Identifying major issues of biological invasions on islands for the 21st century

Biological invasions have emerged as a key feature of recent global change, with substantial impacts on the environment and human livelihoods. Recent research demonstrated that numbers and impacts of alien species are rising unabatedly. At the same time, we lack a thorough understanding of potential future trajectories for the decades to come. Islands are of particular interest for global biodiversity and are disproportionately strongly affected by biological invasions. Understanding the drivers and pathways of biological invasions on islands in the 21st century is crucial to understand the dynamics and threats alien species are imposing on island systems in the future.
This survey aims at identifying major drivers, pathways and challenges of biological invasions on islands throughout the 21st century with respect to an increase in ALIEN SPECIES RICHNESS. The survey is dissected into 7 parts related to (i-iii) drivers, (iv) pathways and (v) challenges. In section (vi-vii) we ask you to provide some background information on your person and field of expertise.
The survey takes about 10-15 minutes.

* Erforderlich

Alien Scenarios

Drivers - Environmental Change

Below you find definitions for the different invasion stages

INTRODUCTION
Arrival of individuals to a new environment outside their native range through human agency (intentional or unintentional).

ESTABLISHMENT
Subsequent stage after initial introduction of alien species consisting of a subset of all introduced species, which are able to form viable, self-sustaining population in the wild.

SPREAD
At this stage alien species have overcome dispersal barriers in the new environment and are able to spread beyond the region of introduction (e.g. within an island).

Below you find definitions for each environmental change driver and their relevance in the context of biological invasions.

CLIMATE CHANGE
Climate change is likely to change mean temperatures, change precipitation patterns etc. and

increase the frequency, magnitude and distribution of extreme events, causing disturbances that may create opportunities for alien species. These changes are likely to interact synergistically with biological invasions, although substantial variation exists among taxa and geographic regions.

OCEAN ACIDIFICATION
Increasing CO2-levels will increase ocean acidification, thereby affecting water chemistry and native biota

EUTROPHICATION & POLLUTION
Anthropogenic input of pollutants and nutrients via fertilization, run off and atmospheric deposition affect many ecosystems, often promoting opportunistic species.

BIODIVERSITY LOSS & DEGRADATION
Downgrading and loss of (near-)natural ecosystems, loss of species and functional groups, and positive feedbacks (facilitation, invasional meltdown) may have distinct implications on species compositions.

1. **The following drivers will significantly increase alien species INTRODUCTIONS to islands in the 21st century** *
   See category definitions above
   Markieren Sie nur ein Oval pro Zeile.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Climate Change					
Ocean Acidification					
Eutrophication & Pollution					
Biodiversity Loss & Degradation					

2. **The following drivers will significantly increase alien species ESTABLISHMENT to islands in the 21st century** *
   See category definitions above
   Markieren Sie nur ein Oval pro Zeile.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Climate Change					
Ocean Acidification					
Eutrophication & Pollution					
Biodiversity Loss & Degradation					

3. **The following drivers will significantly increase alien species SPREAD to islands in the 21st century** *
   See category definitions above
   Markieren Sie nur ein Oval pro Zeile.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Climate Change					
Ocean Acidification					
Eutrophication & Pollution					
Biodiversity Loss & Degradation					

Drivers - Socio-Economic Activity

Below you find definitions for the different invasion stages

INTRODUCTION

Arrival of individuals to a new environment outside their native range through human agency (intentional or unintentional).

ESTABLISHMENT
Subsequent stage after initial introduction of alien species consisting of a subset of all introduced species, which are able to form viable, self-sustaining population in the wild.

SPREAD
At this stage alien species have overcome dispersal barriers in the new environment and are able to spread beyond the region of introduction (e.g. within an island).

Below you find definitions for types of socio-economic activities and their relevance in the context of biological invasions.

TRADE & TRANSPORT
Key features of trade and transport such as the type of goods that are transported, the volumes that are traded, the means and velocity of transport, and the routes of transport are likely to change in the future. Emerging modes of trading (e.g. via internet) that are more difficult to regulate may become more relevant for biological invasions. Trade includes also specific high-risk pathways such as pet and horticultural trade, wood products, ballast water and biofouling, and the emergence of new trade routes that are becoming accessible due to climate change (Arctic shipping routes) or economic interests (Suez Canal and Panama Canal extension, Nicaragua Canal).

LAND-USE & LAND-COVER CHANGE
Demand for food supplies, clothing, housing, etc. and for new materials (e.g. for bioenergy production) will likely increase in the 21st century. The resulting changes in land-use (incl. the intentional use of IAS) and land-use intensity may cause losses of ecosystems, degradation of used ecosystems, increase fragmentation and disturbance of ecosystems, and alter resource dynamics.

SOCIO-ECONOMIC CHANGE
The level of socio-economic activities (as measured by per capita GDP or similar metrics) is correlated with a wide range of changes of the environment (e.g. resource and energy uses, human mobility, land use) that may be relevant for determining the success of biological invasions.

HUMAN POPULATION SIZE & MIGRATION
Changes in the size and distribution of human populations and migration of humans may influence biological invasions via a range of correlated relevant impacts.

4. **The following drivers will significantly increase alien species INTRODUCTIONS to islands in the 21st century** *
   See category definitions above
   Markieren Sie nur ein Oval pro Zeile.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Trade & Transport					
Land-Use & Land-Use Change					
Socio-Economic Change					
Human Population Size & Migration					

5. **The following drivers will significantly increase alien species ESTABLISHMENT to islands in the 21st century** *

See category definitions above
Markieren Sie nur ein Oval pro Zeile.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Trade & Transport					
Land-Use & Land-Use Change					
Socio-Economic Change					
Human Population Size & Migration					

6. **The following drivers will significantly increase alien species SPREAD to islands in the 21st century** *

See category definitions above
Markieren Sie nur ein Oval pro Zeile.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Trade & Transport					
Land-Use & Land-Use Change					
Socio-Economic Change					
Human Population Size & Migration					

Drivers - Society & Technology

Below you find definitions for the different invasion stages

INTRODUCTION
Arrival of individuals to a new environment outside their native range through human agency (intentional or unintentional).

ESTABLISHMENT
Subsequent stage after initial introduction of alien species consisting of a subset of all introduced species, which are able to form viable, self-sustaining population in the wild.

SPREAD
At this stage alien species have overcome dispersal barriers in the new environment and are able to spread beyond the region of introduction (e.g. within an island).

Below you find definitions of society & technology drivers and their relevance in the context of biological invasions.

SOCIETAL AWARENESS & VALUES
The awareness and values of the citizens, stakeholders, business, NGOs and politicians towards biological invasions is important for establishing and implementing invasive alien species (IAS) policies and management. Includes also the views of people who are opposing actions on IAS on ethical grounds (e.g. animal-right movements) or because they consider it unwarranted.

RECREATION & TOURISM
(Outdoor) recreation (incl. gardening, hunting, fishing, hiking) and tourism may impact on biological invasions in a range of different ways.

COMMUNICATION & OUTREACH
The way, tone and intensity of communication on biological invasions with(in) the wider public and decision makers may influence the public perception of and action on invasive alien species (IAS).

TECHNOLOGY & INNOVATION
The general level of innovation, and the extent to which new technologies are introduced,

accepted and become widely applied may have substantial implications for biological invasions (e.g. biocontrol safety).

COOPERATION, LEGISLATION & AGREEMENTS
The level of political and institutional cooperation (within and between nations) and the ensuing legislation and agreements on biosecurity and biological invasions, their relationship with other relevant topics (e.g. trade agreements), and the level of implementing these policies.

IAS SCIENCE
Scientific research on invasive alien species (IAS) may improve the understanding of the invasion process of IAS, improve management techniques, increase data availability on alien species etc. Further, research priorities may be more or less relevant for IAS management and policy.

IAS MANAGEMENT
The comprehensiveness and level of implementation of invasive alien species (IAS) management, and the available resources and institutional capacities may be important for the level of biological invasions.

7. **The following drivers will significantly increase alien species INTRODUCTIONS to islands in the 21st century** *
   See category definitions above
   Markieren Sie nur ein Oval pro Zeile.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Societal Awareness, Values & Lifestyle					
Recreation & Tourism					
Communication & Outreach					
Technology & Innovation					
Cooperation, Legislation & Agreements					
IAS Science					
IAS Management					

8. **The following drivers will significantly increase alien species ESTABLISHMENT to islands in the 21st century** *
   See category definitions above
   Markieren Sie nur ein Oval pro Zeile.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Societal Awareness, Values & Lifestyle					
Recreation & Tourism					
Communication & Outreach					
Technology & Innovation					
Cooperation, Legislation & Agreements					
IAS Science					
IAS Management					

9. **The following drivers will significantly increase alien species SPREAD to islands in the 21st century** *

See category definitions above
Markieren Sie nur ein Oval pro Zeile.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Societal Awareness, Values & Lifestyle					
Recreation & Tourism					
Communication & Outreach					
Technology & Innovation					
Cooperation, Legislation & Agreements					
IAS Science					
IAS Management					

Pathways

Definition of the pathway classes (following Hulme et al. 2008 and the Convention on Biological Diversity 2014)

RELEASE IN NATURE = Intentional introduction as a commodity for release
(e.g. Biocontrol agents, game animals, plants for erosion control)

ESCAPE FROM CONFINEMENT = Intentional introduction as a commodity but escapes unintentionally
(e.g. Feral crops and livestock, pets, garden plants, live bait)

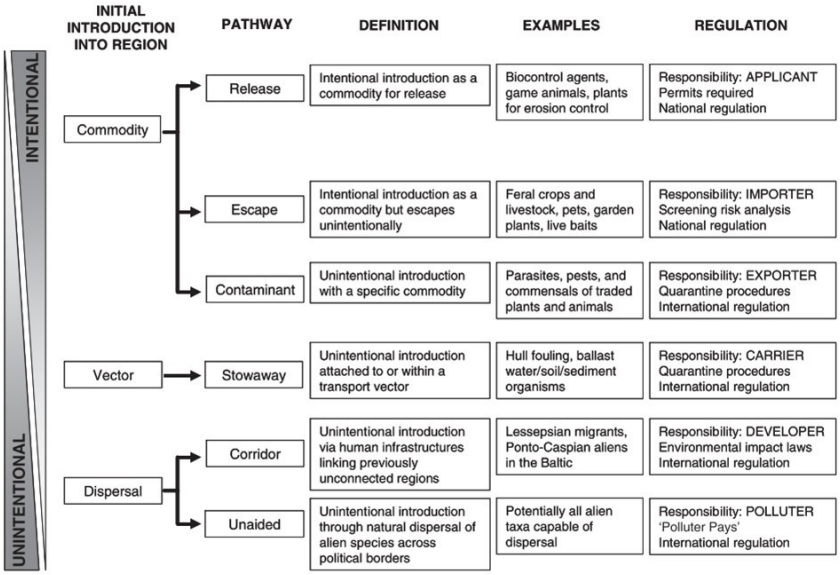
CONTAMINANT = Unintentional introduction with a specific commodity
(e.g. Parasites, pests, commensals of traded plants and animals)

STOWAWAY = Unintentional introduction attached to or within a transport vector
(e.g. Hull fouling, ballast water/soil/sediment organisms)

CORRIDOR = Unintentional introduction linking previously unconnected regions
(e.g. Lessepsian migrants, Ponto-Caspian aliens in the Baltic)

UNAIDED = Unintentional introduction through natural dispersal of alien species across political borders
(e.g. Potentially all alien taxa capable of dispersal)

Sources:
Hulme et al. (2008) Grasping at the routes of biological invasions: A framework for integrating pathways into policy. Journal of Applied Ecology. 45, 403-414.
Convention on Biological Diversity (2014) Pathways of Introduction of Invasive Species, their Prioritization and Management. UNEP/CBD/SBSTTA/18/9/Add.1



Hulme et al. (2008) Journal of Applied Ecology, 45

10. **The following pathways will significantly increase alien species INTRODUCTIONS to islands in the 21st century** *

See category definitions above

Markieren Sie nur ein Oval pro Zeile.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Release					
Escape					
Contaminant					
Stowaway					
Corridor					
Unaided					

11. **The following pathways will significantly increase alien species SPREAD to islands in the 21st century** *

See category definitions above

Markieren Sie nur ein Oval pro Zeile.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Release					
Escape					
Contaminant					
Stowaway					
Corridor					
Unaided					

Study systems

12. **Indicate how strongly different island types will be affected by an increase in alien species richness in the 21st century?** *

Markieren Sie nur ein Oval pro Zeile.

	Low	Medium	Strong
Oceanic islands			
Continental islands			
Atolls			

13. **Indicate how strongly different island systems will be affected by an increase in alien species richness in the 21st century?** *

Markieren Sie nur ein Oval pro Zeile.

	Low	Medium	Strong
Marine			
Terrestrial			
Freshwater			

14. **Indicate how strongly different island habitats will be affected by an increase in alien species richness in the 21st century?** *

Markieren Sie nur ein Oval pro Zeile.

	Low	Medium	Strong
Marine			
Coastal (terrestrial)			
Wetlands			
Natural Grasslands			
Dry Forest			
Wet/Cloud Forest			
Shrubland			
Settlements			
Agricultural Land			
Mountain & Alpine			
Deserts & Semi-Deserts			

Personal expertise

Definitions for the socio-economic situation of the study area:

DEVELOPED COUNTRIES
Socio-economically highly developed countries (i.e. OECD countries)

EMERGING AND TRANSITION COUNTRIES
Socio-economically rapidly developing emerging economies (e.g. China, India, Vietnam, Brazil, Chile, Argentina, South Africa), economies in transition (e.g. former communist countries such as Russia, Poland, Ukraine), and middle income countries (e.g. many countries of North Africa and Latin America).

DEVELOPING COUNTRIES
Socio-economically poor countries with mostly slow rates of economic growth (many sub-Saharan African countries, several countries in SE Asia and Latin America)

15. **Please indicate the socio-economic situation of your study area** *

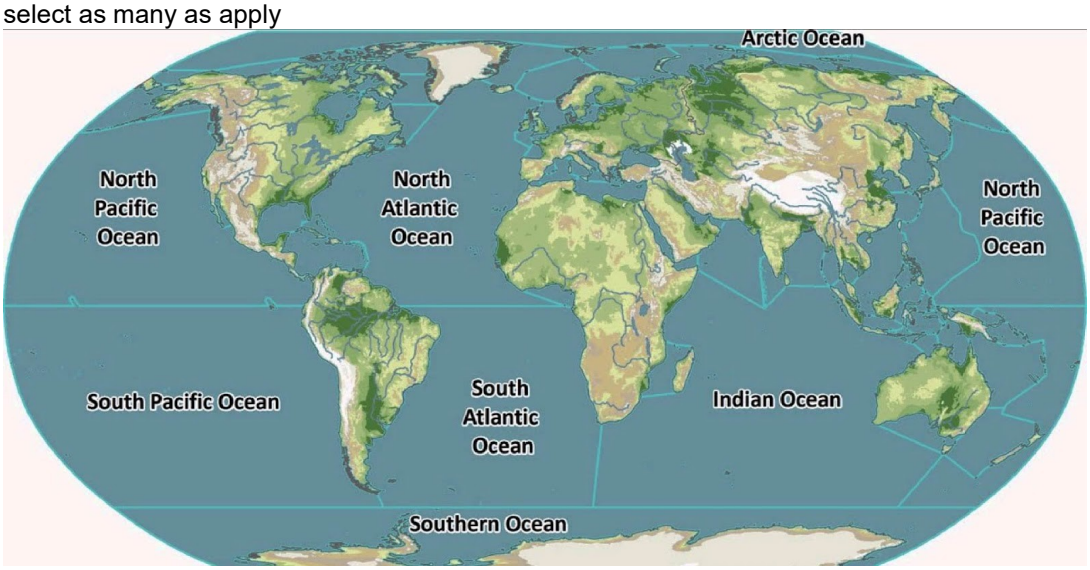
select as many as apply
Wählen Sie alle zutreffenden Antworten aus.

- [ ] Developed countries
- [ ] Emerging and transition countries
- [ ] Developing countries

16. **Please indicate the island type you are mainly working on** *
select as many as apply
Wählen Sie alle zutreffenden Antworten aus.

- [ ] Oceanic islands
- [ ] Continental islands
- [ ] Shelf islands
- [ ] Atolls
- [ ] Sonstiges: _____

17. **Please indicate the geographic region your study islands is situated in** *
select as many as apply



Wählen Sie alle zutreffenden Antworten aus.

- [ ] Arctic Ocean
- [ ] North Atlantic Ocean
- [ ] South Atlantic Ocean
- [ ] Indian Ocean
- [ ] North Pacific Ocean
- [ ] South Pacific Ocean
- [ ] Southern Ocean
- [ ] Global

18. **Please indicate your level of expertise for the following taxonomic groups** *
Markieren Sie nur ein Oval pro Zeile.

	No	Low	Medium	High
Vertebrates (terrestrial)				
Vertebrates (marine)				
Vascular Plants (terrestrial)				
Vascular Plants (marine)				
Invertebrates (terrestrial)				
Invertebrates (marine)				
Microorganisms (terrestrial)				
Microorganisms (marine				

Personal information

Please provide some personal information on yourself and your scientific background

19. **Personal information - Gender** *
Markieren Sie nur ein Oval pro Zeile.

	Male	Female	Other	Prefer not to say
Gender				

20. **Personal information - Age** *
Markieren Sie nur ein Oval pro Zeile.

	< 25	26 - 35	36 - 45	46 - 55	56 - 65	> 65	Prefer not to say
Age							

21. **Please name the country of your home institution** *

22. **Please indicate your professional background** *
Wählen Sie alle zutreffenden Antworten aus.

- [ ] Basic science
- [ ] Applied science
- [ ] Conservation management
- [ ] Environmental policy
- [ ] Other stakeholder
- [ ] Interested citizen
- [ ] Sonstiges: _____

General comments

Please add any comments and suggestions here.

23. **Add any comments or suggestions you have regarding the survey**