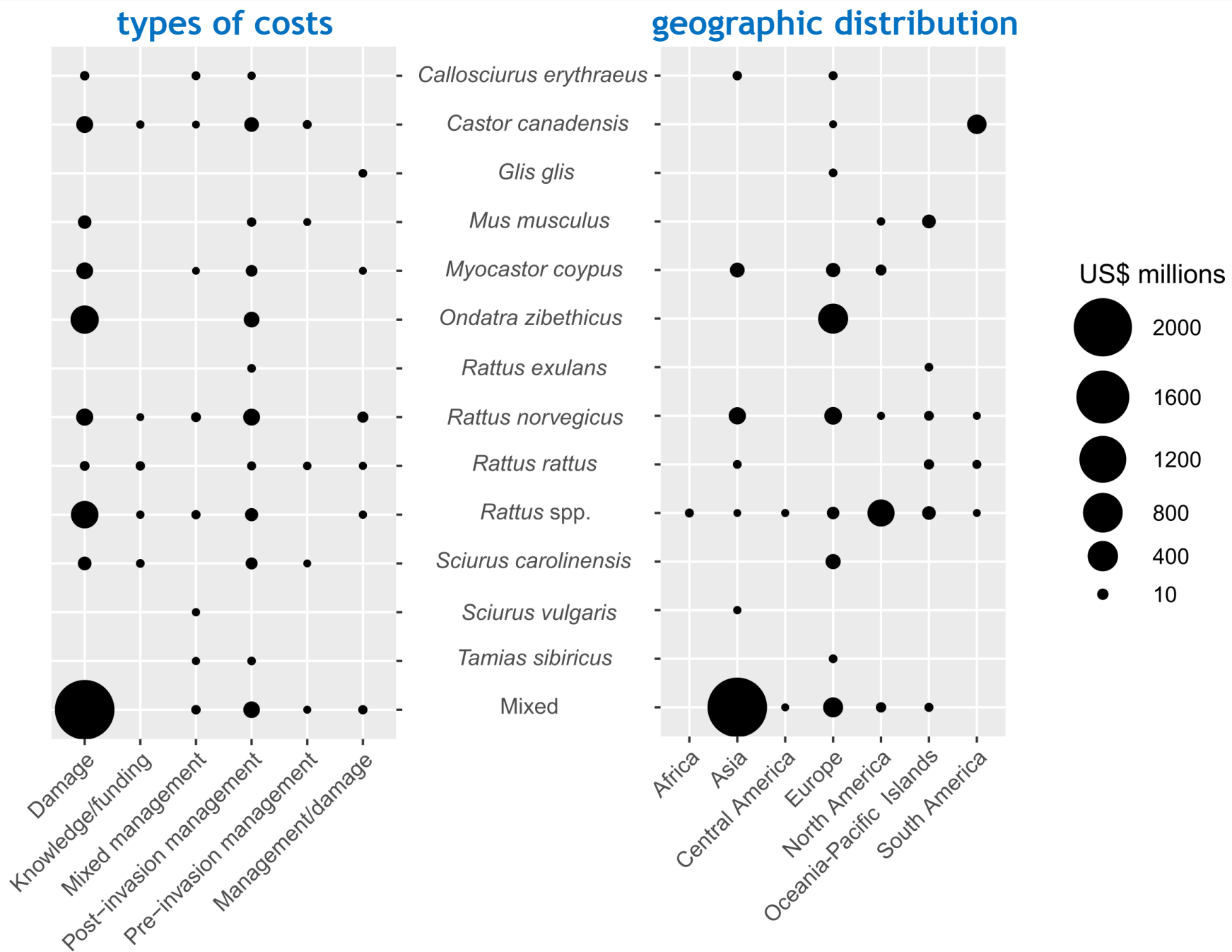
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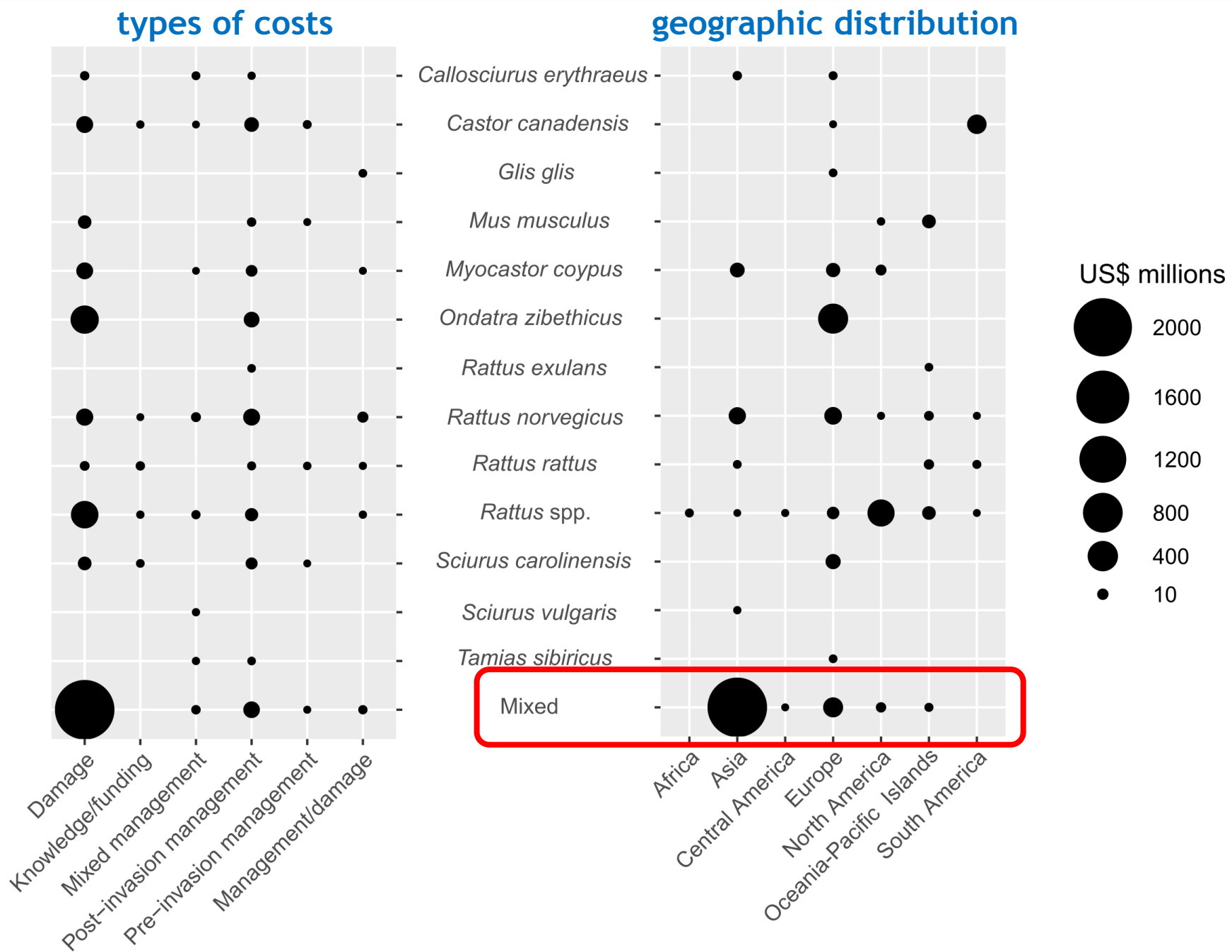
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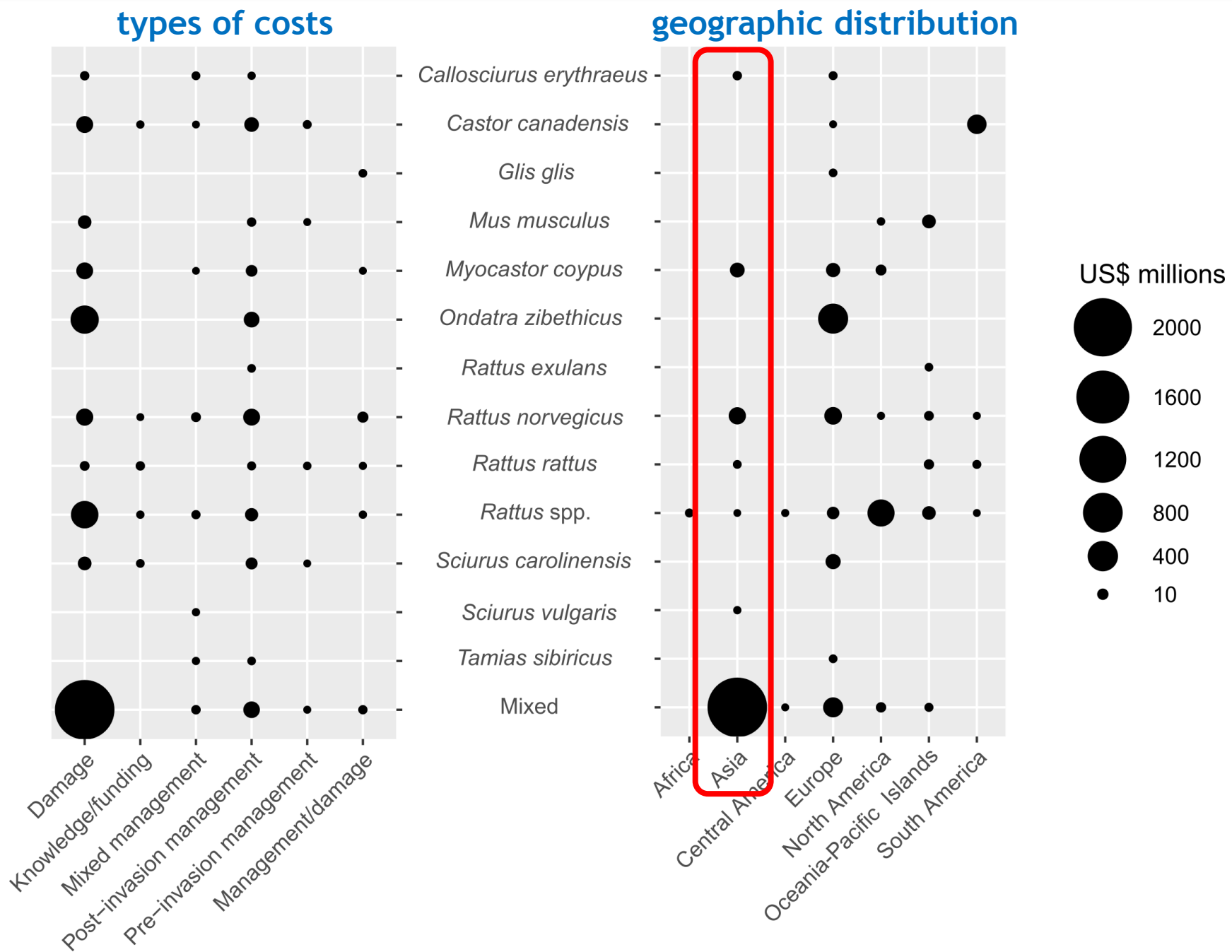
Insight 2: uneven and biased distribution of costs



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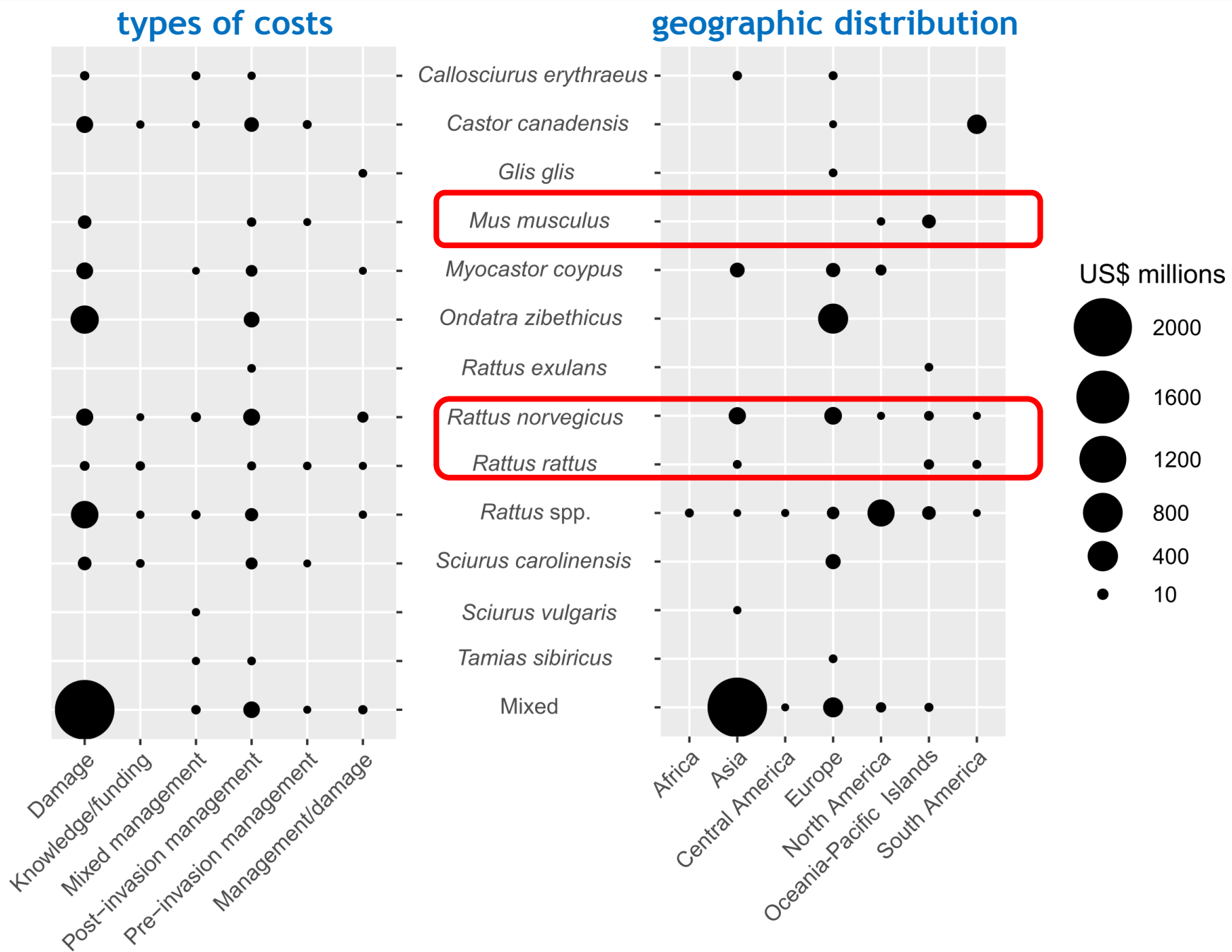
Insight 2: uneven and biased distribution of costs



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Insight 2: uneven and biased distribution of costs

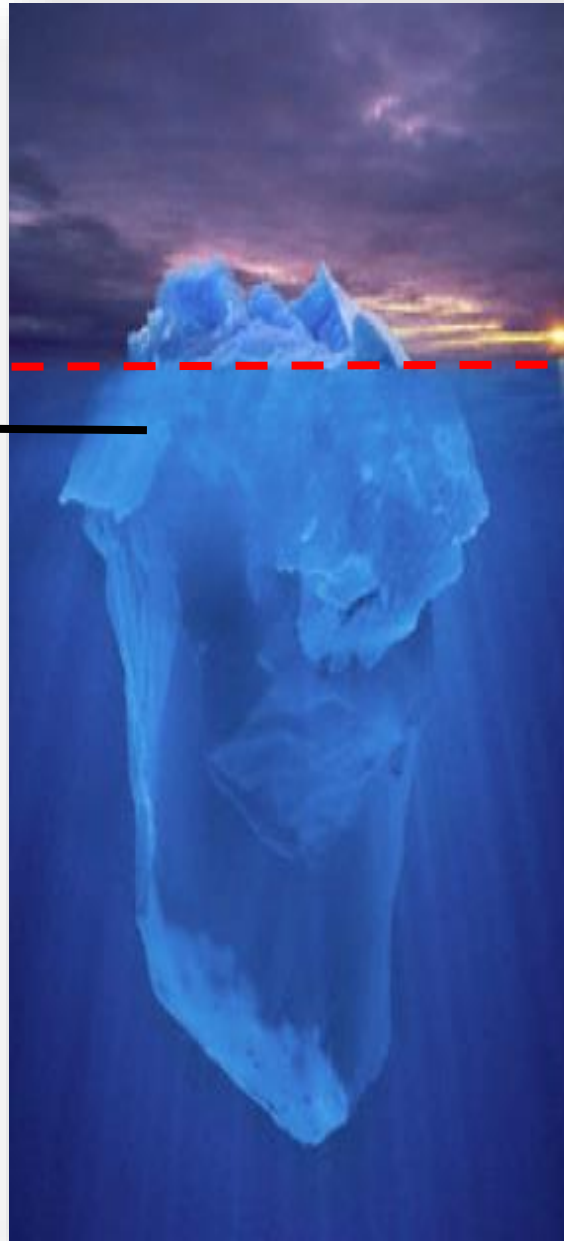


Insight 3: an underestimate burden

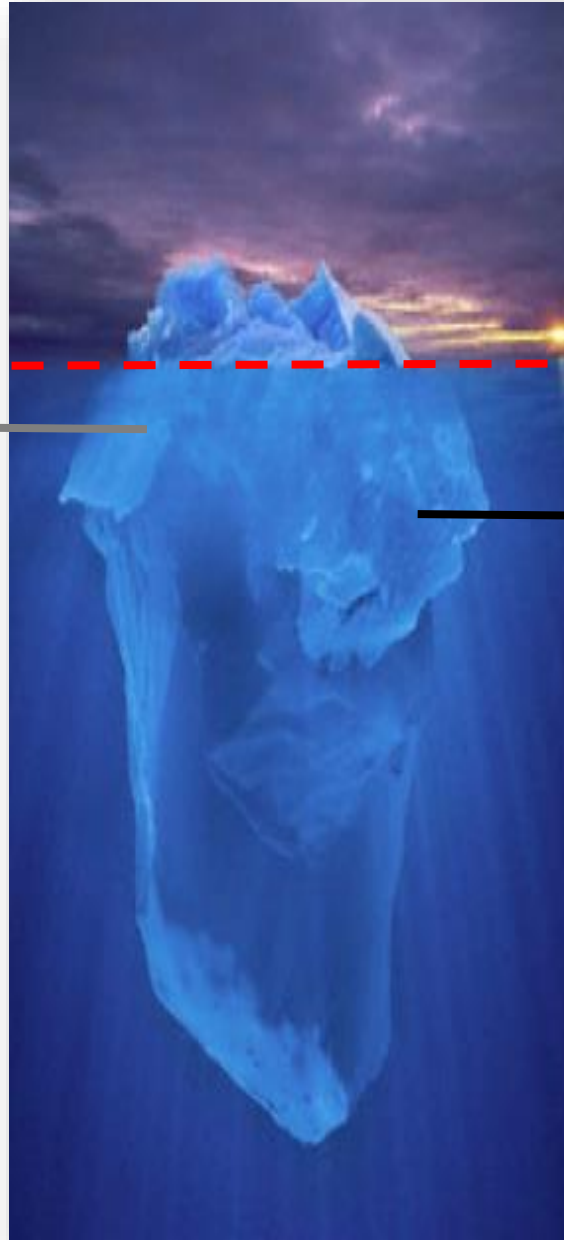


Insight 3: an underestimate burden

**conservative approach
(only the most robust cost data)**



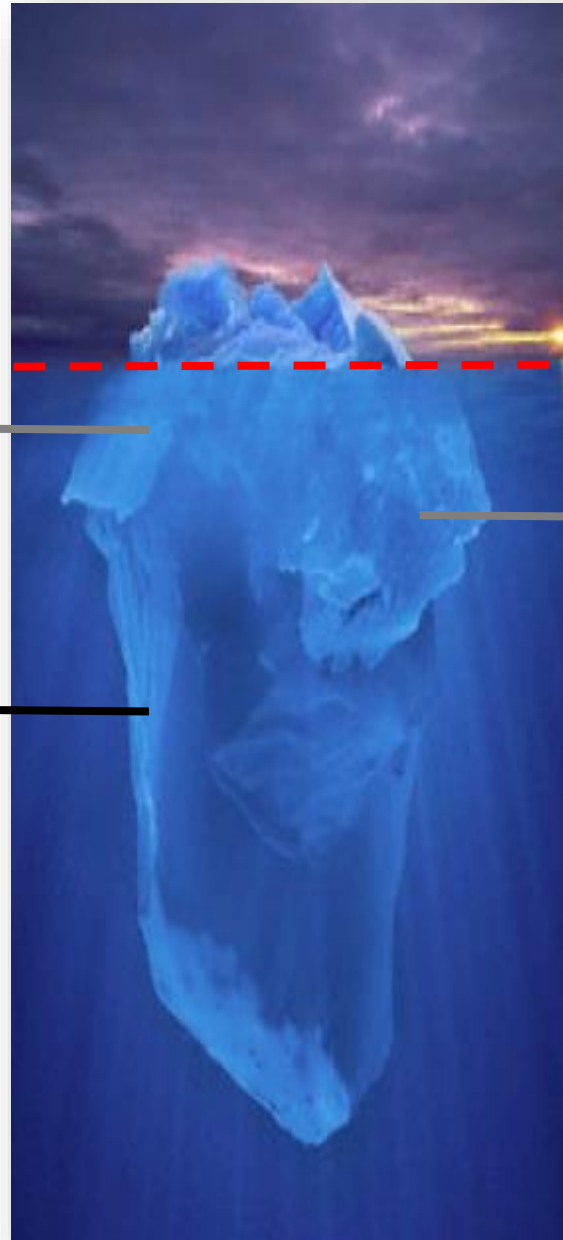
Insight 3: an underestimate burden



conservative approach
(only the most robust cost data)

**hardly accessible cost information
(e.g. grey or unpublished documents)**

Insight 3: an underestimate burden

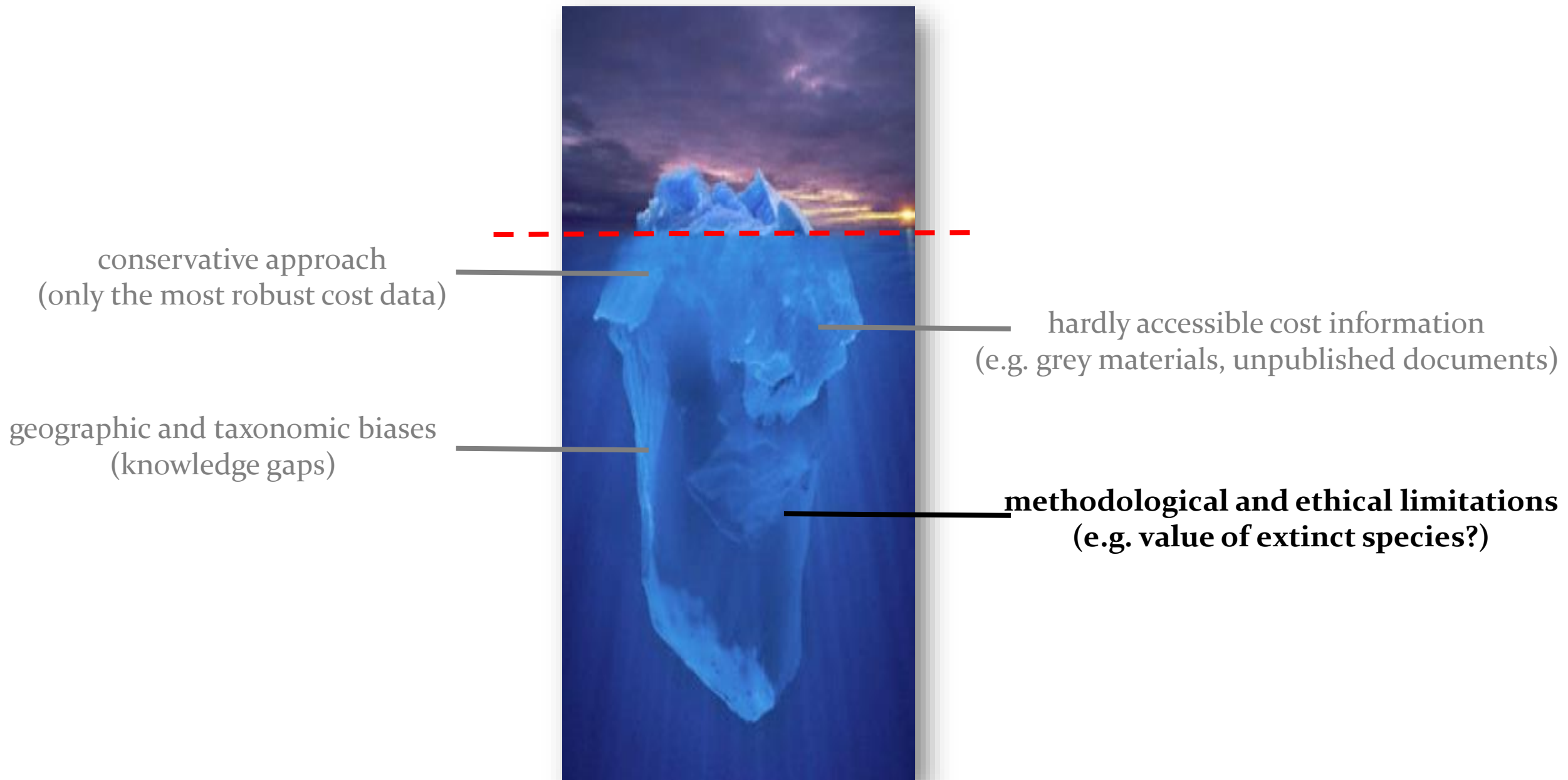


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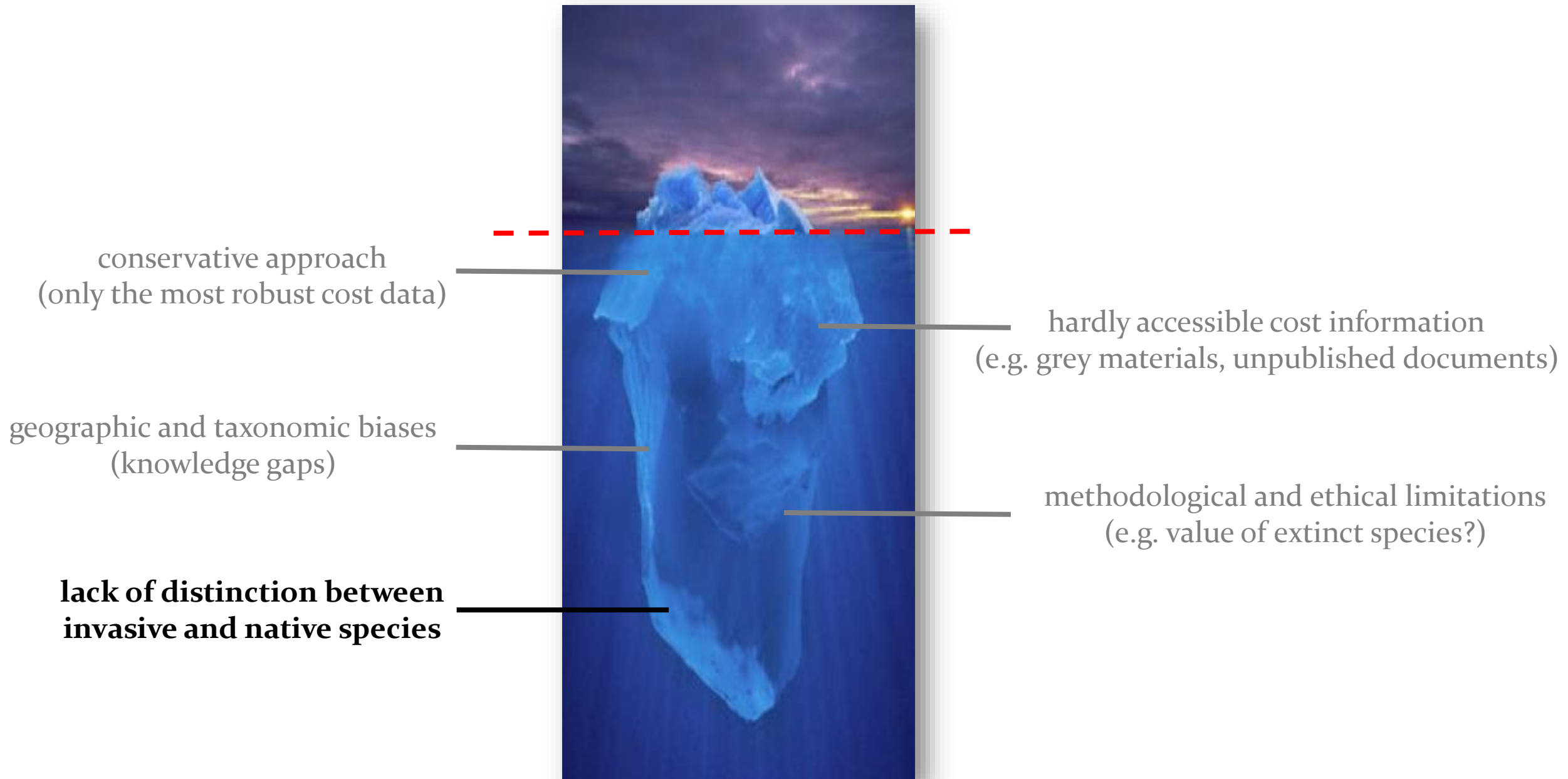
hardly accessible cost information
(e.g. grey materials, unpublished documents)

**geographic and taxonomic biases
(knowledge gaps)**

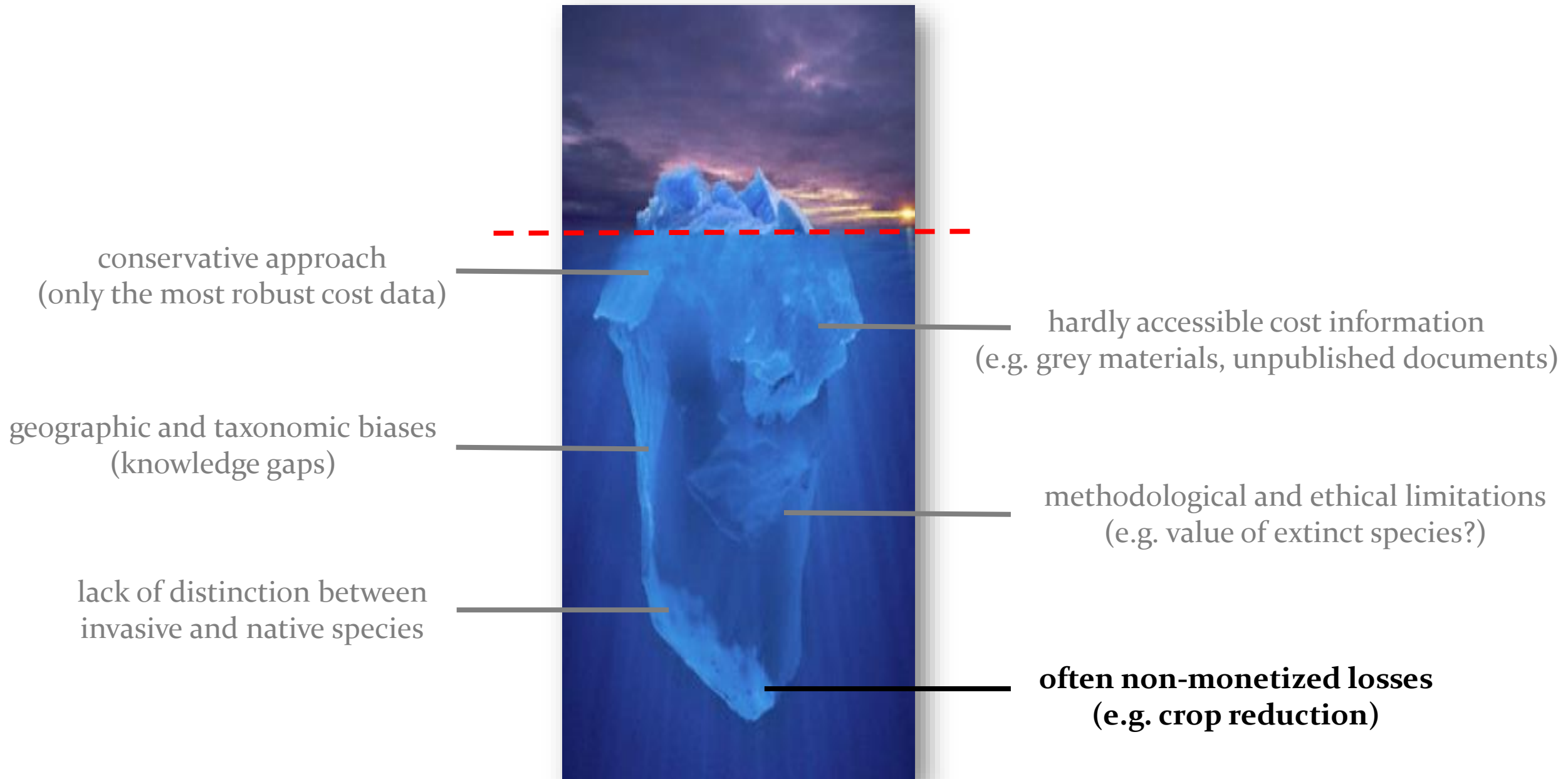
Insight 3: an underestimate burden



Insight 3: an underestimate burden



Insight 3: an underestimate burden





Intensify research efforts towards under-reported regions and taxa

→ incentivizing prevention and control efforts at multiple scales



Increase science-society interactions to improve cost reporting

→ fostering partnerships for coordinated, adapted and sustainable management



Evaluate cost-efficiency of past and current management strategies

→ promoting biosecurity measures and refining local control strategies



Costs are **tremendous, increasing, uneven...** and largely **underestimated**



Springboard for more **standardized, concerted** and **intersectoral** efforts



Costs as an (additional) **alert item** towards the **broader impacts** of invaders



Costs are **tremendous, increasing, uneven...** and largely **underestimated**



Springboard for more **standardized, concerted** and **intersectoral** efforts



Costs as an (additional) **alert item** towards the **broader impacts** of invaders

It's not all about **money**...



...(non-monetizable) **biodiversity** and **sanitary issues** are often the greatest concerns



université **cnrs**
PARIS-SACLAY



Franck Courchamp
(CNRS Orsay, France)

**THANK YOU FOR
YOUR ATTENTION !**

My amazing colleagues

Leroy B. (MNHN Paris)
Gozlan R. (IRD Montpellier)
Roiz D. (IRD Montpellier)
Jourdain F. (IRD Montpellier)
Jaric I. (HBU Prague)
Salles J-M. (CEE Montpellier)
Vaissière A-C. (CNRS Orsay)
Bradshaw C. (CSE Adelaide)
Assailly C. (Univ. Paris-Saclay)
Nuninger L. (Univ. Paris-Saclay)
Angulo E. (Univ. Paris-Saclay)

...
and the wonderful **InvaCost consortium!**

