WHAT MAKES AN ALIEN SPECIES SUCCESSFUL?

Alejandro Ordonez

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Section of Ecoinformatics and Biodiversity

Center for Biodiversity Dynamics in a Changing World (BIOCHANGE)

Center for Sustainable Landscapes under Global Change (SustainScapes)

WHO AM I

- I am a **plant macroecologist.**
- Interested in measuring the **exposure** of biodiversity **to** different drivers of **change**
  - Invasive species.
  - Climate/land-cover change.

- Now also working at the **intersection of ecology and policy**
  - Coordinating author of the upcoming IPBES assessment in IAS

BIOCHANGE
CENTER FOR BIODIVERSITY DYNAMICS IN A CHANGING WORLD

ipbes
Science and Policy for People and Nature

SustainScapes
Center for Sustainable Landscapes under Global Change

What makes an alien species successful?

ALEJANDRO ORDONEZ GLORIA
ASSISTANT PROFESSOR

IT ALL DEPENDS....

https://www.itsligo.ie/invasive-alien-species/

- How **many** individuals arrive...
- The **environmental** suitability of where they arrive...
- The **ecological** suitability of where they arrive...
- The **presence of aliens**...
- The **diversity** of the incoming community...
- The **presence** of related natives...
- The **absence** of predator/parasites...
- The **novelty** of the introduced species...

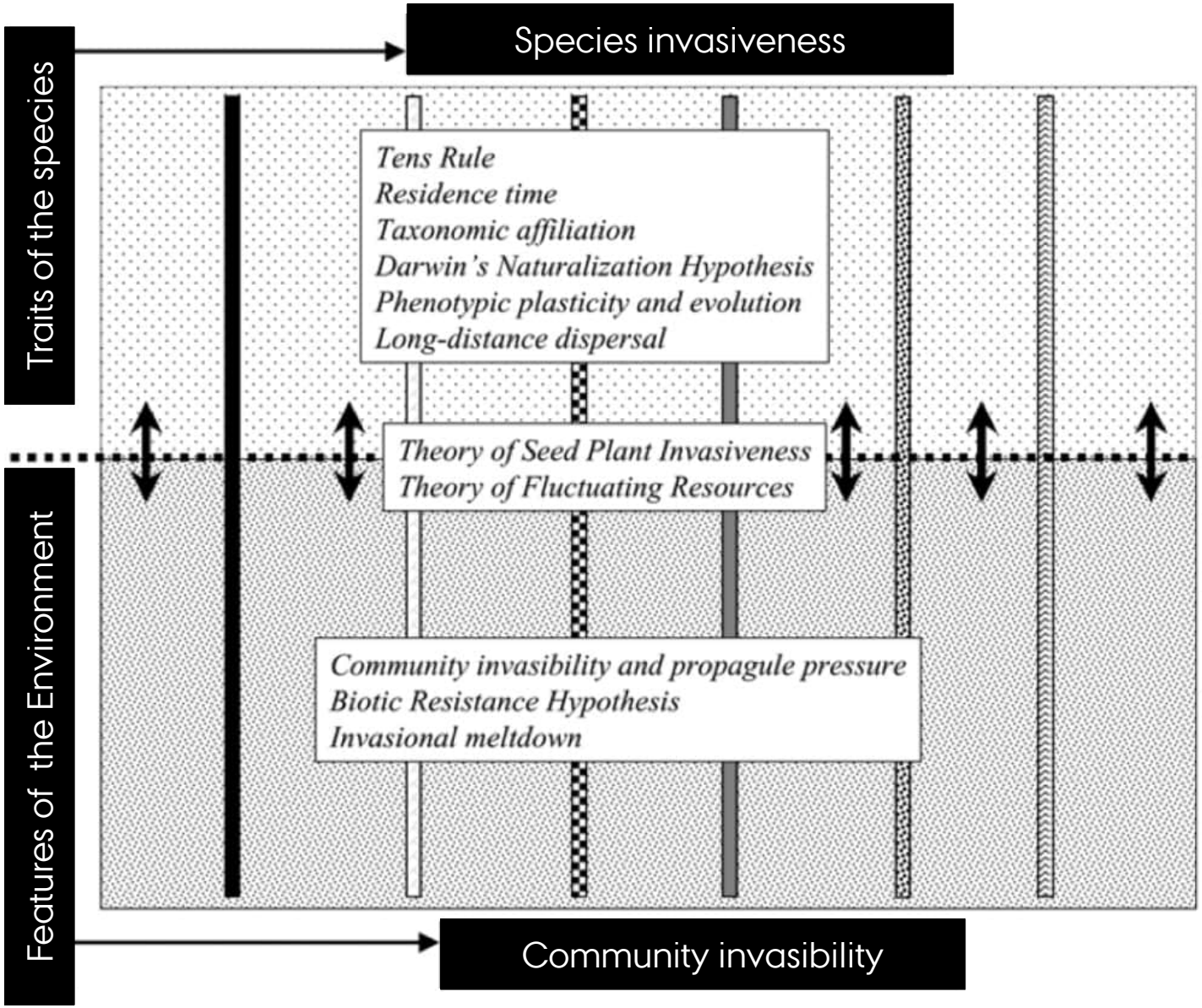

Figure:
Richardson & Pysek 2006 (Prog Phys. Geo)

MEASURING NICHES

A N-dimensional hyper volume

Hutchinson 1959 - Am .Nat.

Two species can't coexist if they share the same niche

Hutchinson, 1959 - Am .Nat.
MacArthur & Levins 1967 - Am. Nat.

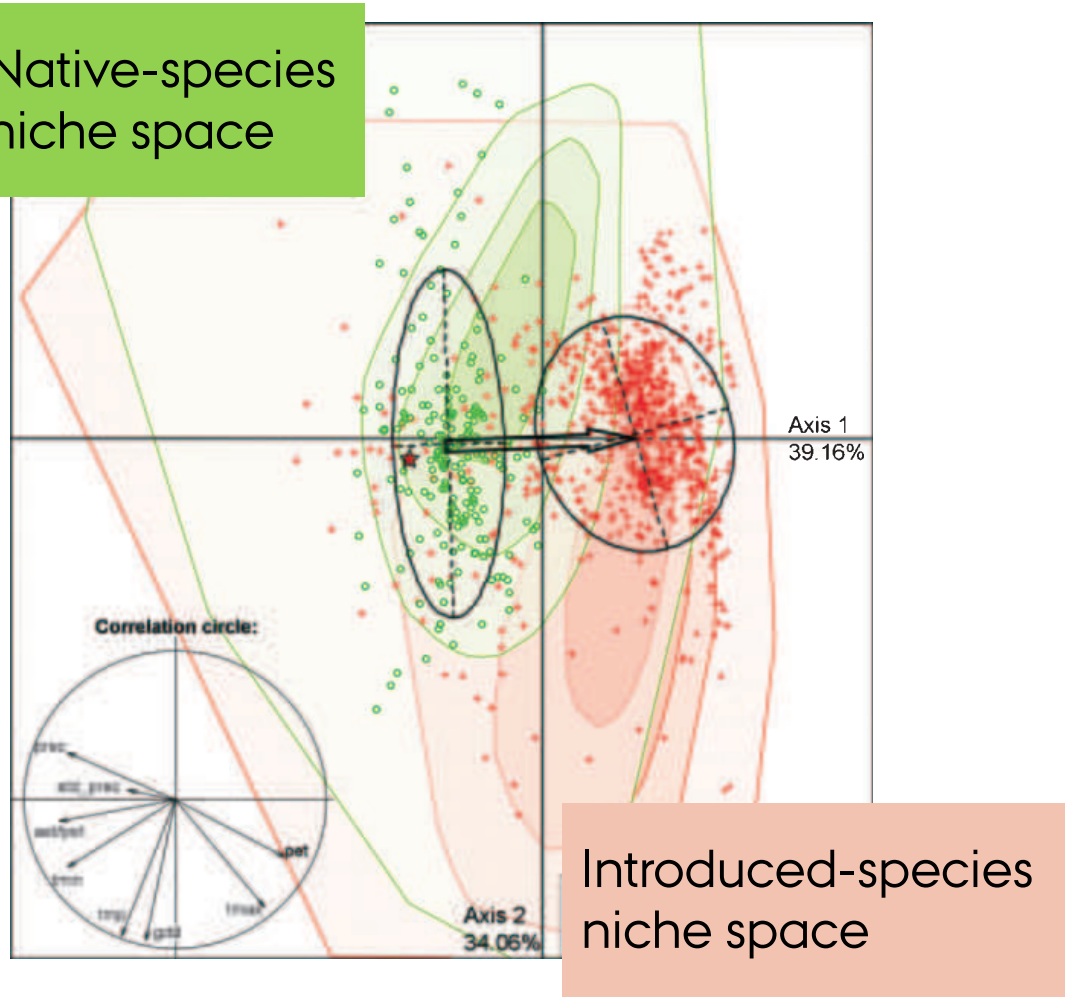

Figure fro
Broennimann 2007 (Ecol Lett)

TODAY'S TALK

- **Leveraging functional ecology** – trait novelty/divergence in the context of ecological strategies.
- **Climate change in the context of functional ecology** – the lasting imprints of climate change on functional diversity and its implications.
- **Where do we go from here?** – a look into the IPBES work.

TODAY'S TALK

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COMMUNITY ASSEMBLY

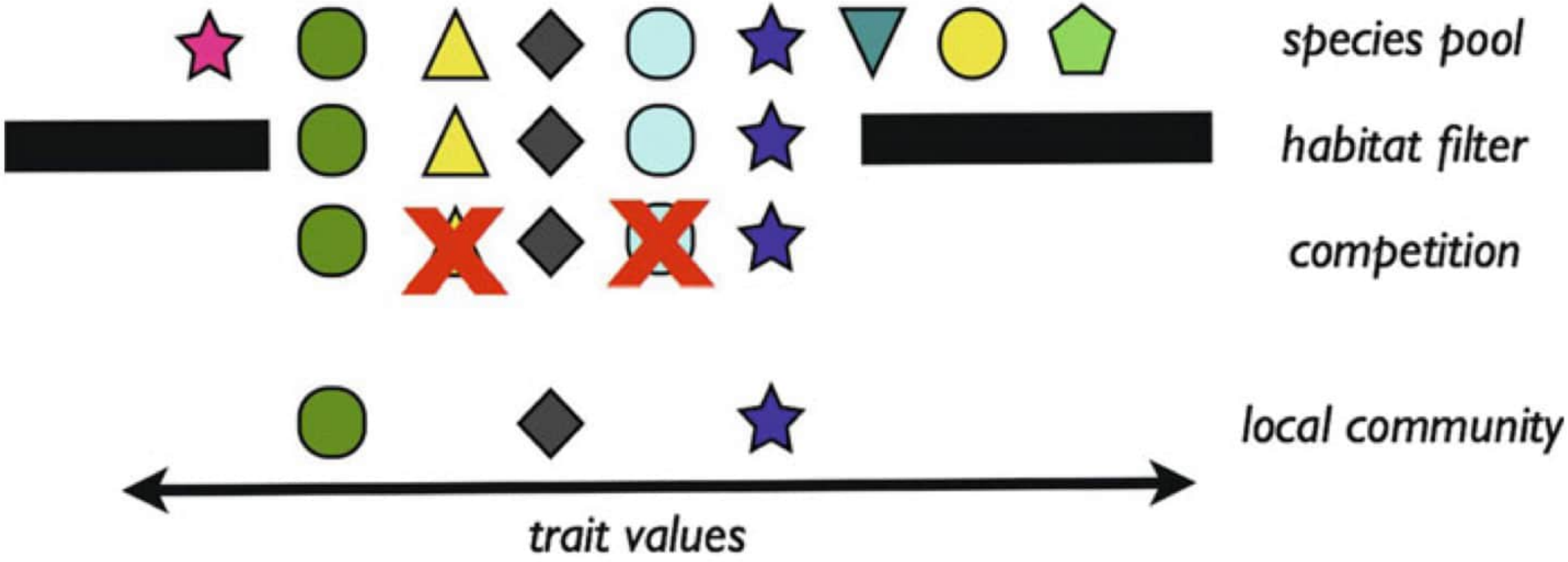


Figure from:
Kraft & Ackerly (2014) in Ecology and the Environment, The Plant Sciences

COMMUNITY ASSEMBLY & ALIEN SPECIES

Biological introductions specific process

Basic conceptual model of community assembly

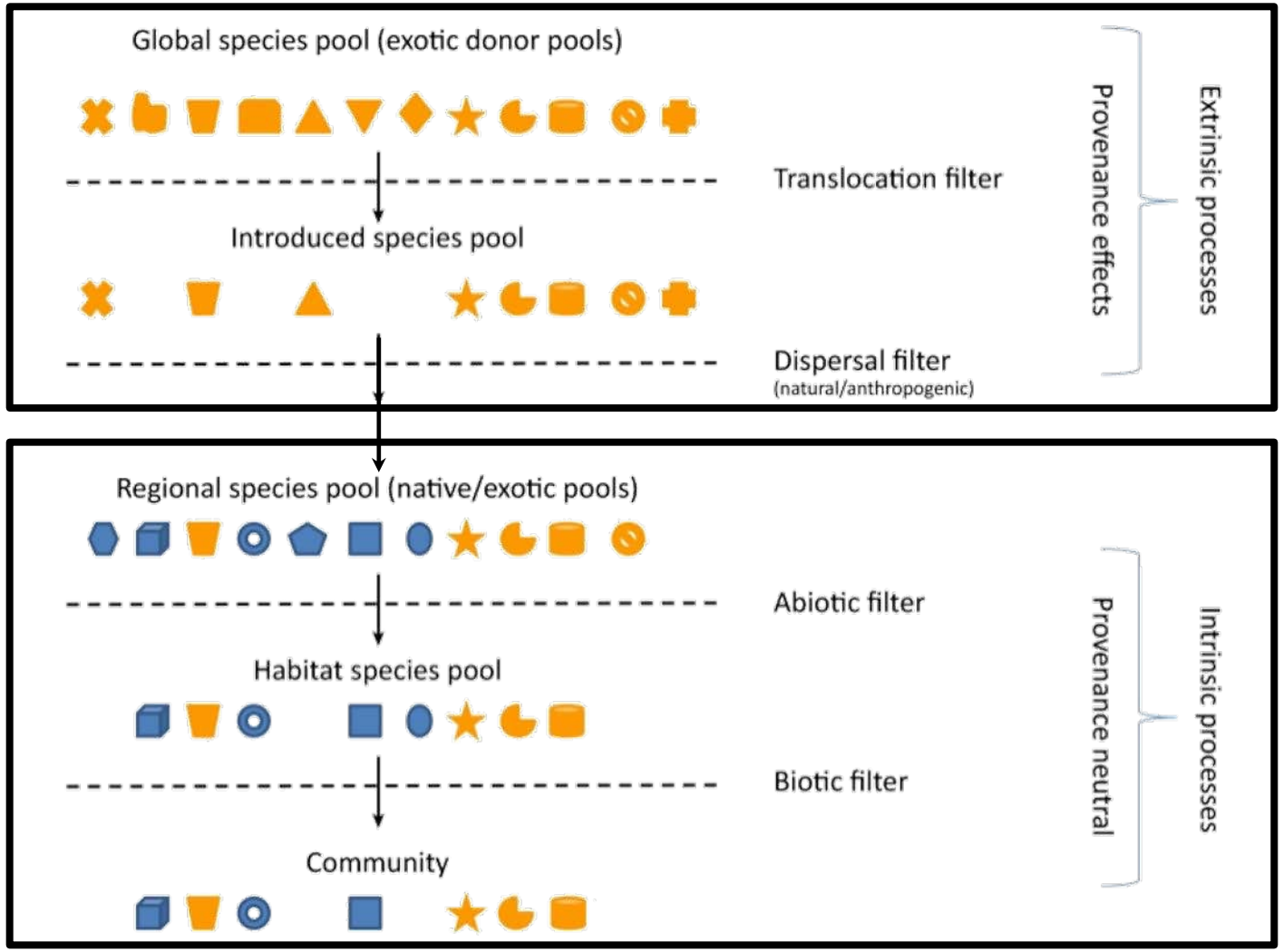


Figure from:
Pearson (2018) TREE

WHAT MAKES AN ALIEN SPECIES SUCCESSFUL? – VER 1

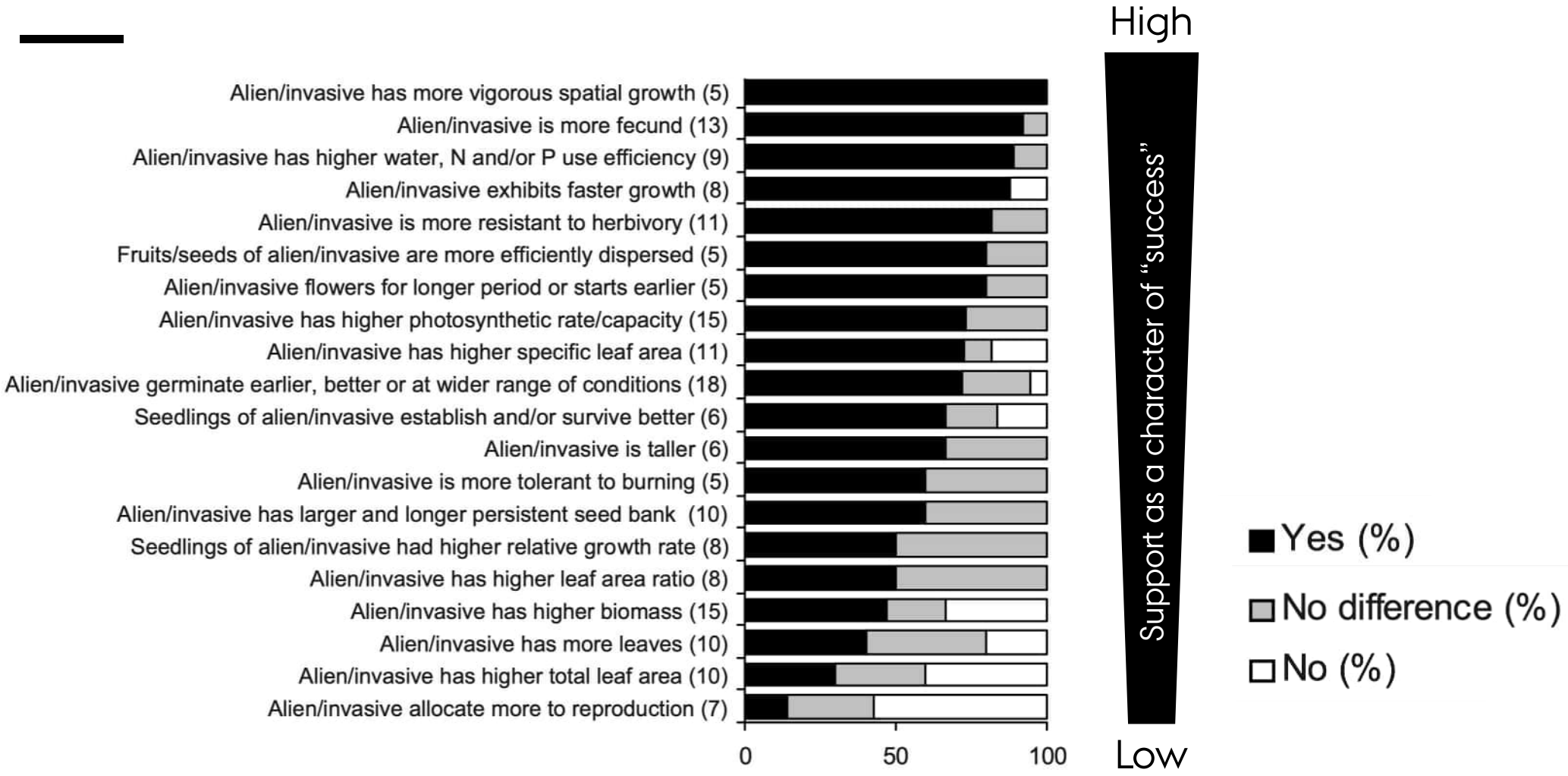


Figure from
Pyšek & Richardson (2007) Bio.Inv

FROM QUALITATIVE TO QUANTITATIVE

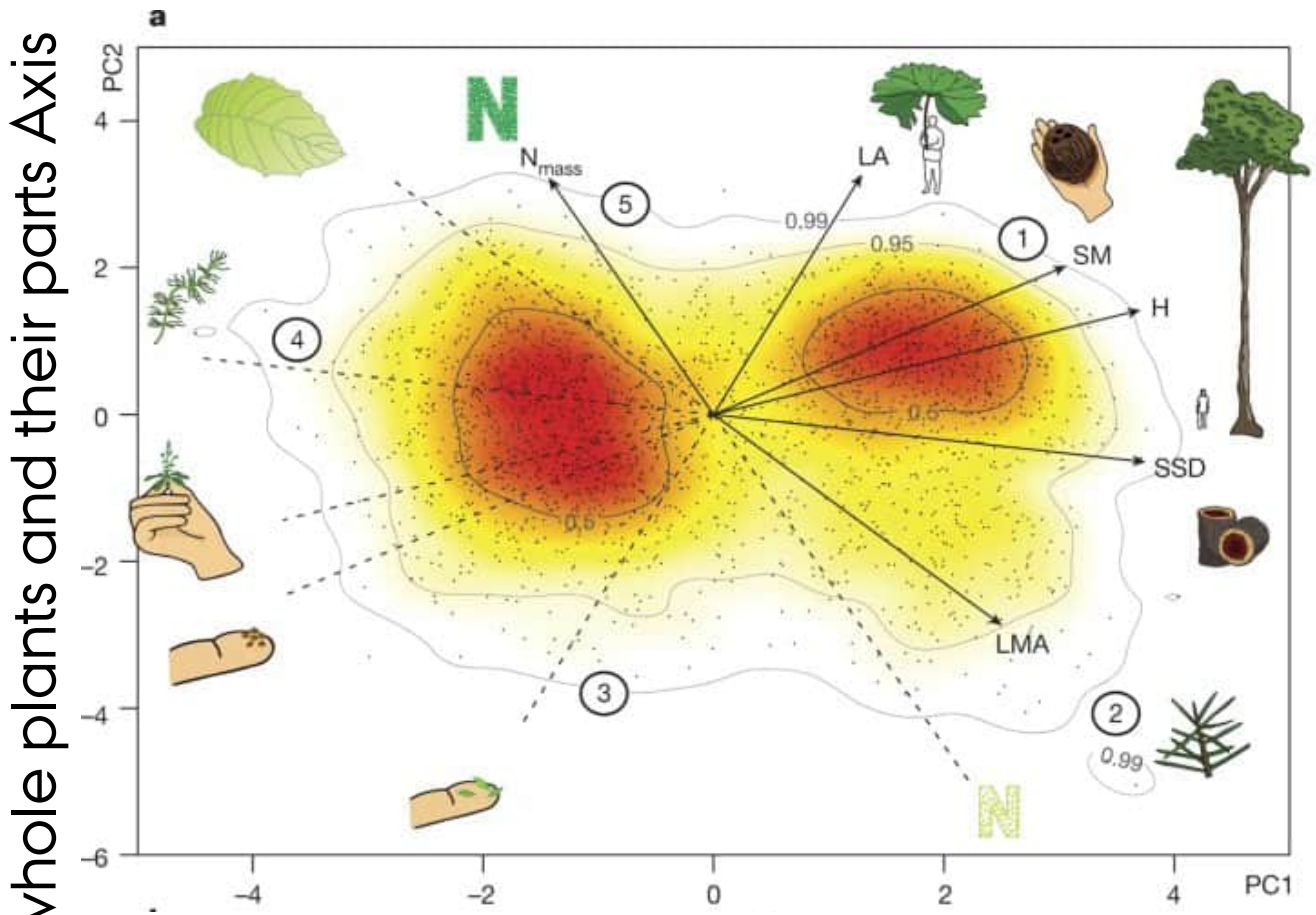
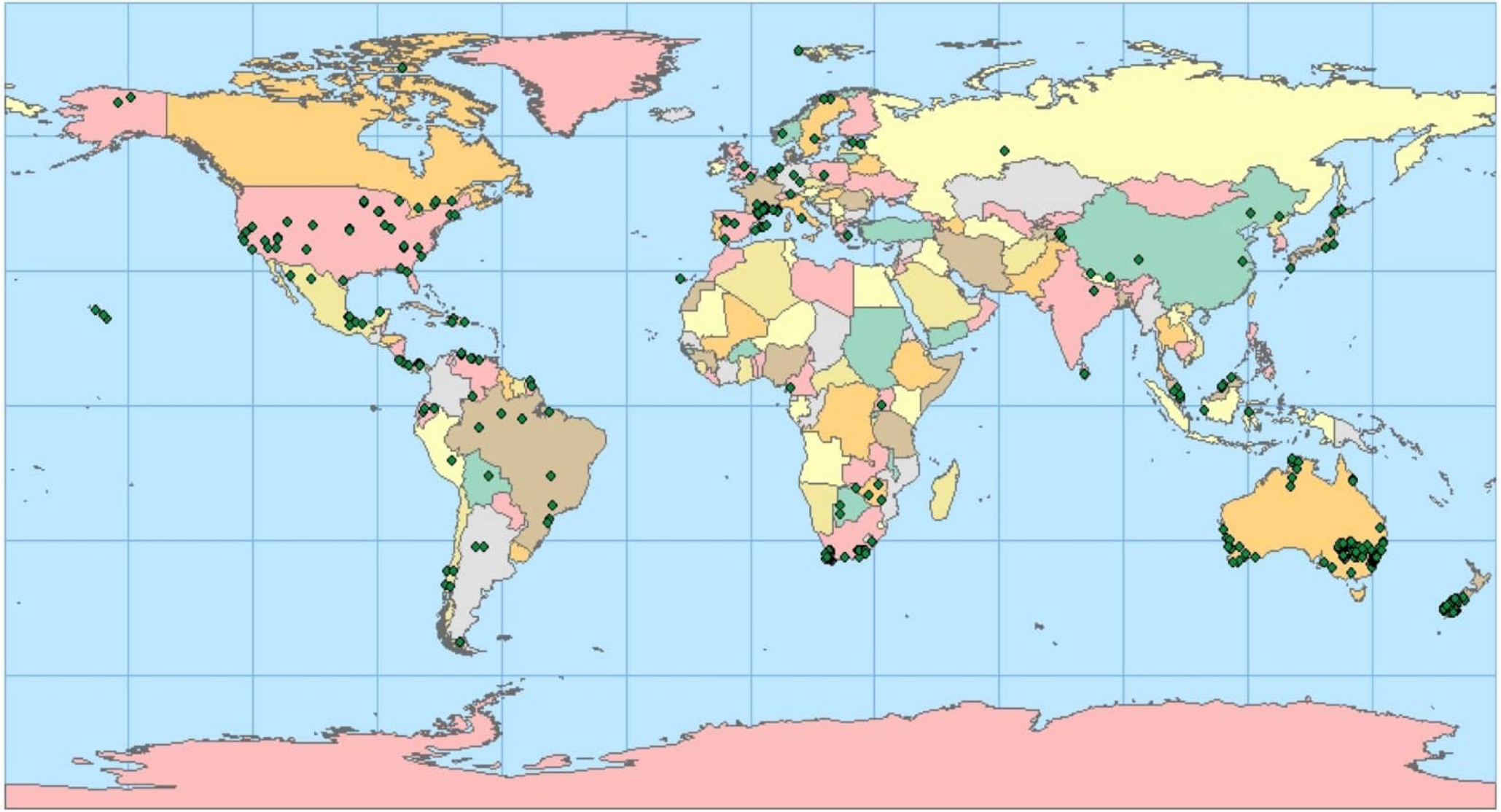


Figure from
Dias et al (2015) Nature



Ian Wright

WESTERN SYDNEY UNIVERSITY

Hawkesbury Institute for the Environment

4473 species sampled over 120 communities
(3784 species measured in their native range, 689 species in their introduced range, 207 in both ranges)

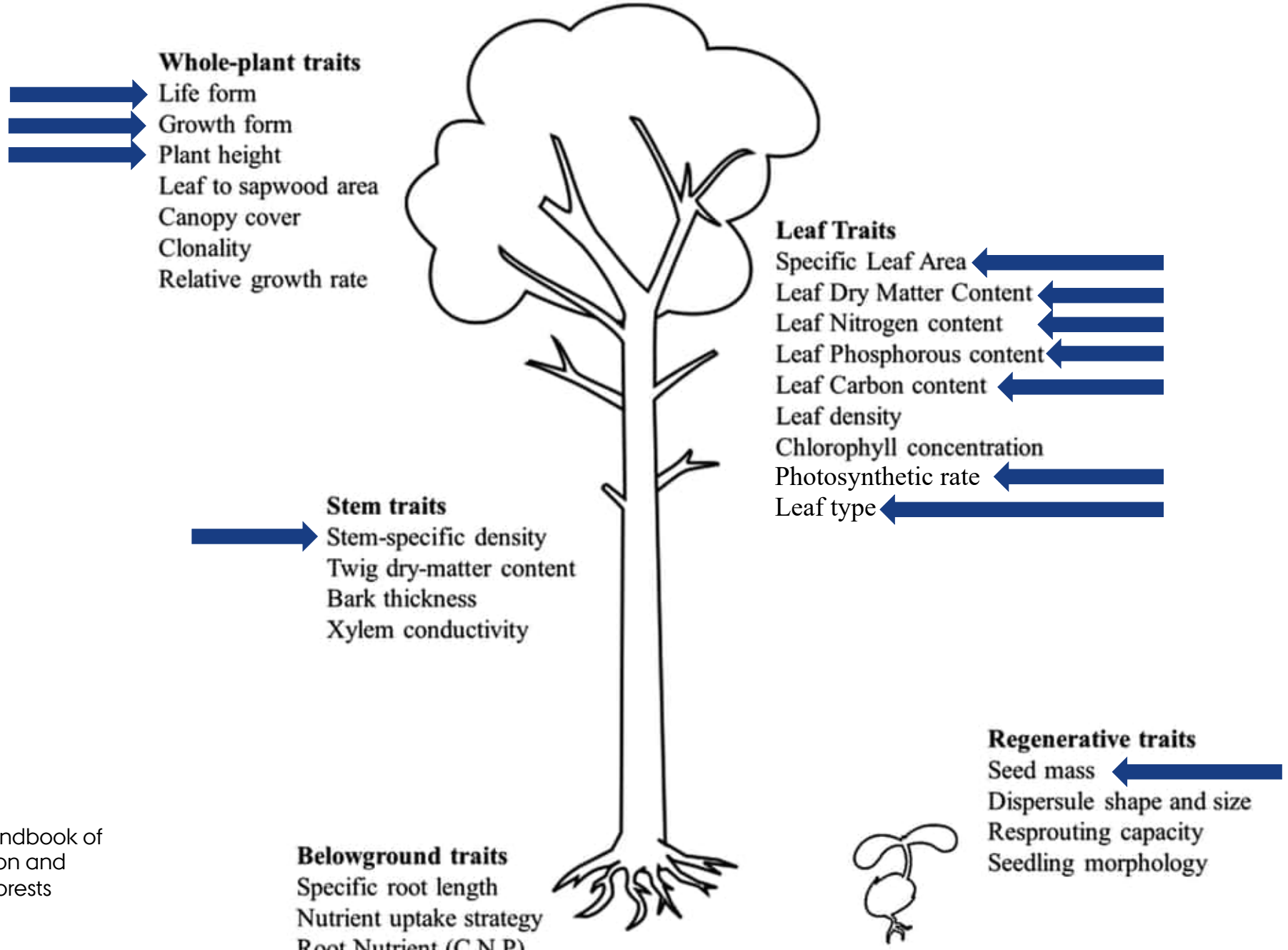


Figure from:
Singh & Verma (2020) in Handbook of Research on the Conservation and Restoration of Tropical Dry Forests

WHICH TRAITS?

Specific leaf area

$$SLA = \frac{\text{area } (mm^2)}{\text{Dry mass } (mg)}$$

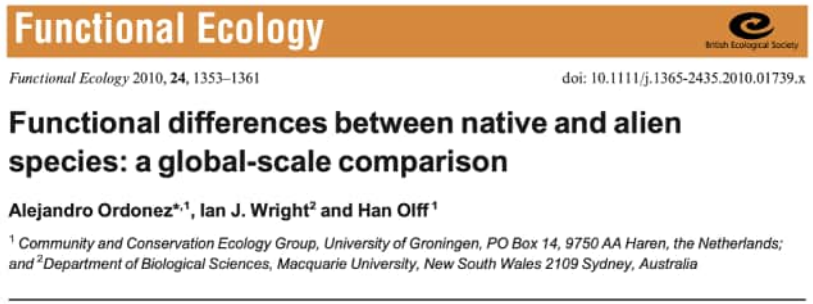
Seed Weight

$SWT = \text{seed weight } (mg)$

Plant height

$Hmax_{max} = \text{Height } (cm)$

FUNCTIONAL DIFFERENCES BETWEEN NATIVE AND ALIEN SPECIES



Functional Ecology

Functional Ecology 2010, **24**, 1353–1361 doi: 10.1111/j.1365-2435.2010.01739.x

Functional differences between native and alien species: a global-scale comparison

Alejandro Ordonez*,[1], Ian J. Wright[2] and Han Olff[1]

[1] *Community and Conservation Ecology Group, University of Groningen, PO Box 14, 9750 AA Haren, the Netherlands; and* [2] *Department of Biological Sciences, Macquarie University, New South Wales 2109 Sydney, Australia*

Goal: provide a synthetic view of multi-trait differences between alien and native species

Univariate trait space

↓

Differences in ecological strategies

Multivariate trait space

↓

Functional space differences

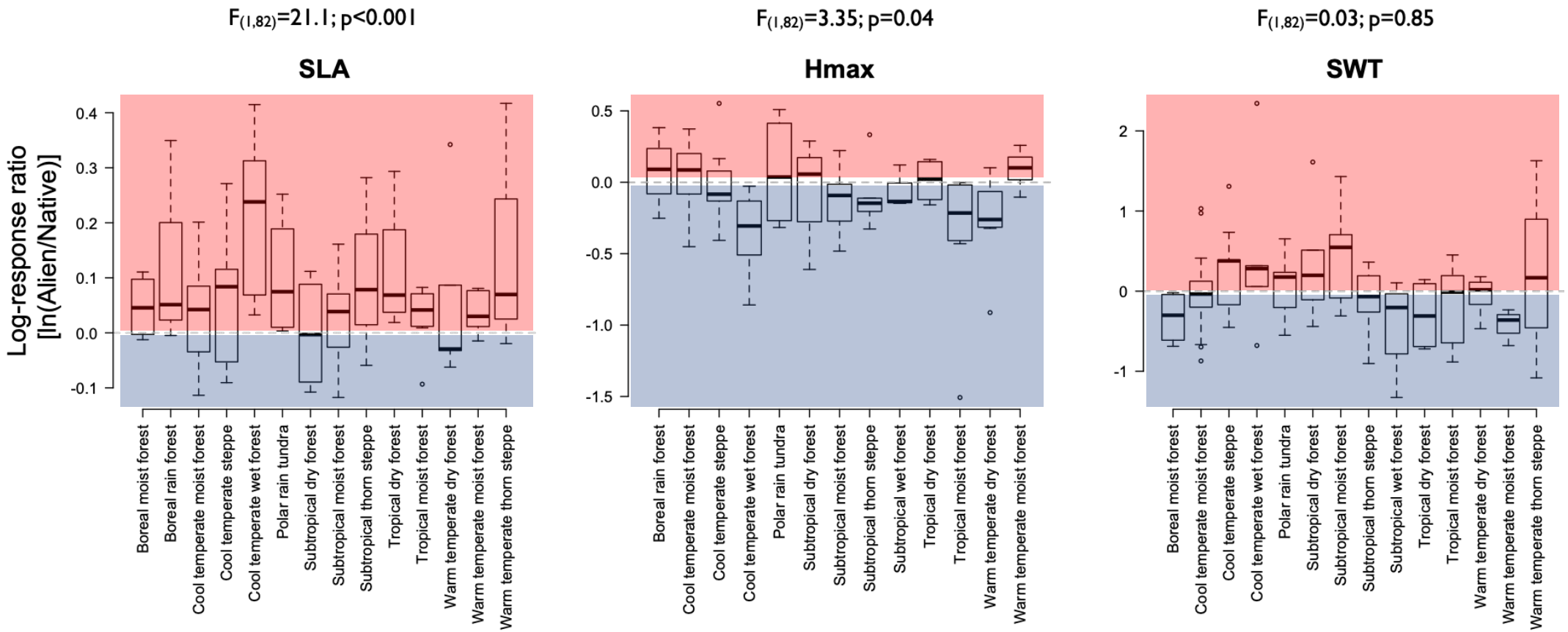
UNIVARIATE FUNCTIONAL DIFFERENCES

Trait [no. of sites]	Alien mean (SE) [no. of species]	Native mean (SE) [no. of species]	Linear mixed model
All			
SLA	133·3 (1·06)	115·1 (1·04)	$t = -5{\cdot}51^{***}$
[138]	[788]	[3164]	
H_{max}	3·3 (1·14)	3·9 (1·11)	$t = 3{\cdot}71^{***}$
[190]	[647]	[3562]	
SWT	5·6 (1·19)	7·6 (1·18)	$t = 2{\cdot}8^{**}$
[190]	[491]	[2319]	

The traits of native and alien species show significant differences.

Table from:
Ordonez et al (2015) Func Ecol

UNIVARIATE FUNCTIONAL DIFFERENCES



Alien > Native

Alien < Native

Figure based on data from Ordonez et al. 2010 FunEcol

MULTIVARIATE FUNCTIONAL DIFFERENCES

Based on their leaf and seed attributes.

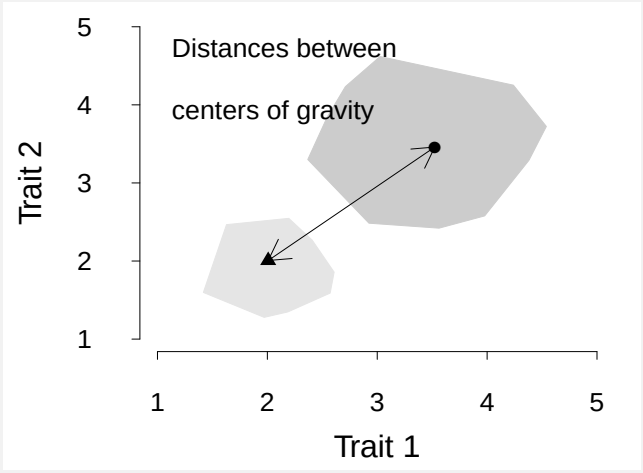
I can accurately discriminate between native and alien species

Group	Trait	Classification function coefficients: Native	Classification function coefficients: Alien	Trait significance test	CCR
All	SLA	24·0	25·8	$F_{(1,1955)} = 72{\cdot}99, ***$	84·5%
	H_{max}	1·8	2·0	$F_{(1,1955)} = 3{\cdot}21, NS$	
	SWT	1·0	0·9	$F_{(1,1955)} = 7{\cdot}52, **$	

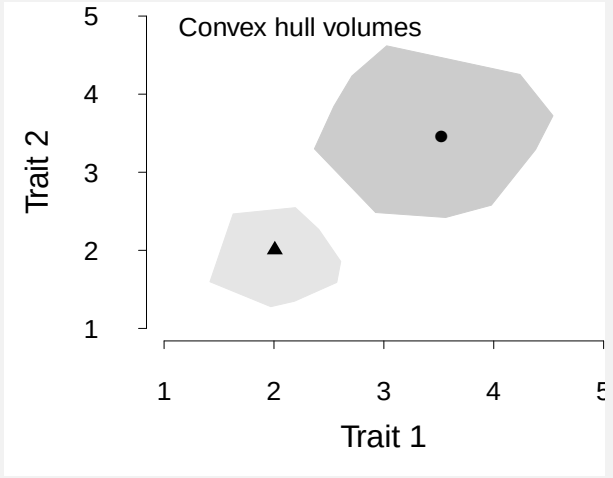
Table from:
Ordonez et al (2015) Func Ecol

MULTIVARIATE FUNCTIONAL DIFFERENCES

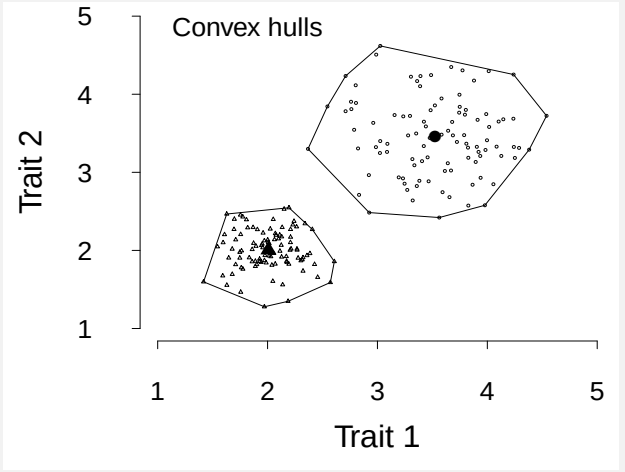
Distance centroids



Convex hull size



Spread in the convex hull



MULTIVARIATE FUNCTIONAL DIFFERENCES

Pair	Native (*N*)	Alien (*N*)	Functional richness: Differences (%)	Functional richness: Wilcoxon *P*	Functional richness: % trials Obs. > Exp.	Functional divergence: Differences (%)	Functional divergence: Wilcoxon *P*	Functional divergence: % trials Obs. > Exp.	Trait similarity: Wilcoxon *P*	Trait similarity: % trials Obs. > Exp.
All	1651	305	−55·8	***	1000/1000	5·0	***	572/1000	***	933/1000

Aliens occupy a smaller functional space.

Aliens are farther apart from the convex hull centre.

The functional space of native and alien species is more different than randomly expected.

Table from:
Ordonez et al (2015) Func Ecol

DO FUNCTIONAL DIFFERENCES TRANSLATE TO BETTER PERFORMANCE?

A Journal of Macroecology

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2013) 22, 648–658

META-ANALYSIS

Do alien plant species profit more from high resource supply than natives? A trait-based analysis

Alejandro Ordonez[1,2]* and Han Olff[1]

[1]Community and Conservation Ecology Group, University of Groningen, Groningen, The Netherlands, [2]The Nelson Institute Center for Climatic Research (CCR), University of Wisconsin – Madison, Madison, WI, USA

ABSTRACT

Aim Previous studies comparing conditions of high- versus low-resource environments have pointed at differences in key traits that would allow aliens to perform better than natives under high-resource conditions. We generalize and test the robustness of this idea by exploring how trait differentiation between aliens and natives changes along continuous resource gradients.

Location Global.

Goal: Would the observed functional differences allow aliens to perform better than natives?

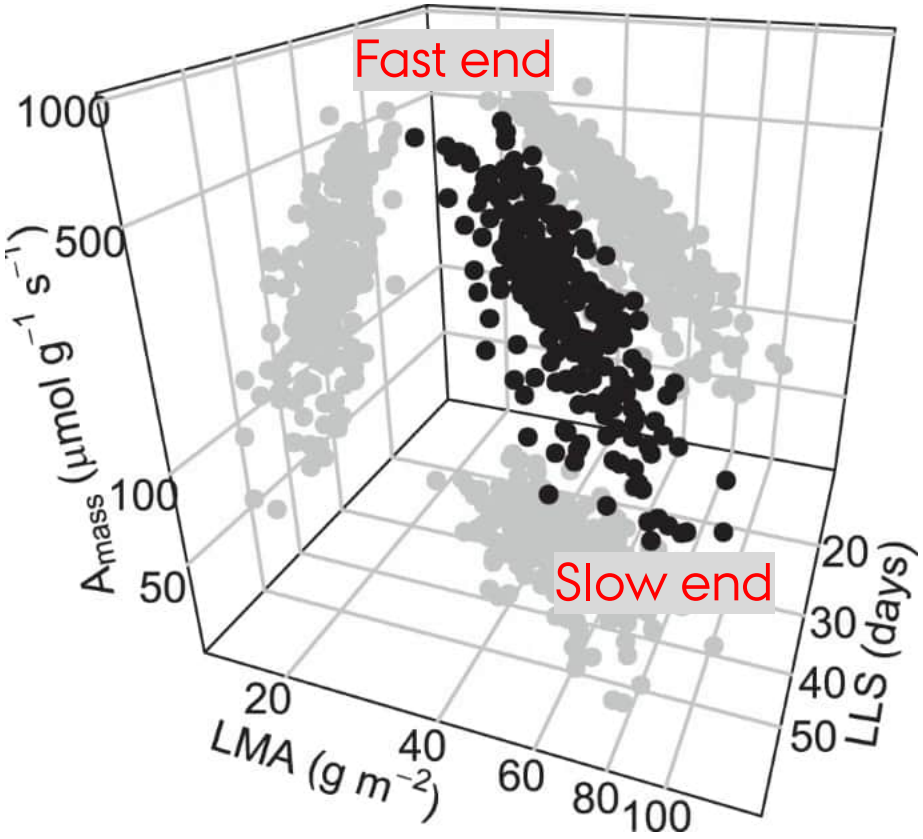
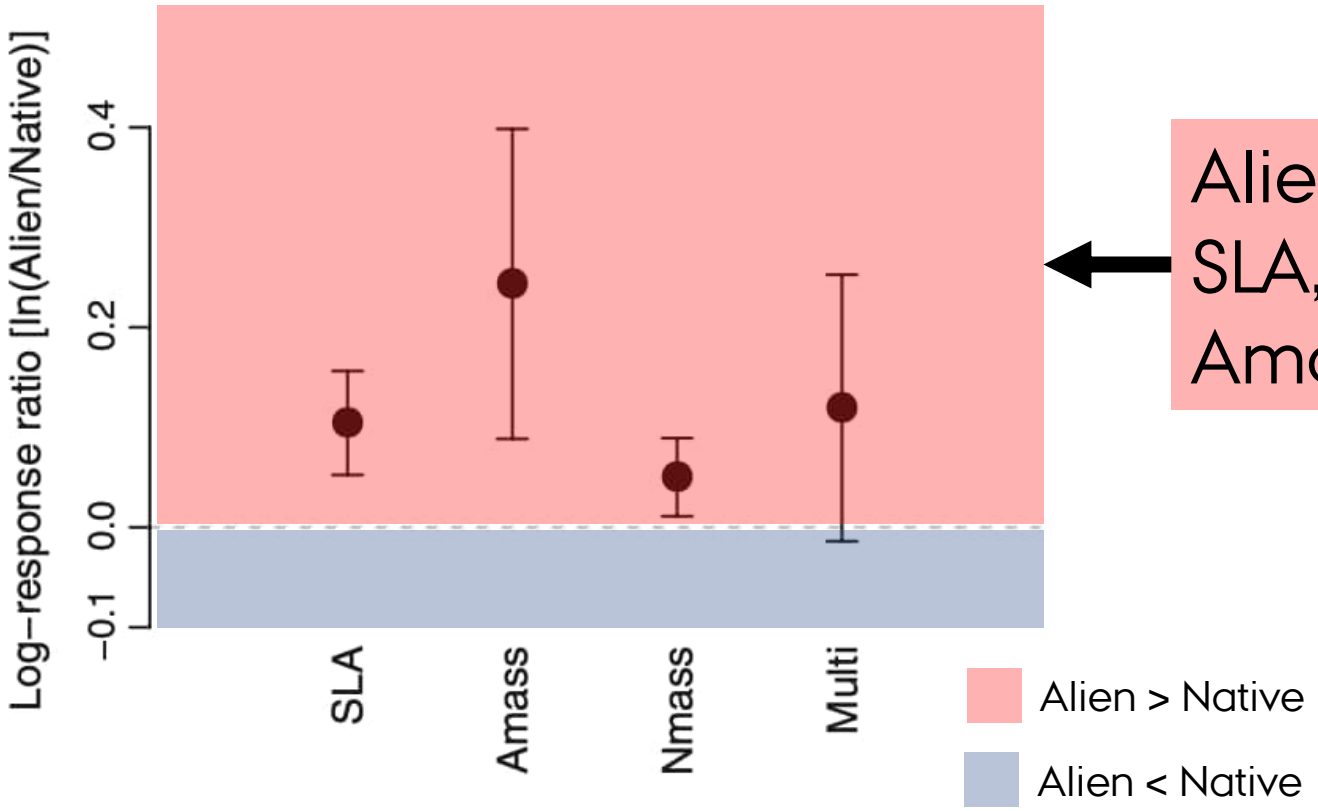


Figure from:
Wright et al 2004 Nature

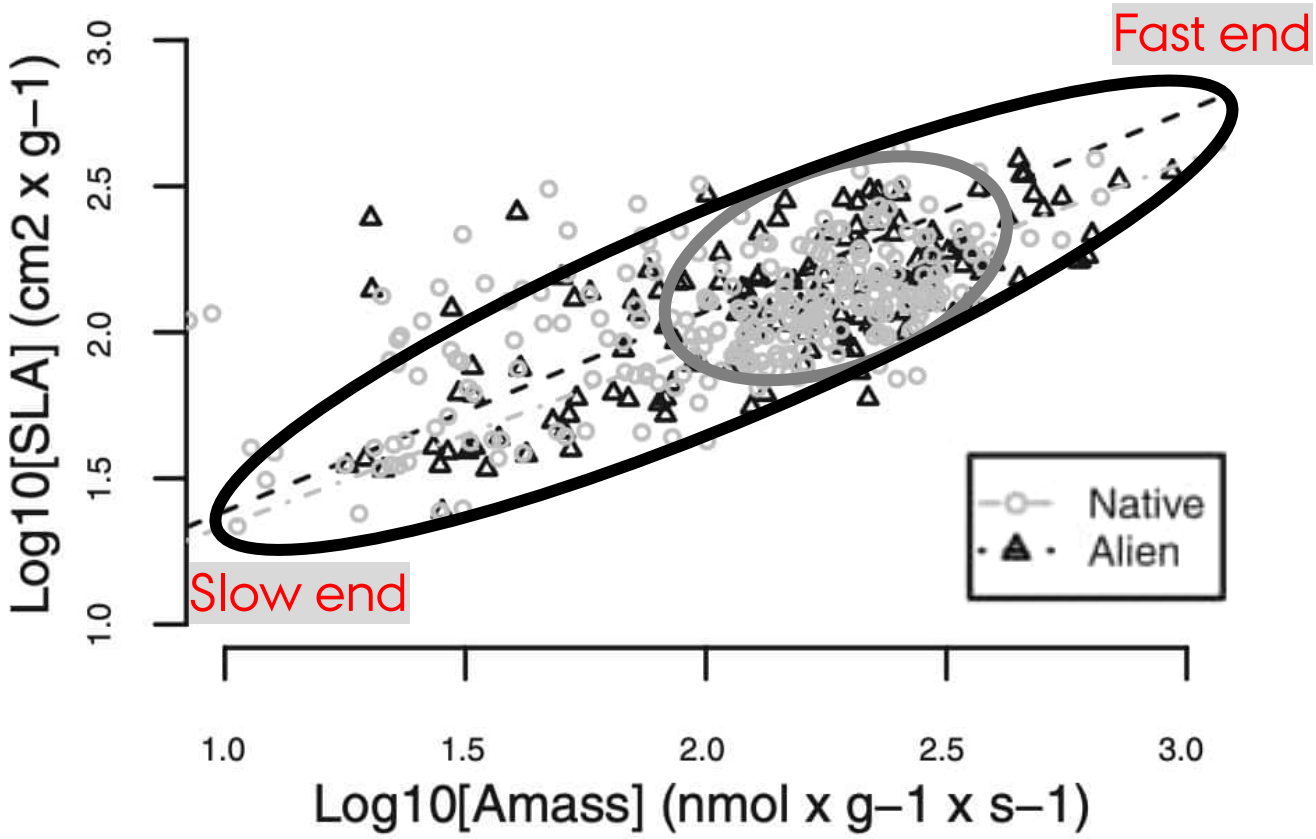
DO FUNCTIONAL DIFFERENCES TRANSLATE TO BETTER PERFORMANCE?



Aliens have higher SLA, Nmass and Amass than natives.

Figure from Ordonez & Olff 2012 GEB

DO FUNCTIONAL DIFFERENCES TRANSLATE TO BETTER PERFORMANCE?



Aliens are at the fast end of the leaf economics spectrum.

Figure from
Ordonez & Olff 2012 GEB

CONSIDERING THE LOCAL CONTEXT

Ecology, 95(5), 2014, pp. 1191–1202

Functional and phylogenetic similarity of alien plants to co-occurring natives

ALEJANDRO ORDONEZ[1]

Ecoinformatics and Biodiversity, Department of Bioscience, Aarhus University, Ny Munkegade 114, DK-8000 Aarhus C, Denmark Center for Evolutionary and Ecological Studies (CEES), Community and Conservation Ecology Group (COCON), University of Groningen, 9700 CC Groningen, The Netherlands
Nelson Institute Center for Climatic Research (CCR), University of Wisconsin, Madison 53706 Wisconsin, USA

Goal: Determine if alien species are "really" novel to the recipient community.

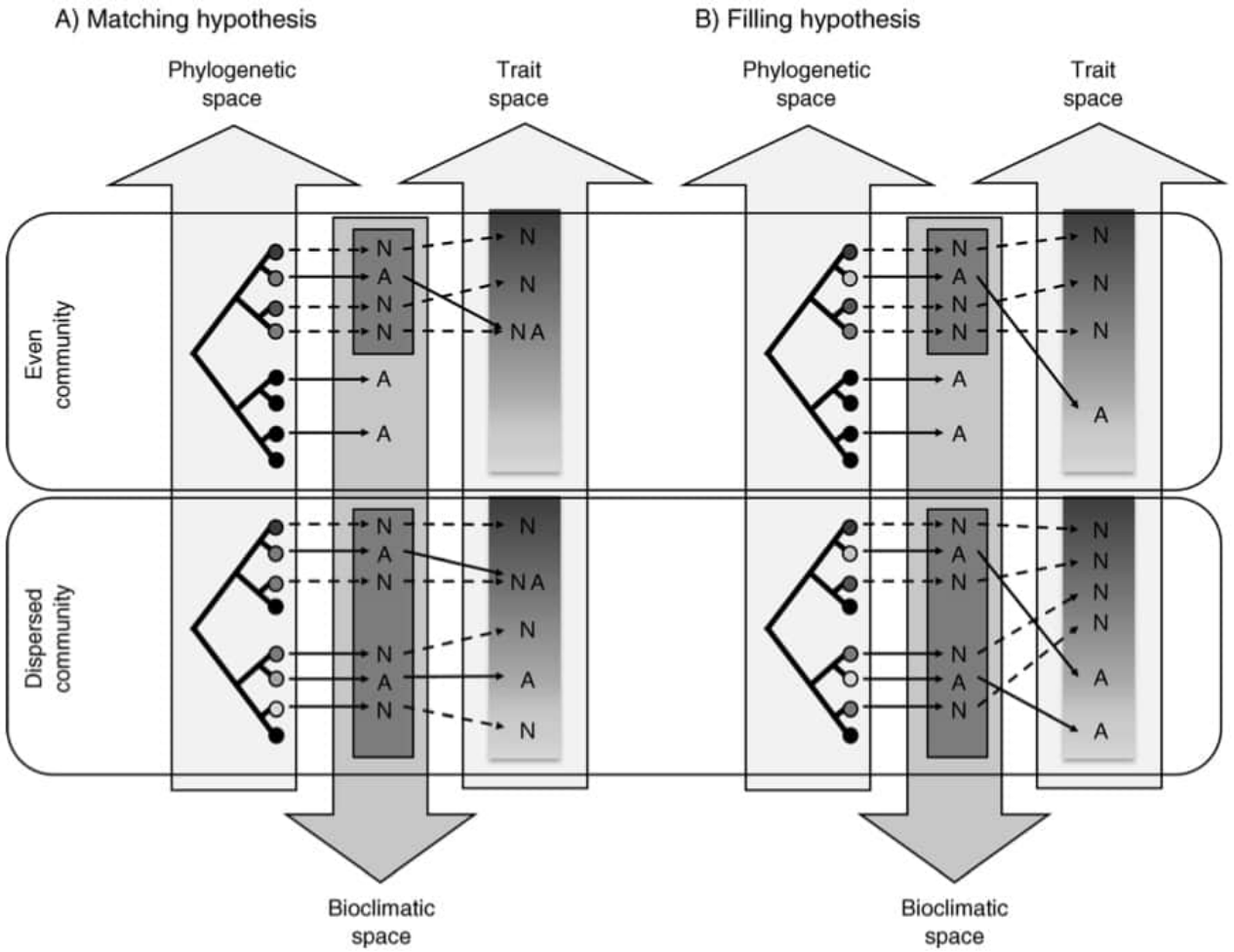
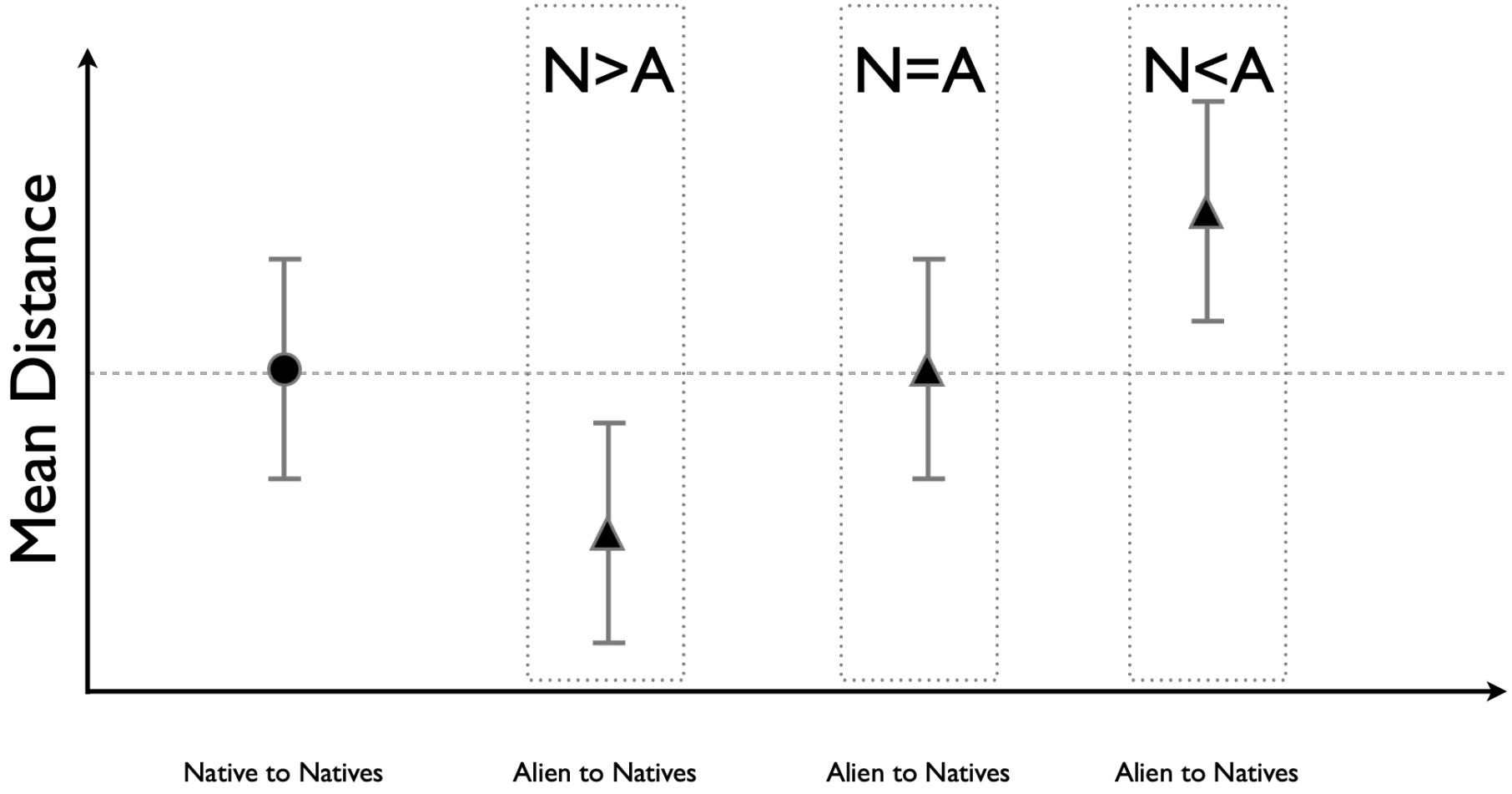


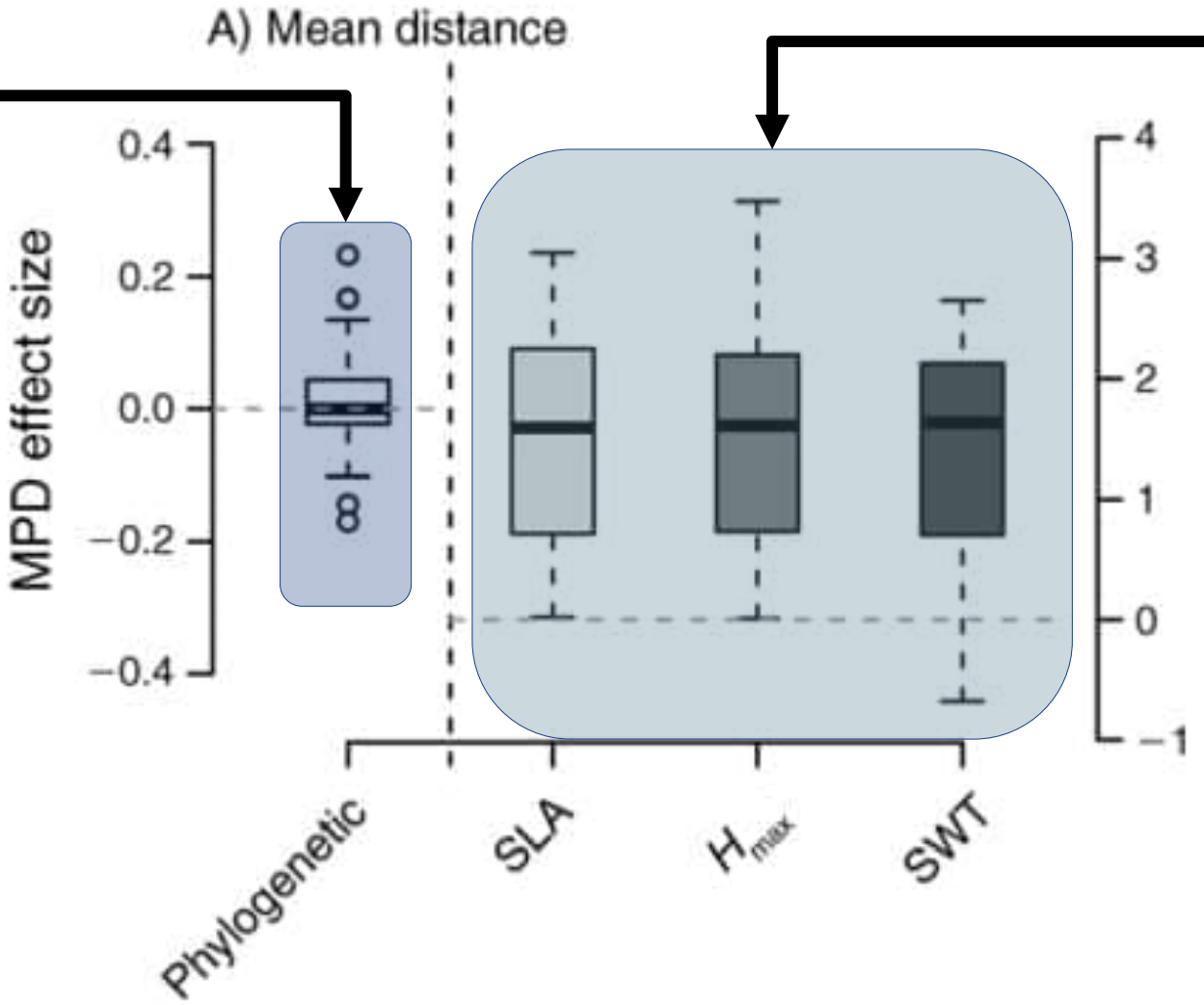
Figure from Ordonez 2014 Ecology

CONSIDERING THE LOCAL CONTEXT



CONSIDERING THE LOCAL CONTEXT

Aliens are as phylogenetically close to the incumbent native community



Aliens are as functionally district to the incumbent native community

Figure from Ordonez 2014 Ecology

What makes an alien species successful?

ALEJANDRO ORDONEZ GLORIA
ASSISTANT PROFESSOR

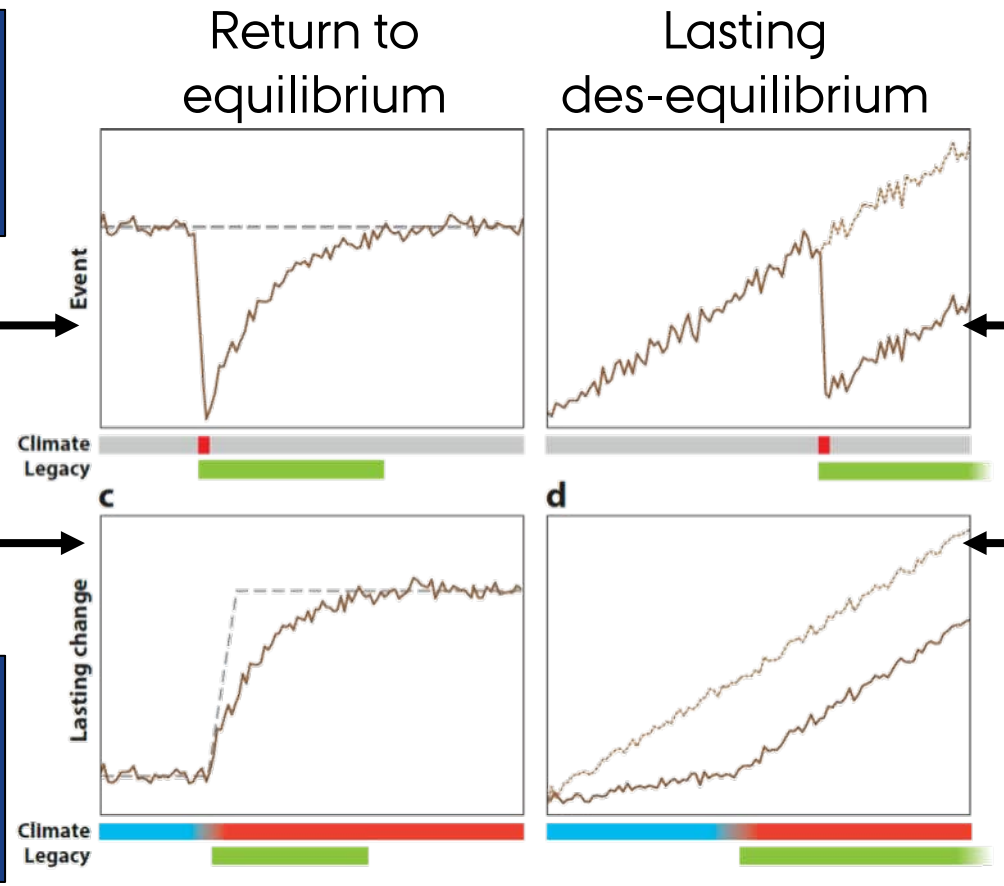
TODAY'S TALK

- **Leveraging functional ecology** – trait novelty/divergence in the context of ecological strategies.
- **Climate change in the context of functional ecology** – the lasting imprints of climate change on functional diversity and its implications.
- **Where do we go from here?** – a look into the IPBES work.

HOW DO HISTORICAL PALEOCLIMATIC CHANGE LEAVE A LEGACY?

A climatic event (red) has a transient effect on the outcome of an equilibrium process

A climatic event (red) has a permanent effect on cumulative processes

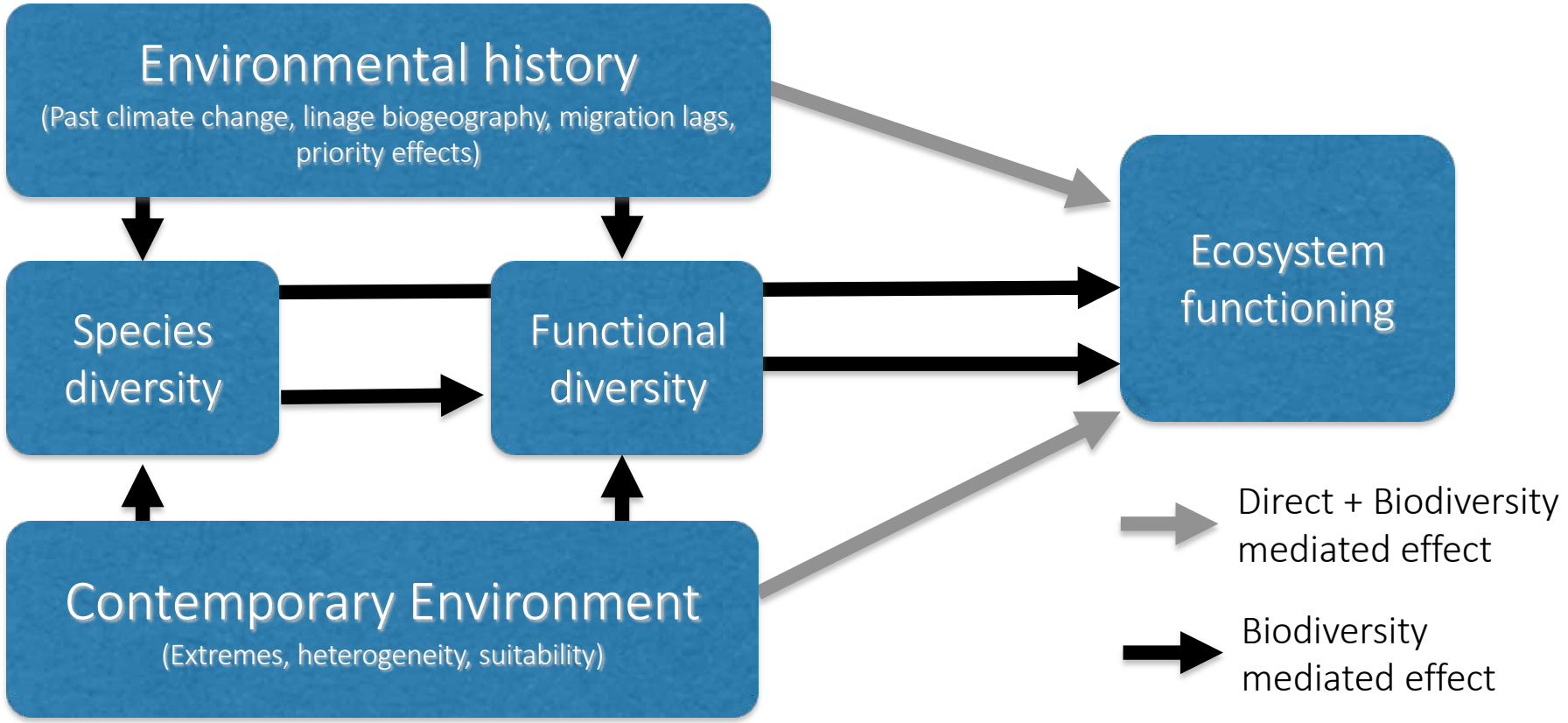


A permanent change in climate (from blue to red) shifts the equilibrium state (dashed line)

A permanent change in climate has a permanent effect on a cumulative process

Figure from Svenning et al with Ordonez – (2015) AREES

LONG-TERM CONSTRAINTS ON FUNCTIONAL DIVERSITY



www.nature.com/scientificreports

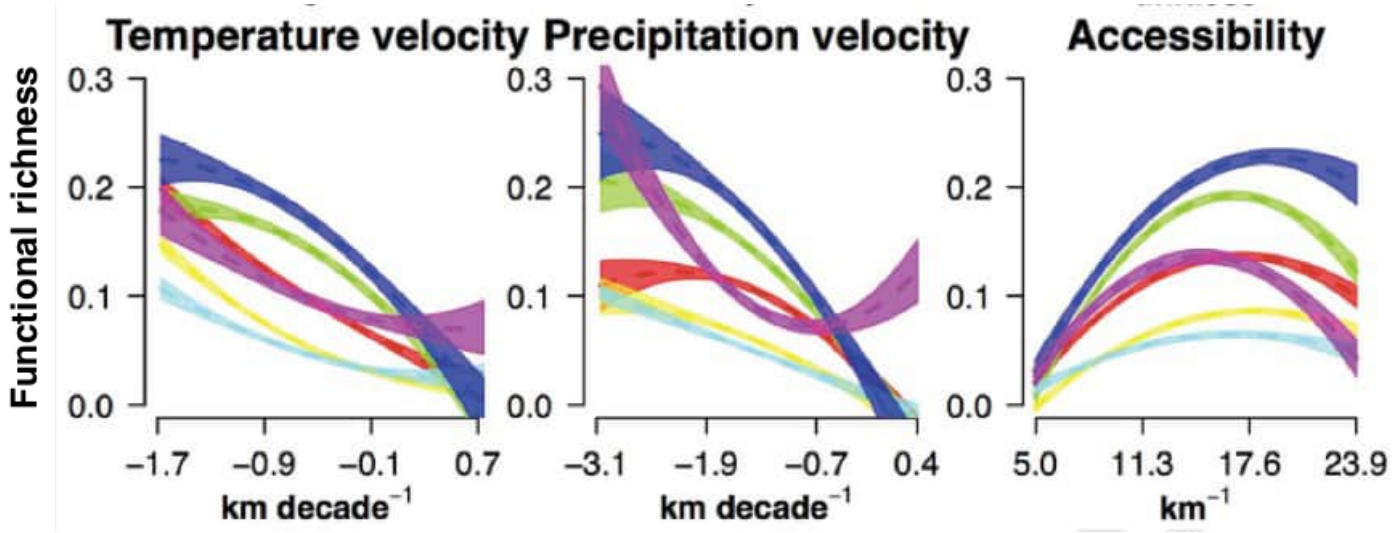
SCIENTIFIC REPORTS

OPEN

Consistent role of Quaternary climate change in shaping current plant functional diversity patterns across European plant orders

Received: 12 April 2016
Accepted: 17 January 2017
Published: 23 February 2017

Alejandro Ordonez & Jens-Christian Svenning



Approximate latitudinal limit to glacial refugia

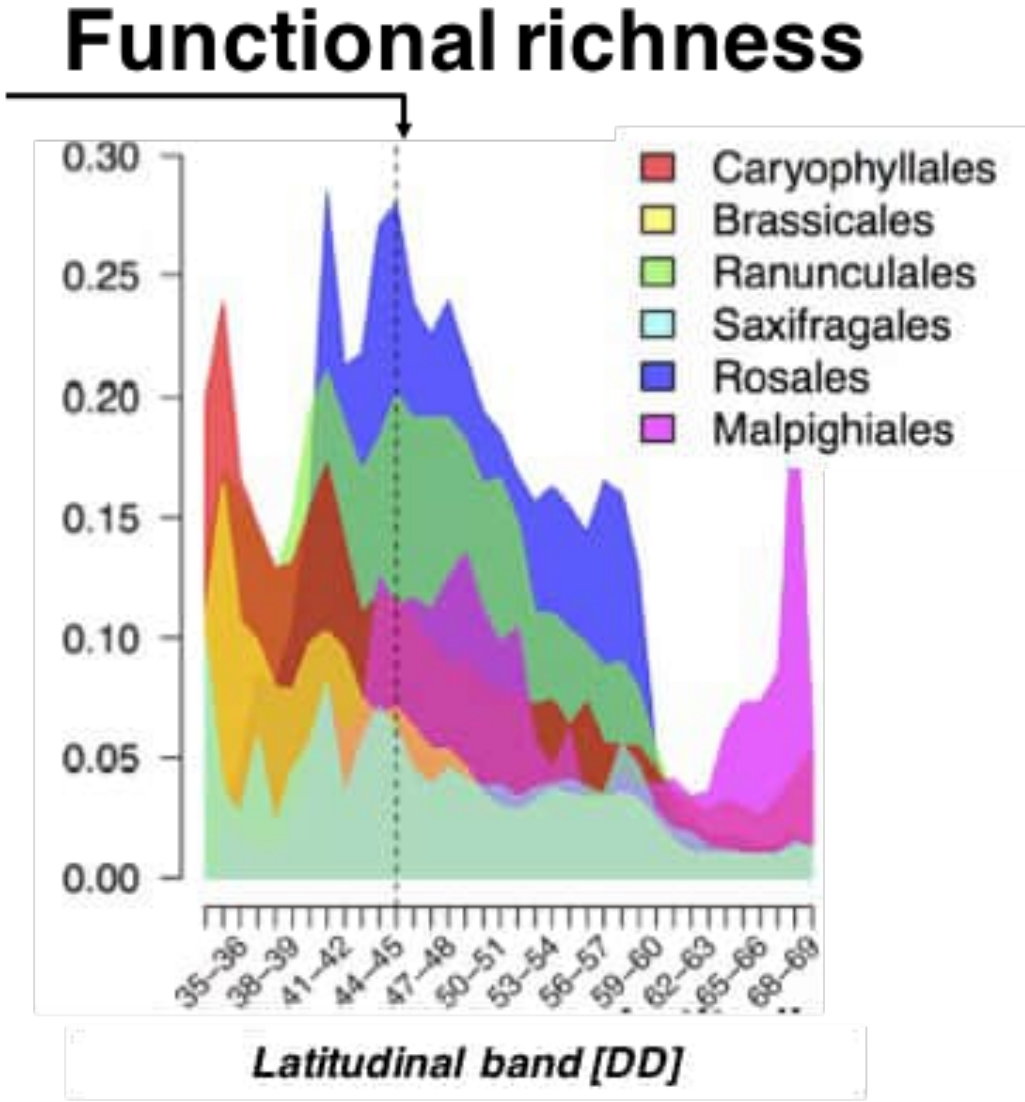
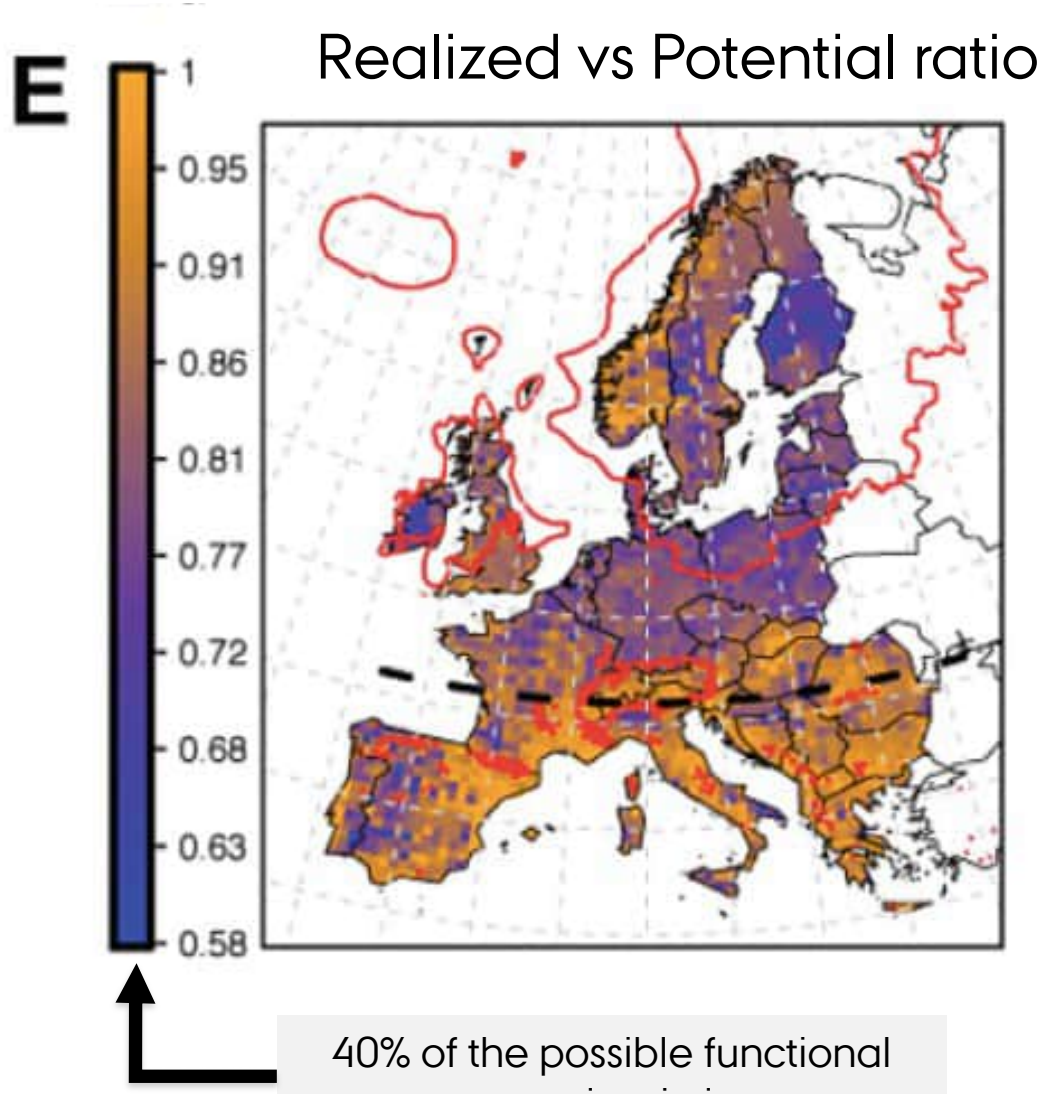


Figure from
Ordonez & Svenning (2017) Sci Rep

Functional richness

Realized vs Potential ratio



40% of the possible functional space is missing

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2015) **24**, 826–837

A Journal of Macroecology

RESEARCH PAPERS

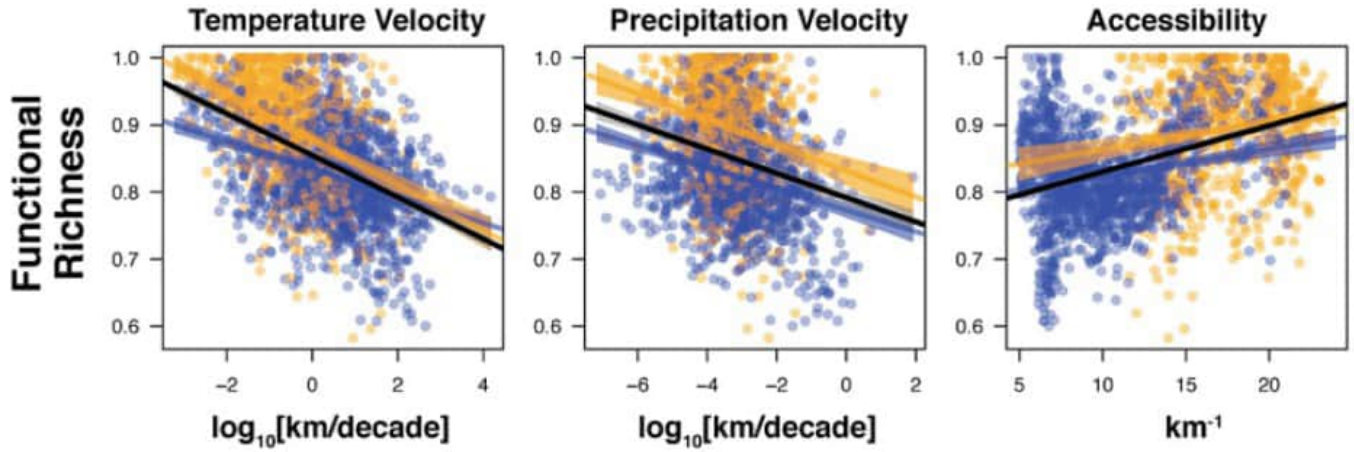
Geographic patterns in functional diversity deficits are linked to glacial-interglacial climate stability and accessibility

Alejandro Ordonez* and Jens-Christian Svenning

Section for Ecoinformatics and Biodiversity, Department of Bioscience, Aarhus University, Ny Munkegade 114, DK-8000, Aarhus C, Denmark

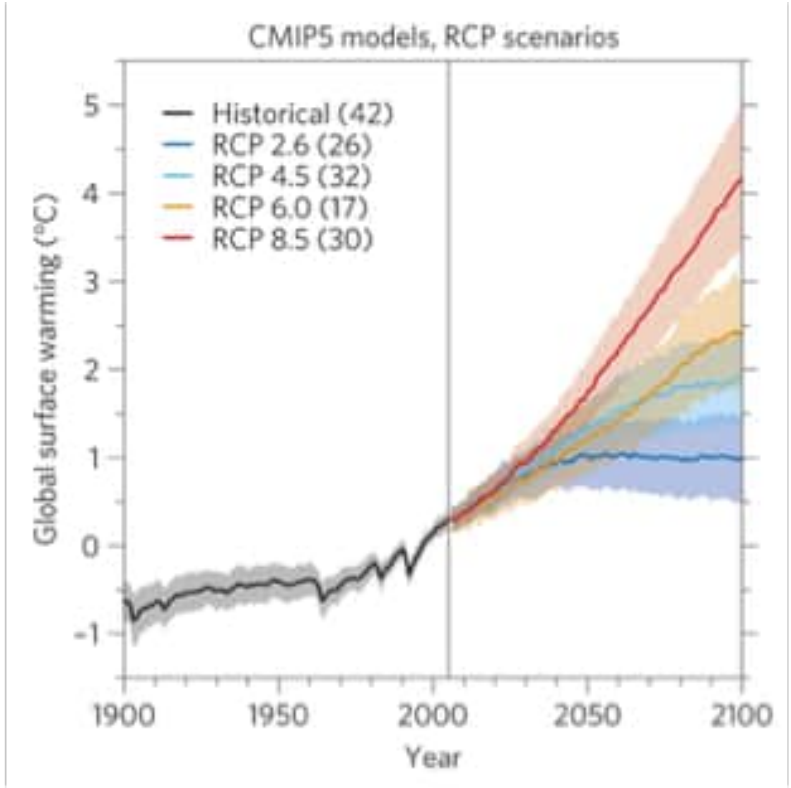
ABSTRACT

Aim Late Quaternary climate change can be an important determinant of large-scale species richness patterns, but it is currently unknown if its effects also extend



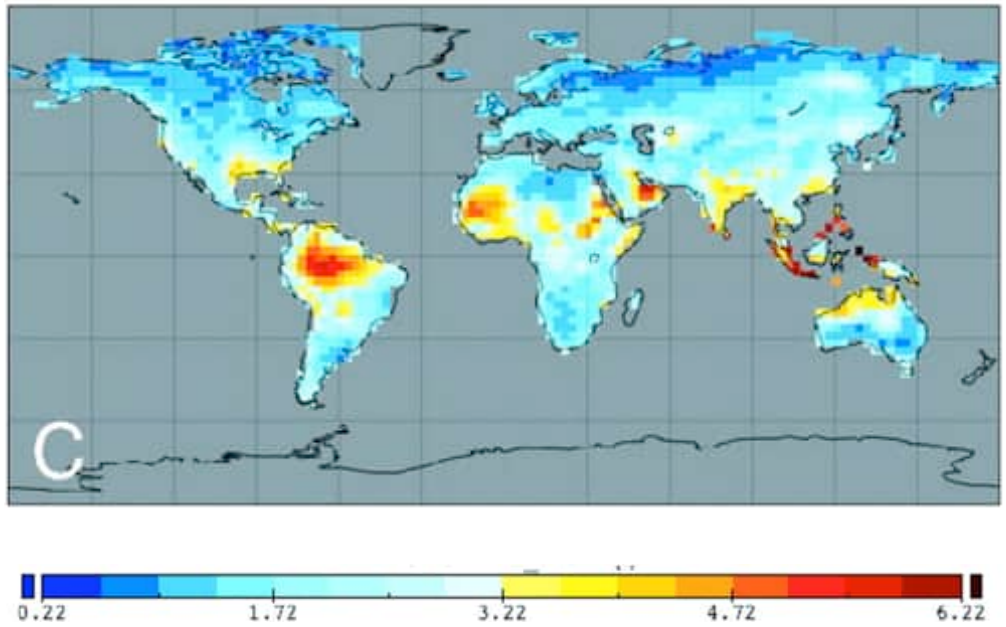
Figures from
Ordonez & Svenning (2014) GEB

CLIMATIC CONDITIONS ARE CHANGING AT FAST RATES



Emergence of novel climates

(2100 - A2 Scenario)



Figures from the IPCC AR5 Synthesis Report (SYR); Williams et al (2007) PNAS

TODAY'S TALK

- **Leveraging functional ecology** – trait novelty/divergence in the context of ecological strategies.
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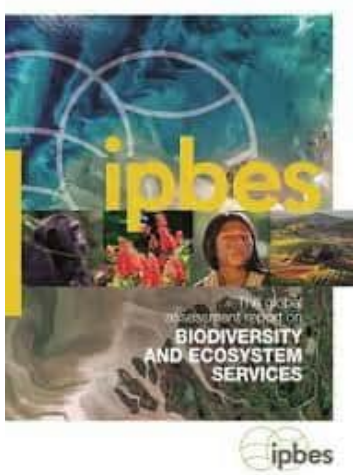
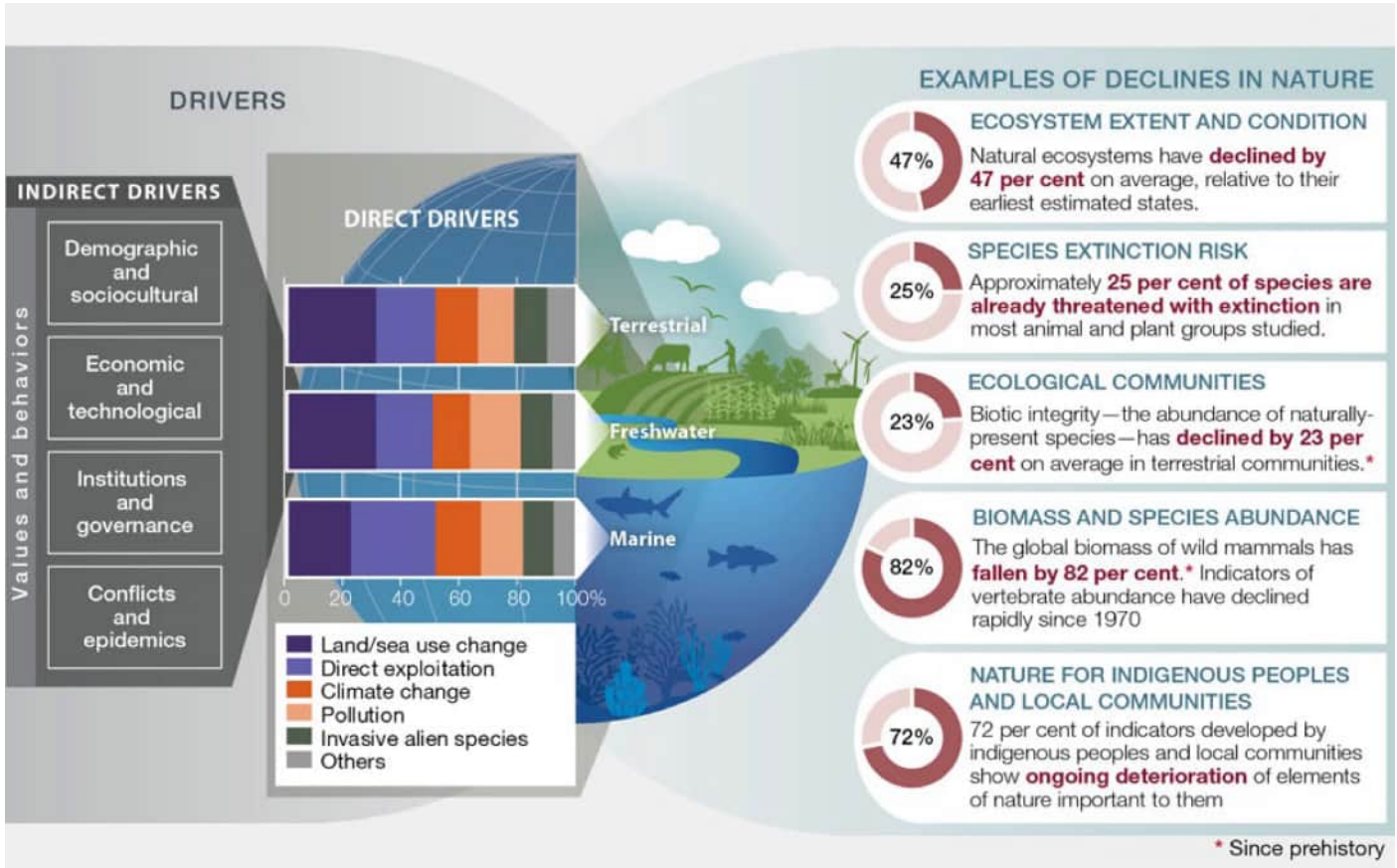
INVASIONS AS A MAJOR DRIVER OF BIODIVERSITY CHANGE





PUSHING FOR TRANSFORMATIVE CHANGE

What does this mean for biological invasions?

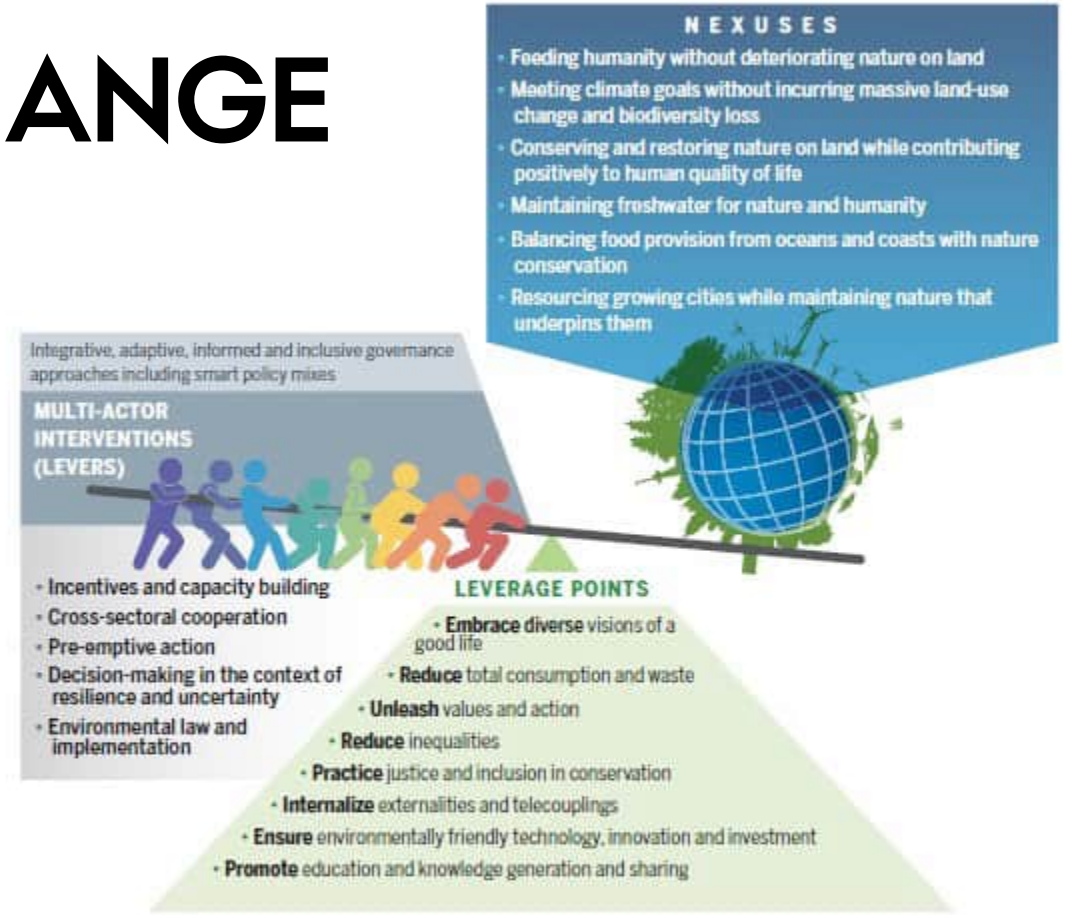


Fig. 7. Enabling transformative change. Collaborative implementation of priority interventions (levers) targeting key points of intervention (leverage points representing major indirect drivers) could enable transformative change from current trends toward more sustainable ones. Effectively addressing these levers and leverage points requires innovative governance approaches and organizing the process around nexuses, representing closely interdependent and complementary goals (*1*, 94). [Modified from (*1*).]

INTEGRATION ACROSS SECTORS

One Biosecurity


PORTLAND PRESS

Review Article

One Biosecurity: a unified concept to integrate human, animal, plant, and environmental health

NEED FOR INTEGRATED GOVERNANCE

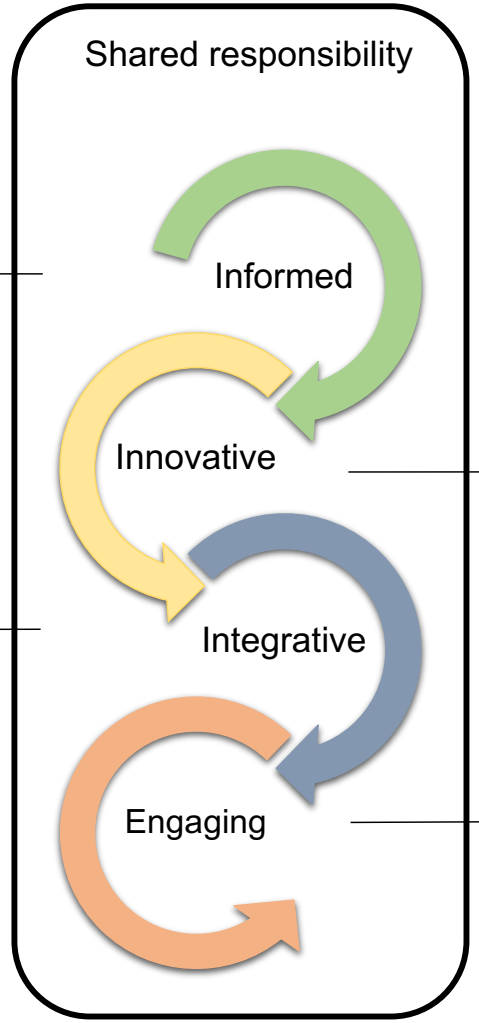
What?/Levers

- Promoting knowledge generation, maintenance, interoperability, and exchange that incorporate multiple knowledge systems.
- Development of indicators of biological invasion that can be used to track the impacts of IAS on nature, NCP, and GQL

What?/Levers

- Aligning/Harmonising international and regional agreements.
- Harmonising legal and regulatory instruments and codes of conduct across different sectors.
- Develop holistic approaches to the broad array of global environmental problems.
- Better connect biotechnological advances and their regulation.

Approaches to enable transformative change in the prevention, eradication, and management of IAS



What?/Levers

- Develop an integrative, adaptive, informed and inclusive approach to environmental governance.
- Reforming sectoral and segmented decision-making to promote integration.
- Devising and implementing national strategies and action plans that s**pecifying the distribution of responsibilities among stakeholders.**
- Strengthening environmental laws and policies and their implementation.

What?/Levers

- Develop tools for stakeholder engagement and dialogue to improve the efficiency of prevention, eradication and management efforts.
- Increase the representations of underrepresented groups in the decision-making process.

IN SUMMARY

- While we can have a general answer to the "*What makes an alien species successful?*" question is clear that going from these patterns to preventative actions requires an understanding of the local conditions.

- The legacies of current environmental change would mean a high potential for aliens' successful introduction.

- To address the problem of invasions, we need a system reset that engages all sectors and activates all stakeholders and rights holders.

THANKS FOR YOUR ATTENTION

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AARHUS
UNIVERSITY

TODAY'S TALK

- **Functional convergence/divergence** in the context of invasive species
- **Leveraging functional ecology** – niche novelty/divergence in the context of ecological strategies.
- **Climate change in the context of functional ecology** – the lasting imprints of climate change on functional diversity and its implications.
- **All good things end** – How long would the benefits of niche novelty/divergence last?
- **Where do we go from here?** – a look into the IPBES work.