Biogeographic lessons for weed risk assessment: building a global perspective of a worldwide problem

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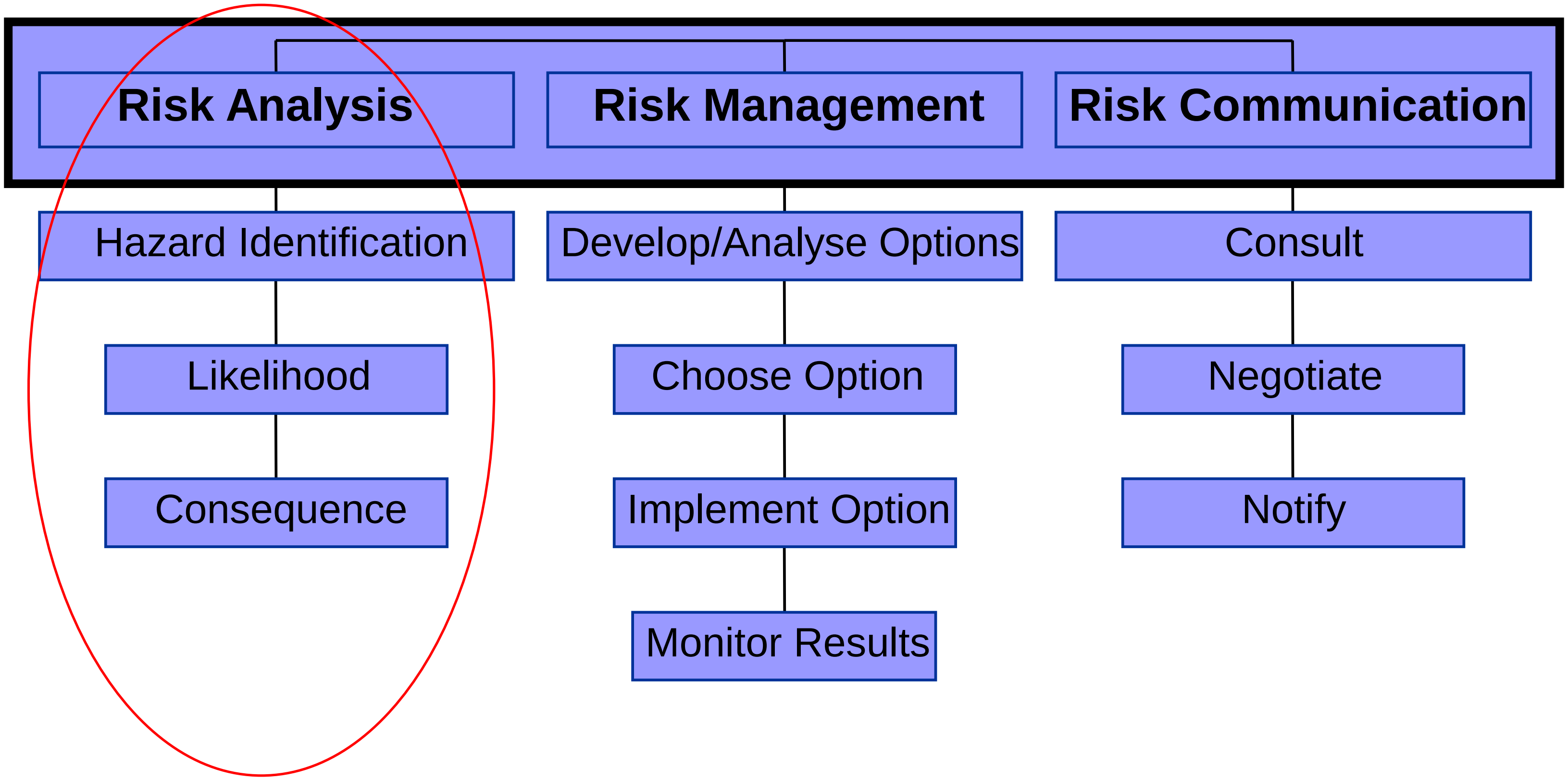
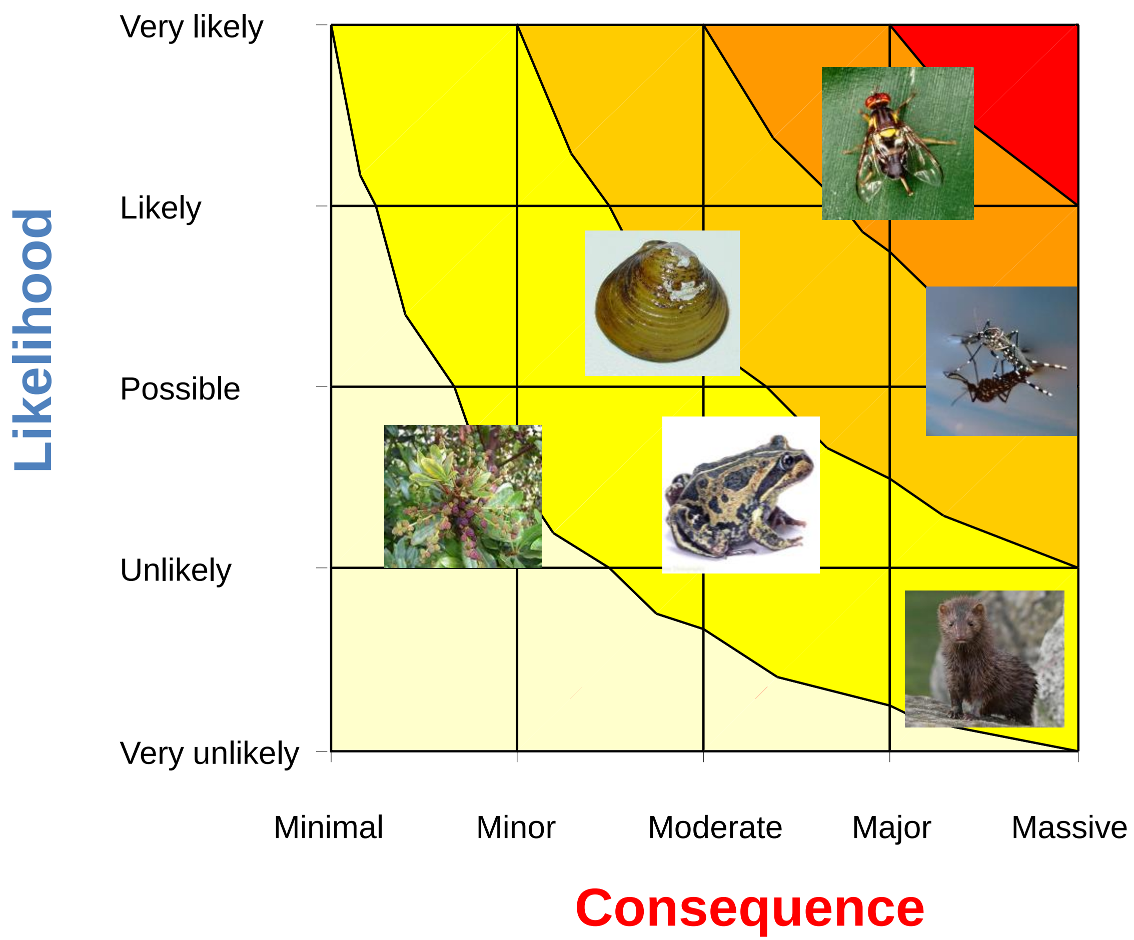
September 2019

Components of risk assessment

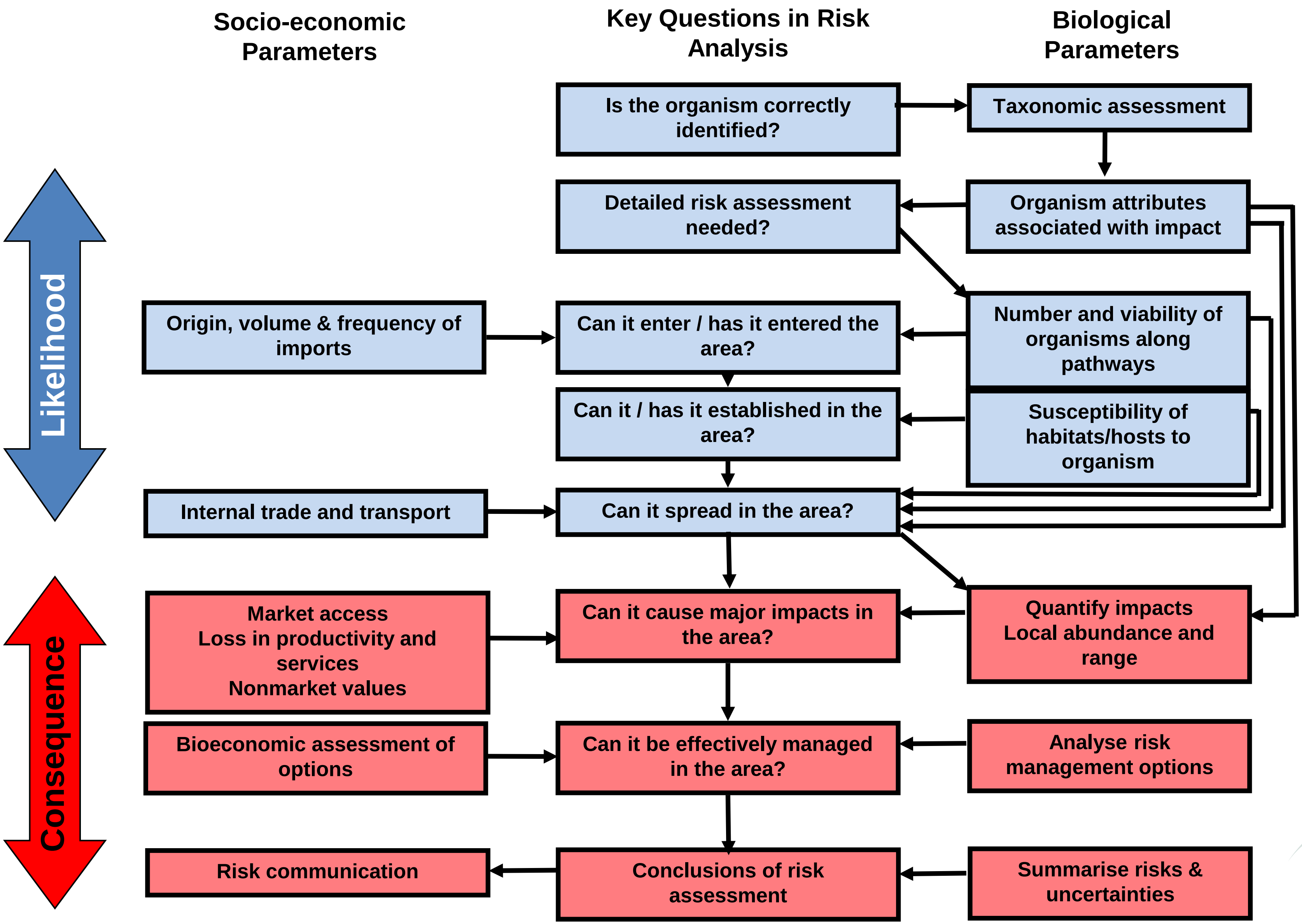


What is a risk analysis?

Risk assessment is a scientifically based process to identify hazards, characterize their adverse impacts, evaluate the level of exposure of a target to those hazards and estimate the risk



Key components in risk analysis



Australian Weed Risk Assessment Tool

Weed Risk Assessment System

Run | Get | Store | Print report
Species | Save | Help

Outcome: Evaluate
Score: 5
herbicide/insect demo

A.	**History/ Biogeography**			
1	*Domestication/ cultivation*	1.01	Is the species highly domesticated? If answer is 'no' go to 2.01	
		1.02	Is species naturalised where grown?	
		1.03	Does the species have weedy races?	
2	*Climate and Distribution*	2.01	Species suited to Australian climates (0-low; 1-intermediate; 2-high)	2
		2.02	Quality of climate match data (0-low; 1-intermediate; 2-high)	2
		2.03	Broad climate suitability (environmental versatility)	y
		2.04	Native or naturalised in regions with extended dry periods	y
		2.05	Does the species have a history of repeated introductions outside its natural range?	n
3	*Weed Elsewhere (interacts with 2.01 to give a weighted score)*	3.01	Naturalised beyond native range	y
		3.02	Garden/amenity/disturbance weed	y
		3.03	Weed of agriculture/horticulture/forestry	
		3.04	Environmental weed	
		3.05	Congeneric weed	n
B.	**Biology/Ecology**			
4	*Undesirable traits*	4.01	Produces spines, thorns or burrs	n
		4.02	Allelopathic	
		4.03	Parasitic	n
		4.04	Unpalatable to grazing animals	n
		4.05	Toxic to animals	n
		4.06	Host for recognised pests and pathogens	y
		4.07	Causes allergies or is otherwise toxic to humans	y
		4.08	Creates a fire hazard in natural ecosystems	n
		4.09	Is a shade tolerant plant at some stage of its life cycle	
		4.10	Grows on infertile soils	
		4.11	Climbing or smothering growth habit	n
		4.12	Forms dense thickets	n
5	*Plant type*	5.01	Aquatic	n
		5.02	Grass	y
		5.03	Nitrogen fixing woody plant	n
		5.04	Geophyte	n
6	*Reproduction*	6.01	Evidence of substantial reproductive failure in native habitat	
		6.02	Produces viable seed	y
		6.03	Hybridises naturally	y
		6.04	Self-fertilisation	n
		6.05	Requires specialist pollinators	n
		6.06	Reproduction by vegetative propagation	y
		6.07	Minimum generative time (years)	1.0

Biol Invasions (2010) 12:4085–4098
DOI 10.1007/s10530-010-9819-3

ORIGINAL PAPER

Evaluation of the Australian weed risk assessment system for the prediction of plant invasiveness in Canada

Alec McClay · Andrea Sissons · Claire Wilson · Sarah Davis

Biol Invasions
DOI 10.1007/s10530-012-0368-9

ORIGINAL PAPER

Testing the Australian Weed Risk Assessment with different estimates for invasiveness

T. A. A. Speek · J. A. R. Davies · L. A. P. Lotz · W. H. van der Putten

Biol Invasions (2010) 12:463–476
DOI 10.1007/s10530-009-9451-2

ORIGINAL PAPER

Predicting plant invaders in the Mediterranean through a weed risk assessment system

Núria Gassó · Corina Basnou · Montserrat Vilà

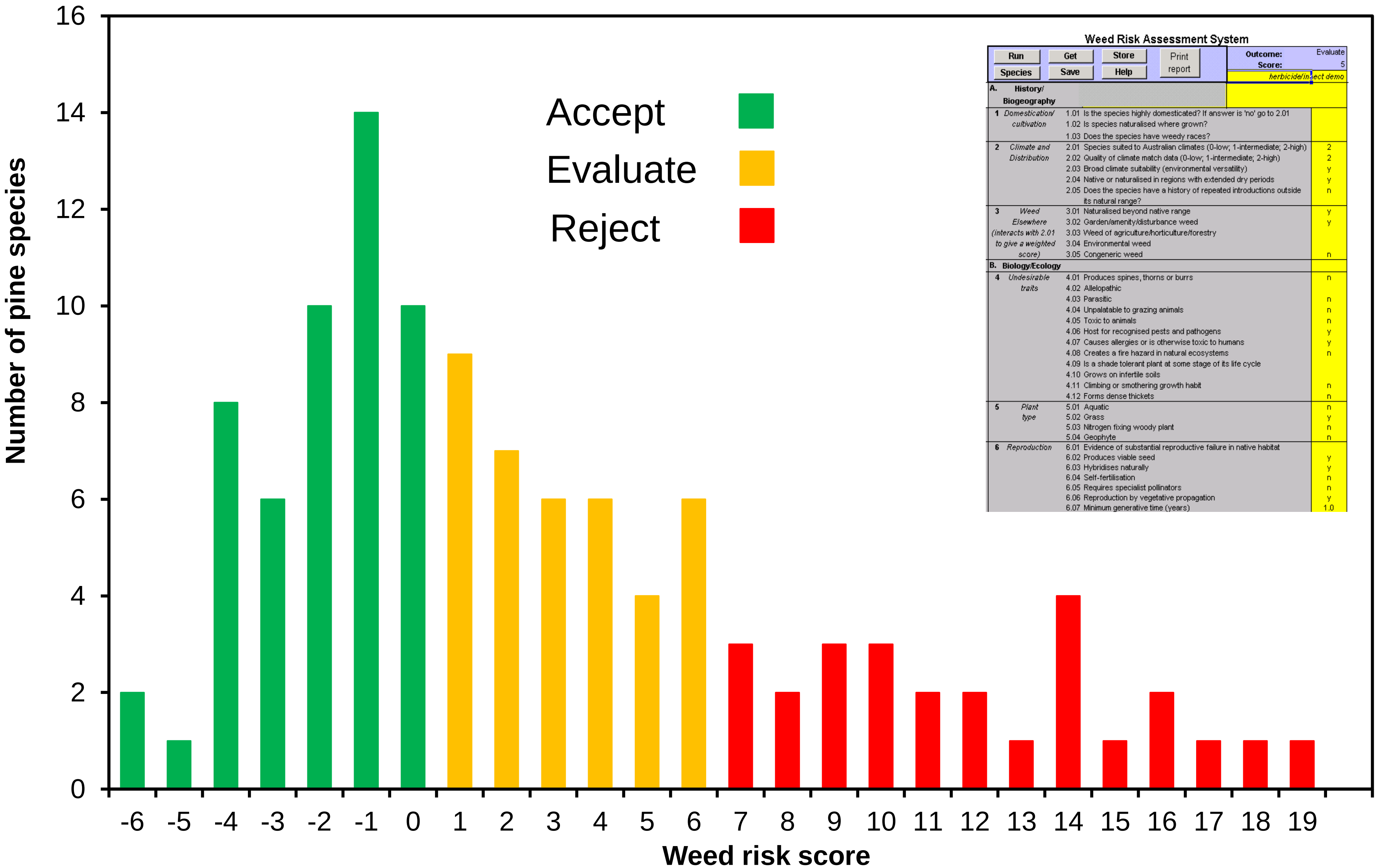
Biol Invasions
DOI 10.1007/s10530-011-0133-5

ORIGINAL PAPER

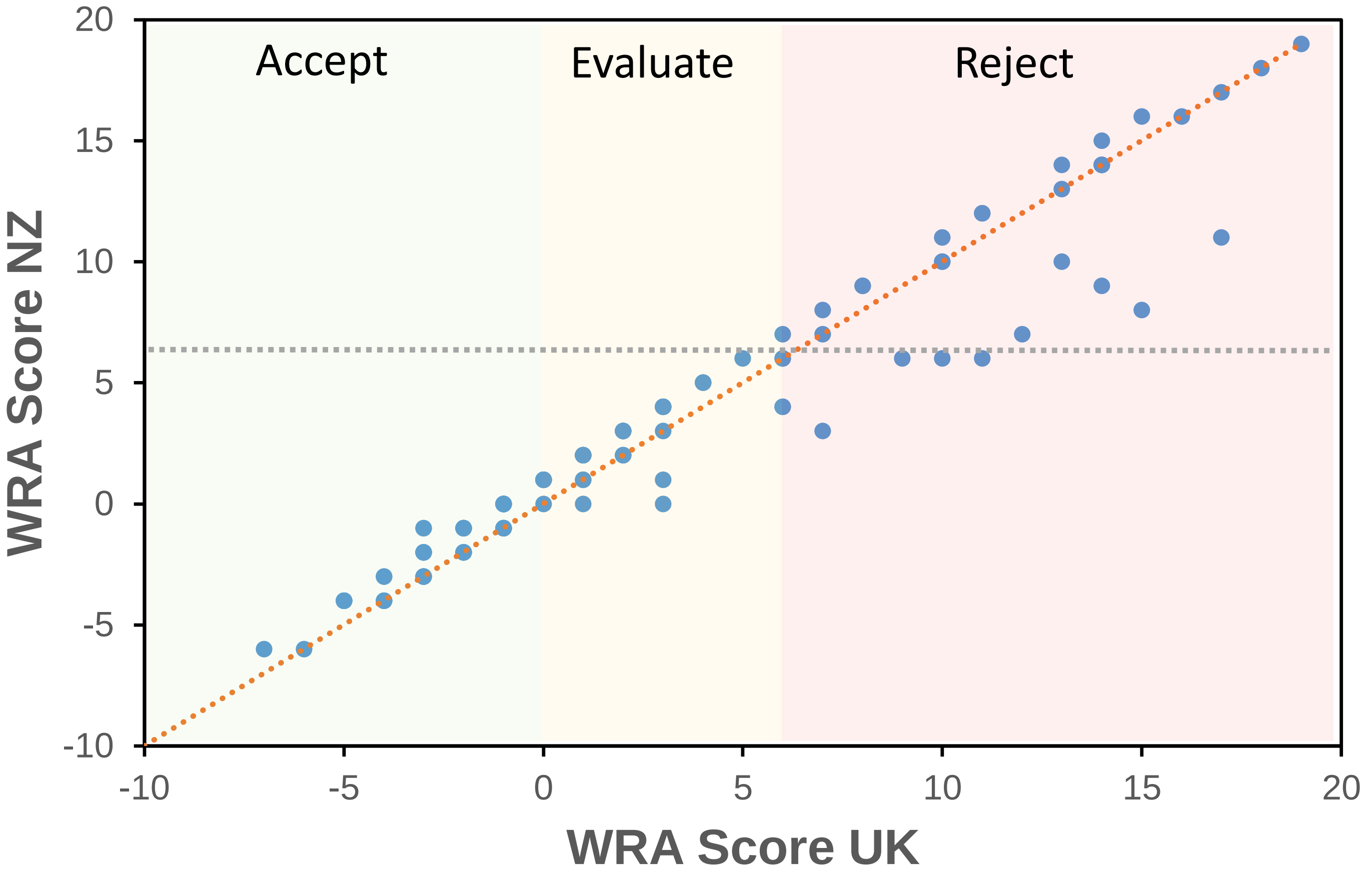
How robust is the Australian Weed Risk Assessment protocol? A test using pine invasions in the Northern and Southern hemispheres

Kirsty F. McGregor · Michael S. Watt · Philip E. Hulme · Richard P. Duncan

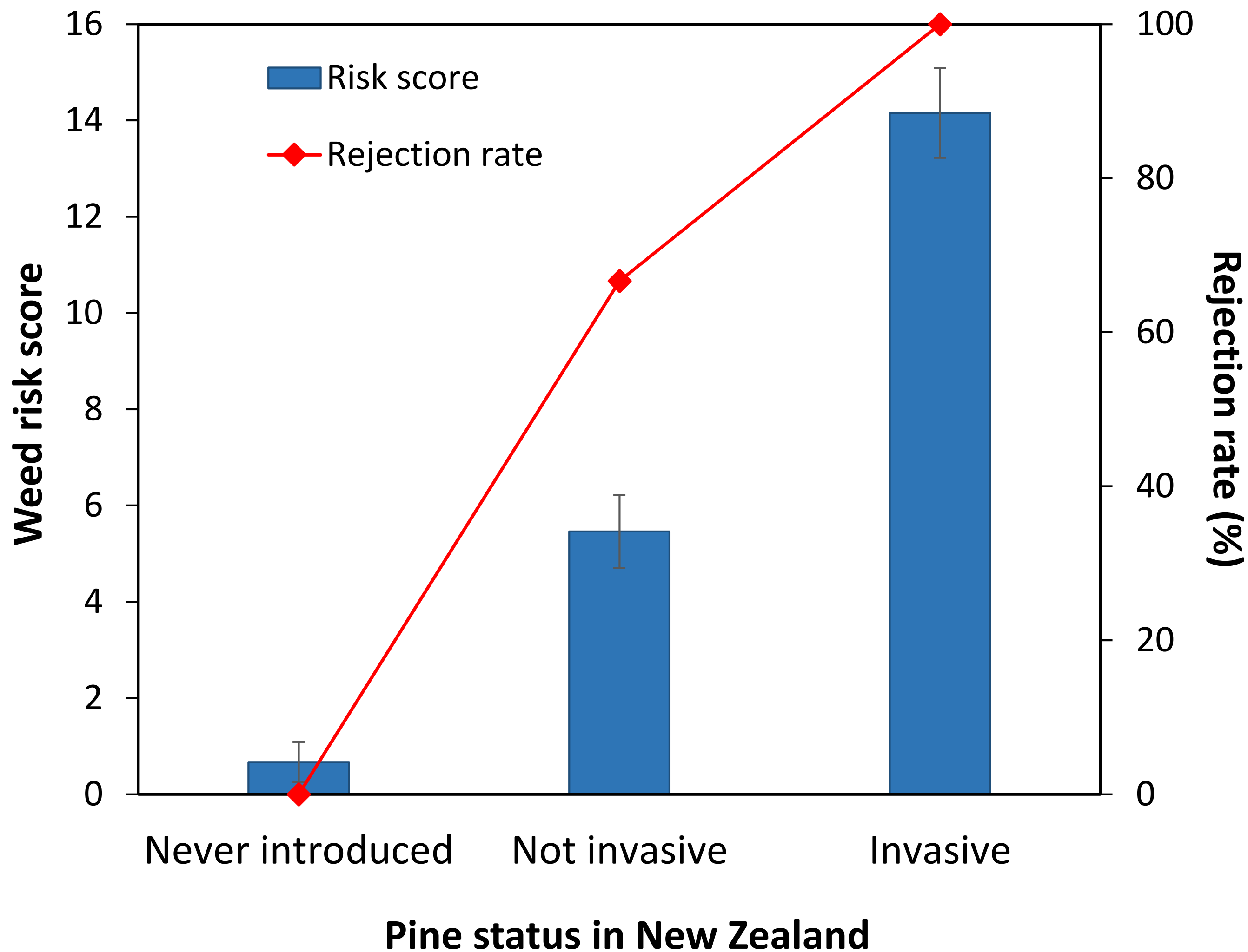
Risk assessment for pines (*Pinus* spp.)



Little variation in WRA between regions



Quantitative approaches are not perfect

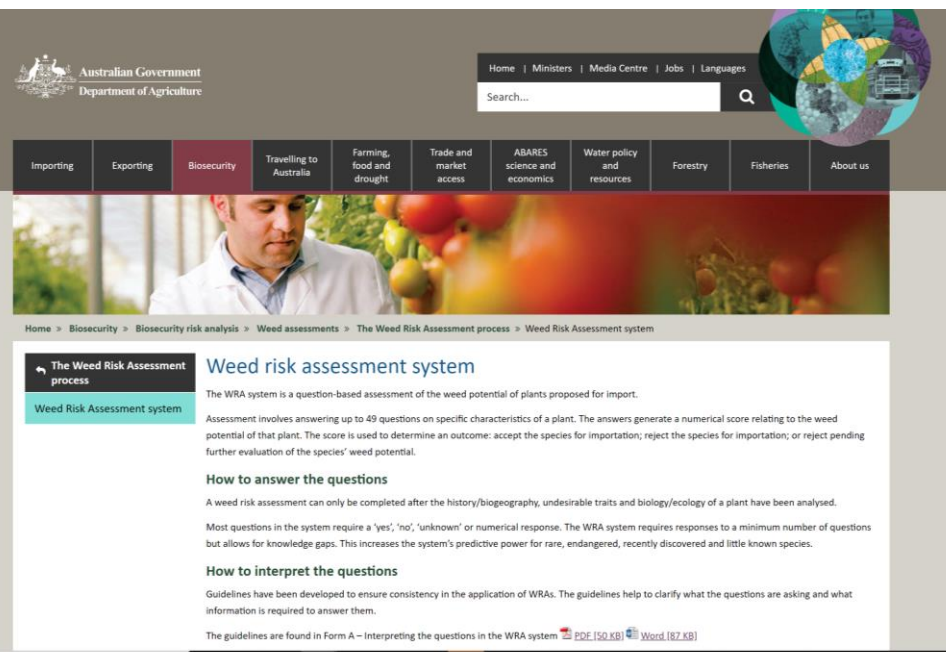


McGregor KF, Watt MS, Hulme PE & Duncan RP (2012) How robust is the Australian weed risk assessment protocol? A test using pine invasions in the Northern and Southern Hemisphere. *Biological Invasions*, **14**, 987–998.

So what is wrong with risk analysis?

Significant limits to the utility of current risk analysis approaches:

1. Strongly species focused but ignores socioeconomic drivers
2. Often ignores specifics of recipient ecosystem
3. Fails to adequately quantify introduction effort
4. Difficulties in quantifying uncertainty and variability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The Weed Risk Assessment process

Weed Risk Assessment system

Weed risk assessment system

The WRA system is a question-based assessment of the weed potential of plants proposed for import.

Assessment involves answering up to 49 questions on specific characteristics of a plant. The answers generate a numerical score relating to the weed potential of that plant. The score is used to determine an outcome: accept the species for importation; reject the species for importation; or reject pending further evaluation of the species' weed potential.

How to answer the questions

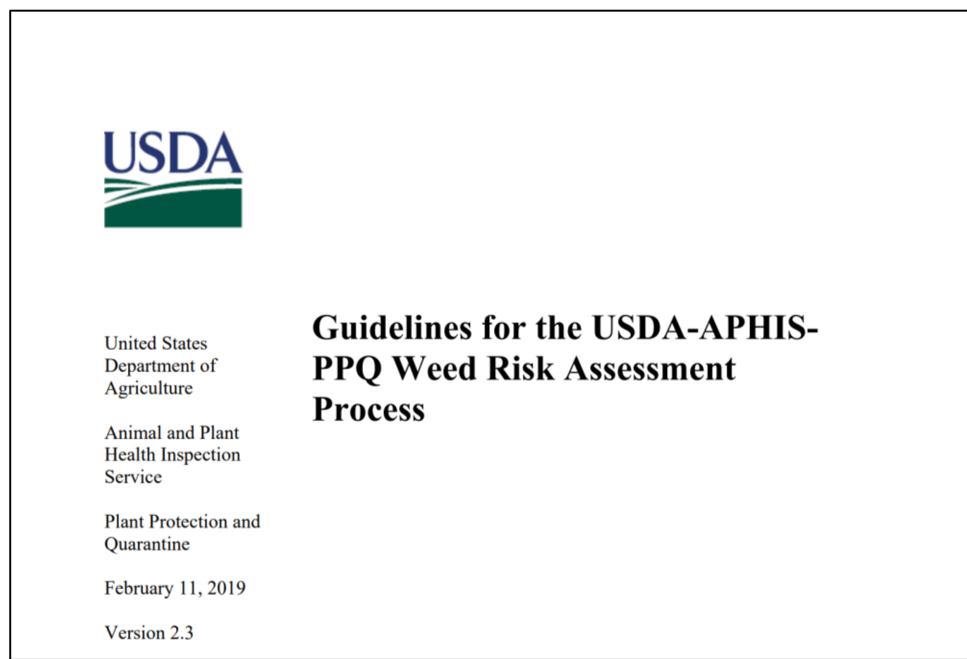
A weed risk assessment can only be completed after the history/biogeography, undesirable traits and biology/ecology of a plant have been analysed.

Most questions in the system require a 'yes', 'no', 'unknown' or numerical response. The WRA system requires responses to a minimum number of questions but allows for knowledge gaps. This increases the system's predictive power for rare, endangered, recently discovered and little known species.

How to interpret the questions

Guidelines have been developed to ensure consistency in the application of WRAs. The guidelines help to clarify what the questions are asking and what information is required to answer them.

The guidelines are found in Form A – Interpreting the questions in the WRA system PDF [50 KB] Word [87 KB]


USDA

United States Department of Agriculture

Animal and Plant Health Inspection Service

Plant Protection and Quarantine

February 11, 2019

Version 2.3

Guidelines for the USDA-APHIS-PPQ Weed Risk Assessment Process

Likelihood: how do invasive plants arrive

Deliberate release

Grain contaminants

Canal corridors

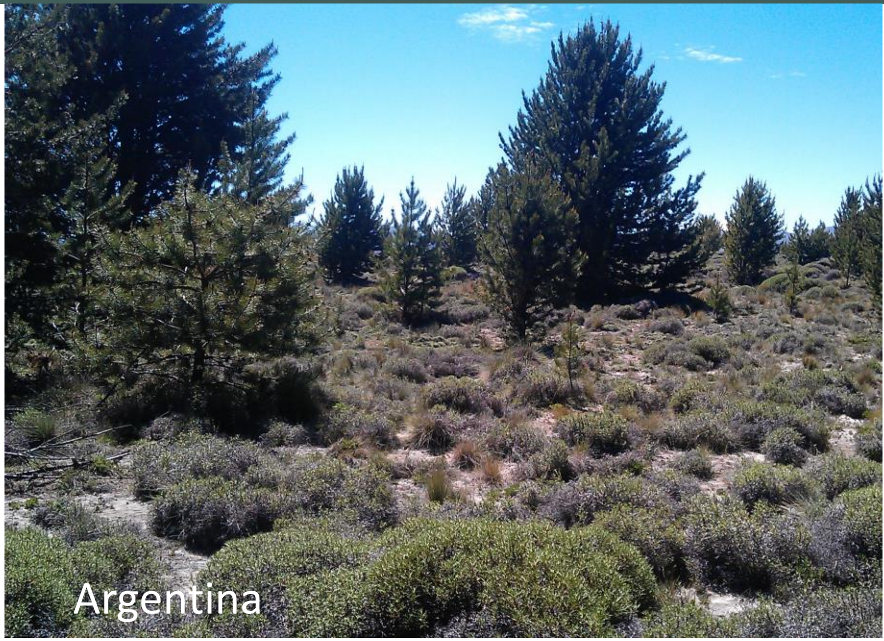
Escape from cultivation

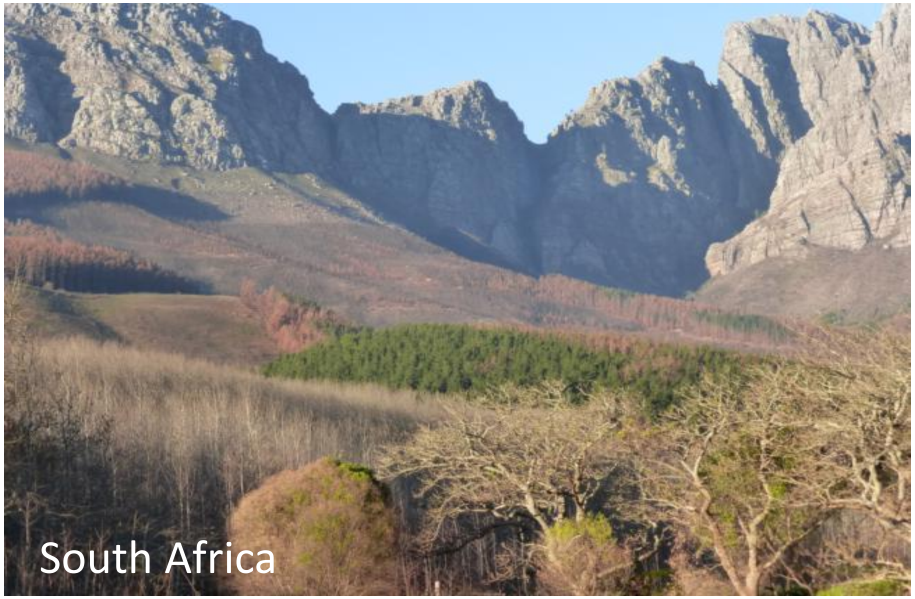
Stowaway on clothes

Natural dispersal

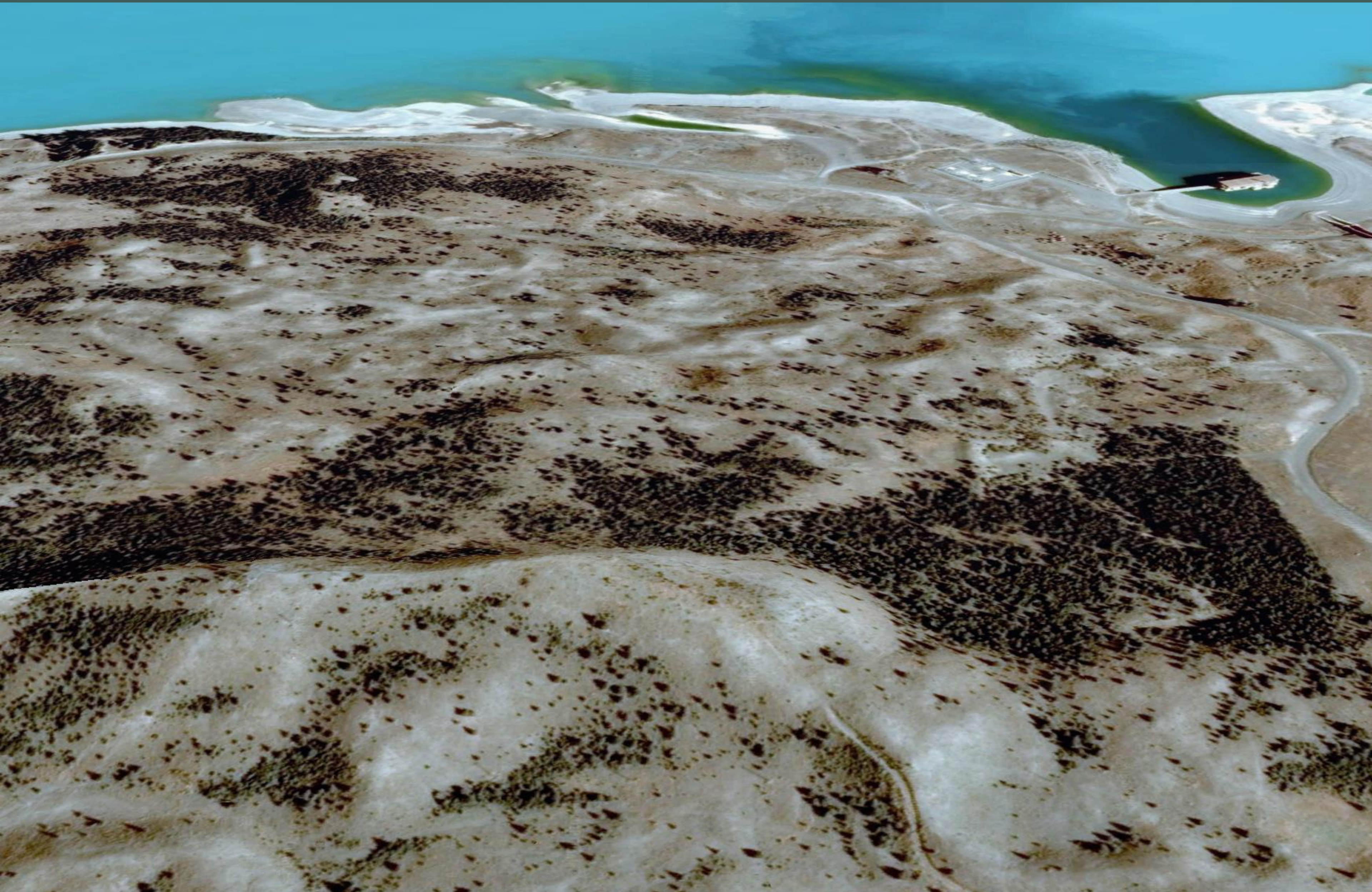
Hulme PE, Bacher S, Kenis M, Klotz S, Kühn I, Minchin D, Nentwig W, Olenin S, Panov V, Pergl J, Pyšek P, Roques A, Sol D, Solarz W & Vilà, M (2008) Grasping at the routes of biological invasions: a framework to better integrate pathways into policy *Journal of Applied Ecology*, **45**, 403-414

Pine invasions are a global phenomenon

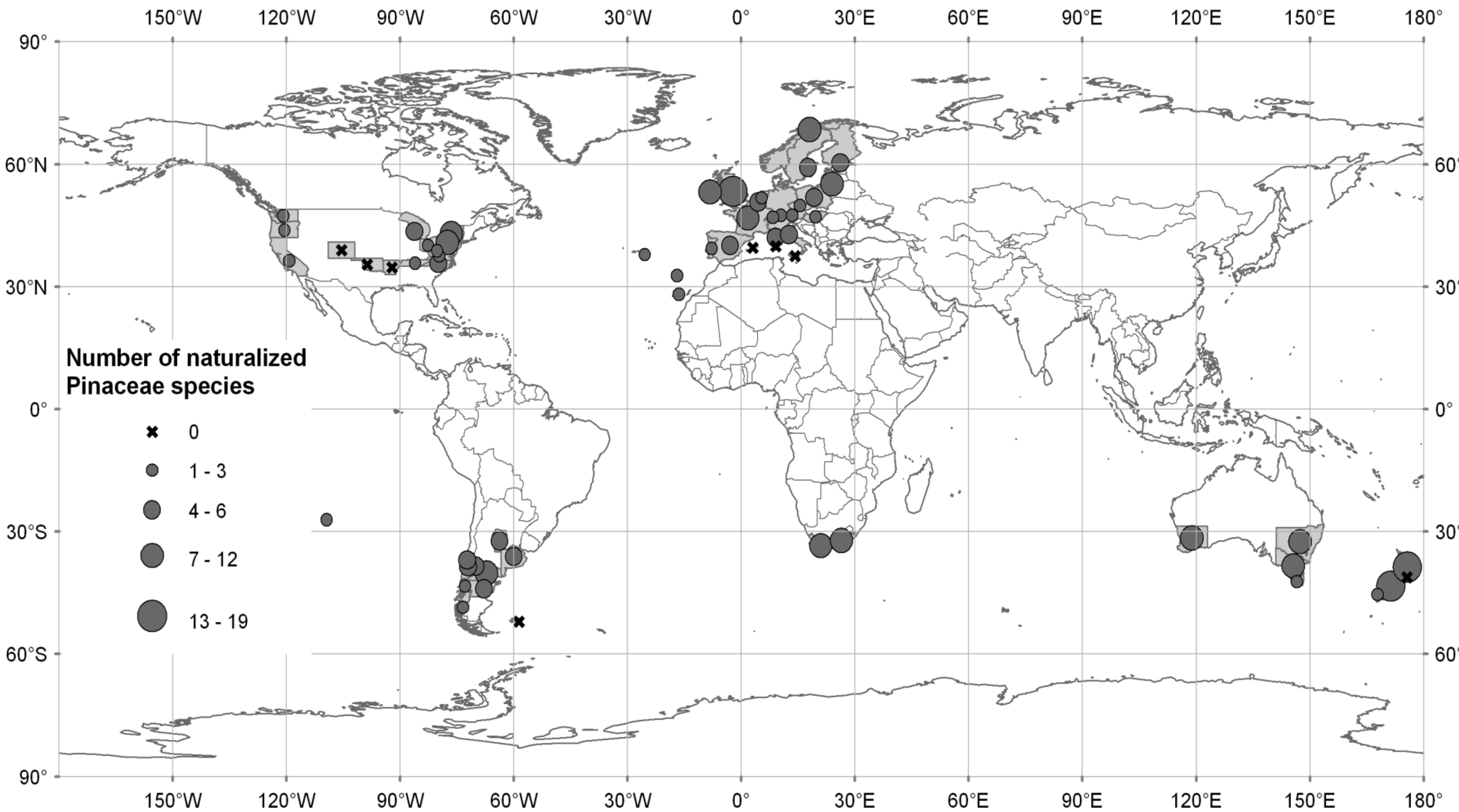




Wilding pine invasion in New Zealand

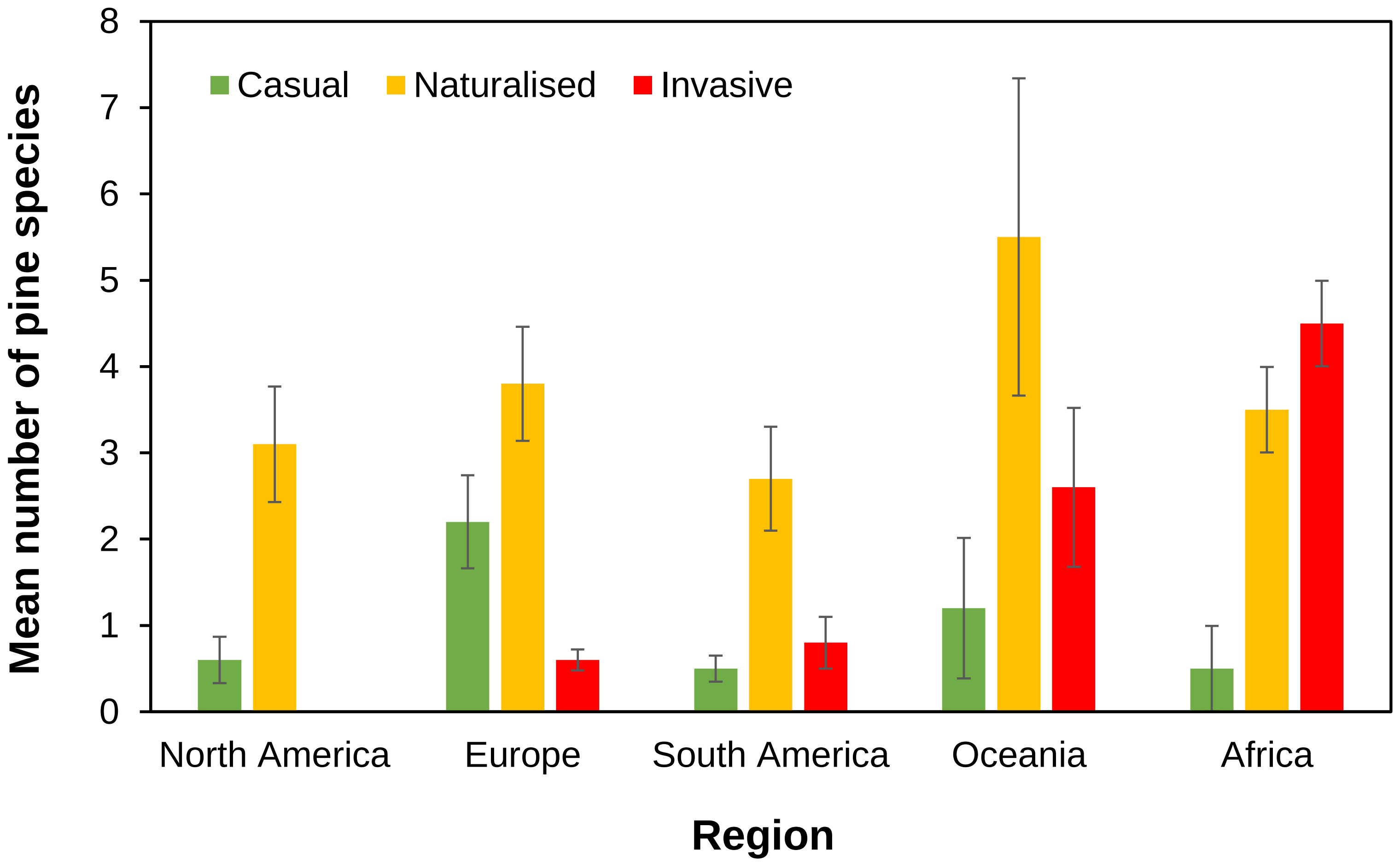


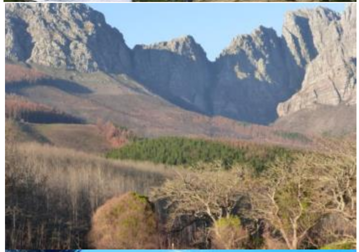
Biogeography of pine invasions



Essl F, Mang T, Dullinger S, Moser D & Hulme PE (2011) Macroecological drivers of alien conifer naturalizations worldwide. *Ecography*, **34**, 1076-1084.

Biogeography of pine invasions





Essl F, Mang T, Dullinger S, Moser D & Hulme PE (2011) Macroecological drivers of alien conifer naturalizations worldwide. *Ecography*, **34**, 1076-1084.

Biogeographic predictors of pine invasions

Predictor	Coefficient	Std. error	p-value
Region variables			
Hemisphere (southern)	0.64	0.25	0.01
Latitudinal range	0.59	0.13	<0.0001
Native vascular plant species richness	0.34	0.14	0.02
Alien conifer plantation area	0.32	0.11	0.003
Zonobiome match	1.08	0.21	<0.0001
Species variables			
Use as forestry species	1.75	0.32	<0.0001

Essl F, Mang T, Dullinger S, Moser D & Hulme PE (2011) Macroecological drivers of alien conifer naturalizations worldwide. *Ecography*, **34**, 1076-1084.

Consequence: multiple complex impacts

environmental

Competition

Pollination

Hybridisation

economic

Toxicity

Hydrology

Productivity

social

Aesthetics

Flammability

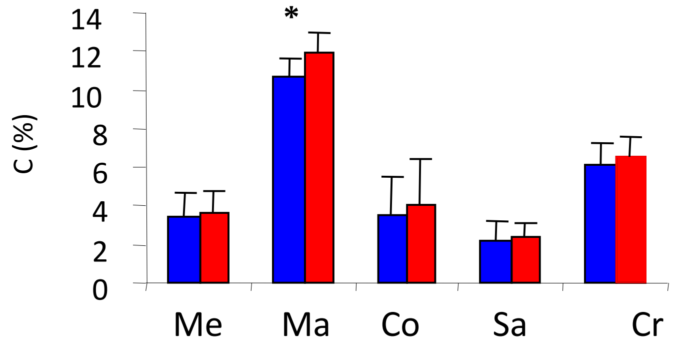
Allergy

Macroecological impact assessment

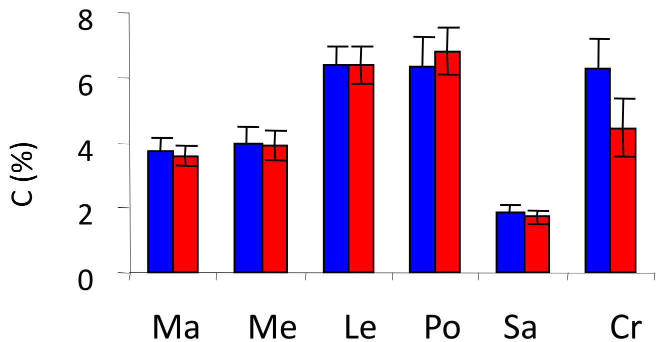
Geographic variation in impacts on soil C

Uninvaded

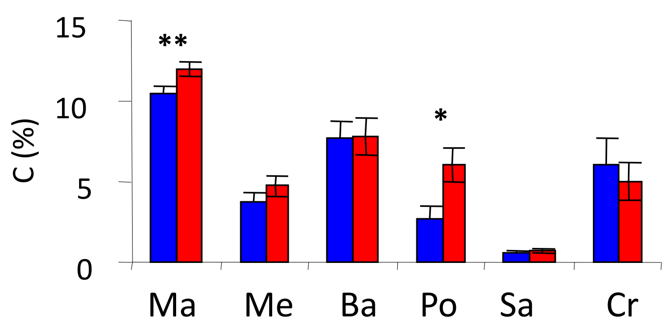
Invaded



Ailanthus altissima



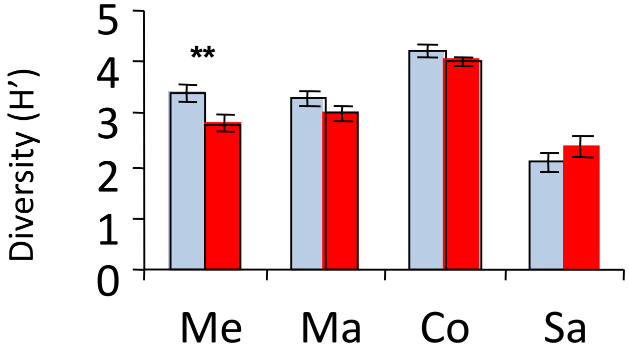
Oxalis pes caprae



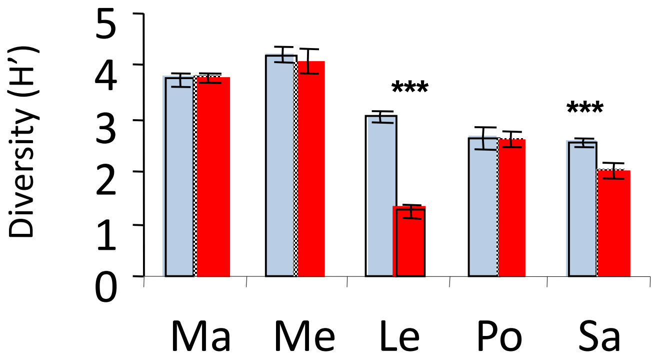
Carpobrotus spp.

Geographic variation in impacts on diversity

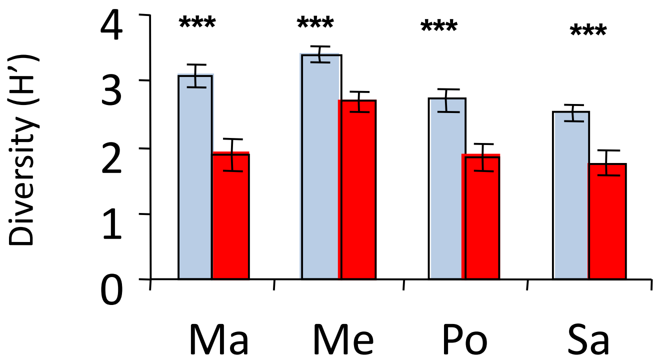
Uninvaded
Invaded



Ailanthus altissima

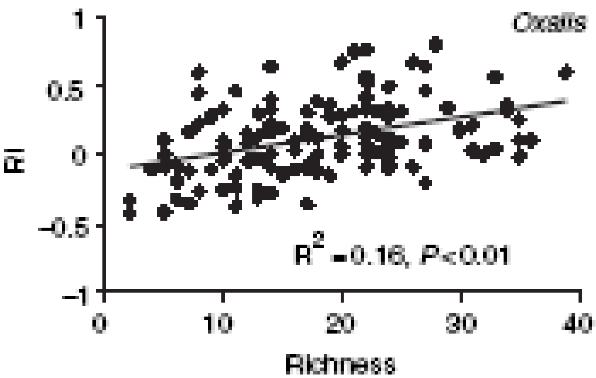


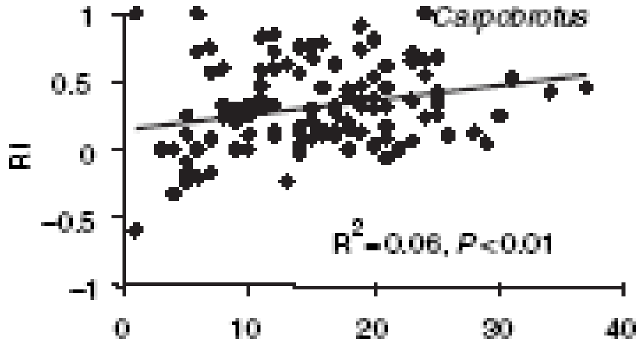
Oxalis pes caprae

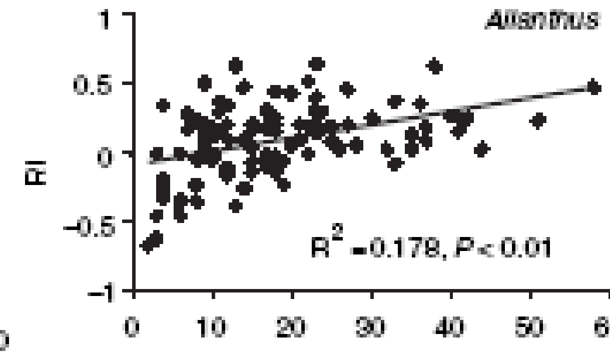


Carpobrotus spp.

Impacts depend on invaded community







Oxalis pes caprae

Carpobrotus edulis

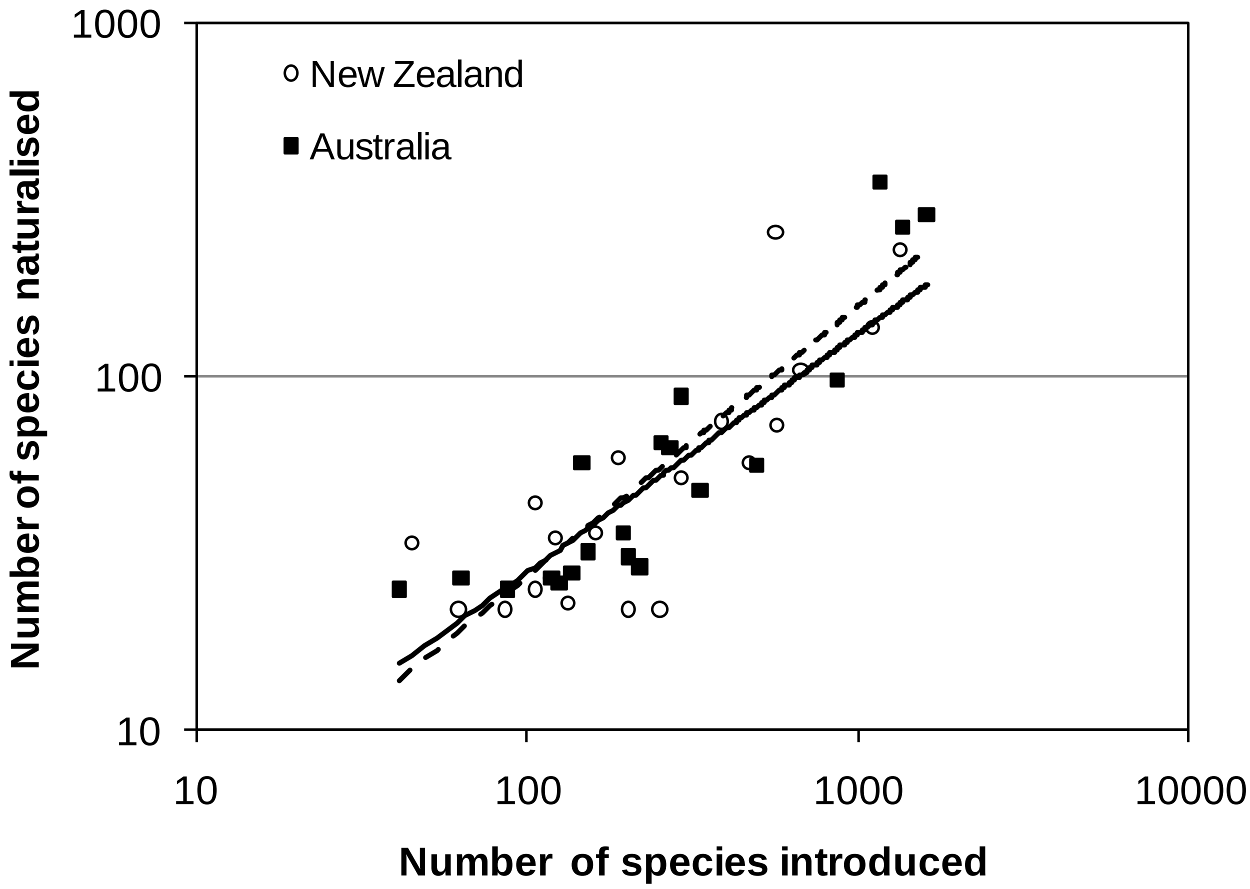
Ailanthus altissima

Aliens INCREASE diversity in species poor habitats but DECREASE diversity in species rich habitats

Variation in likelihood and consequence

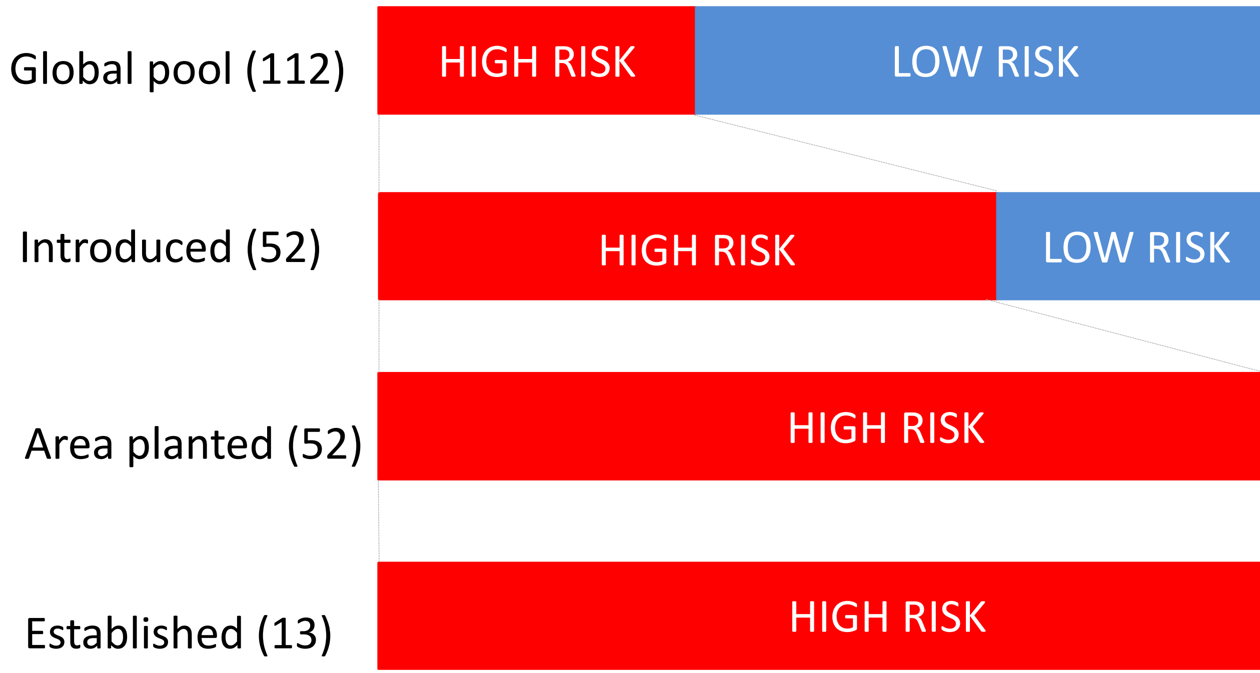
1. Likelihood is influenced by species traits, especially climate match and species ability to survive in a wide range of environments
2. However, likelihood also determined by characteristics and availability of recipient ecosystems.
3. Sociological attributes such as pathways and introduction effort also shape risk
4. Consequences are often complex and changes to different ecosystem attributes may not be correlated in that invasion may increase some functions but decrease others.
5. Even within a similar ecosystem, the magnitude of any impacts can be strongly context-dependent and reflect attributes such as ecosystem productivity

Importance of introduction effort



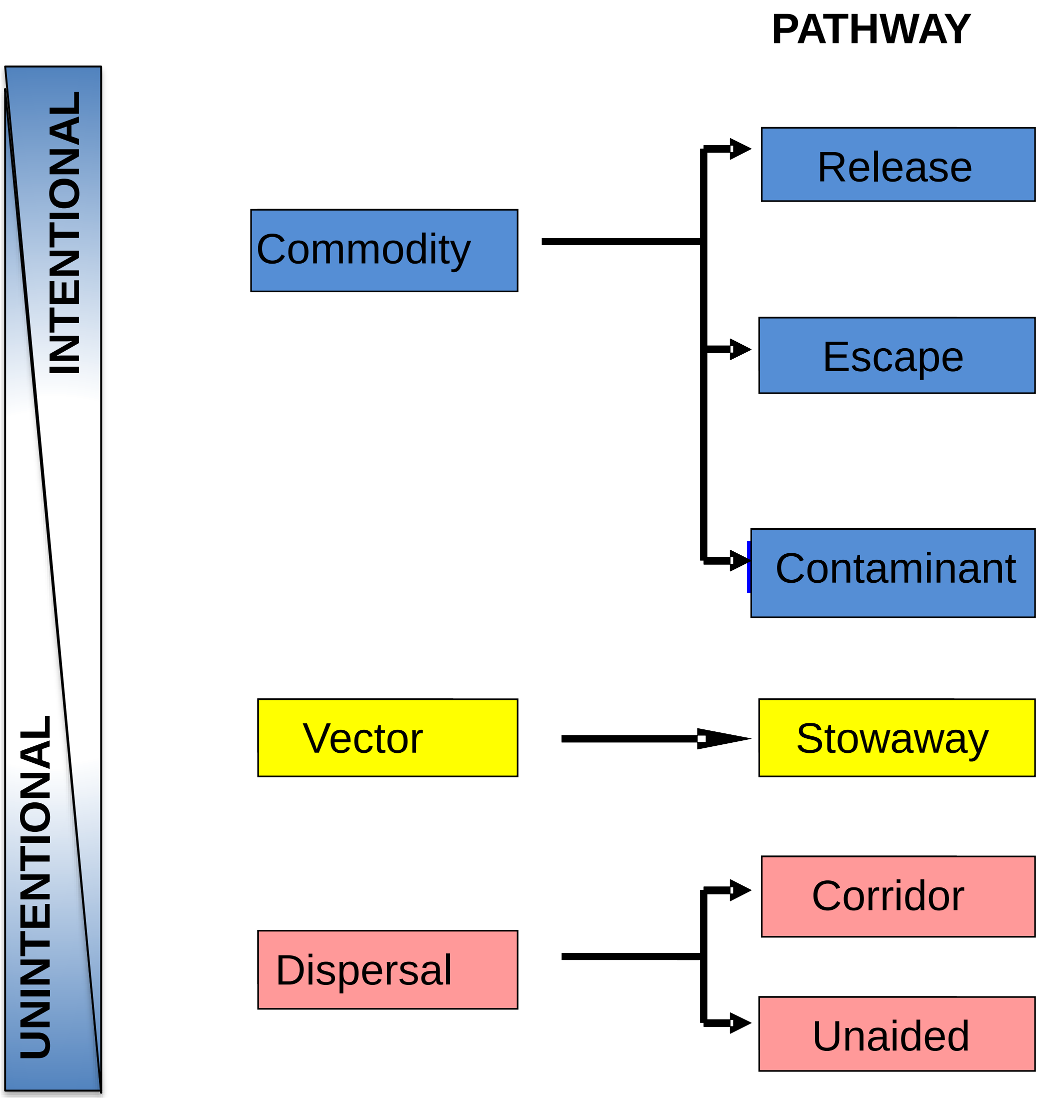
Hulme PE (2012) Weed risk assessment: a way forward or a waste of time? *Journal of Applied Ecology,* **49**, 10-19

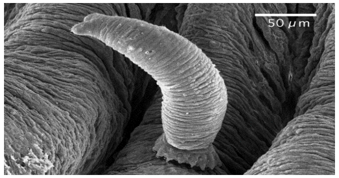
Introduction effort not independent of traits



McGregor KF, Watt MS, Hulme PE & Duncan RP (2012) What determines pine naturalization: species traits, climate suitability or forestry use? *Diversity & Distributions*, **18**, 1013–1023.

Pathways: a measure of introduction effort





Pathways: success across multiple stages

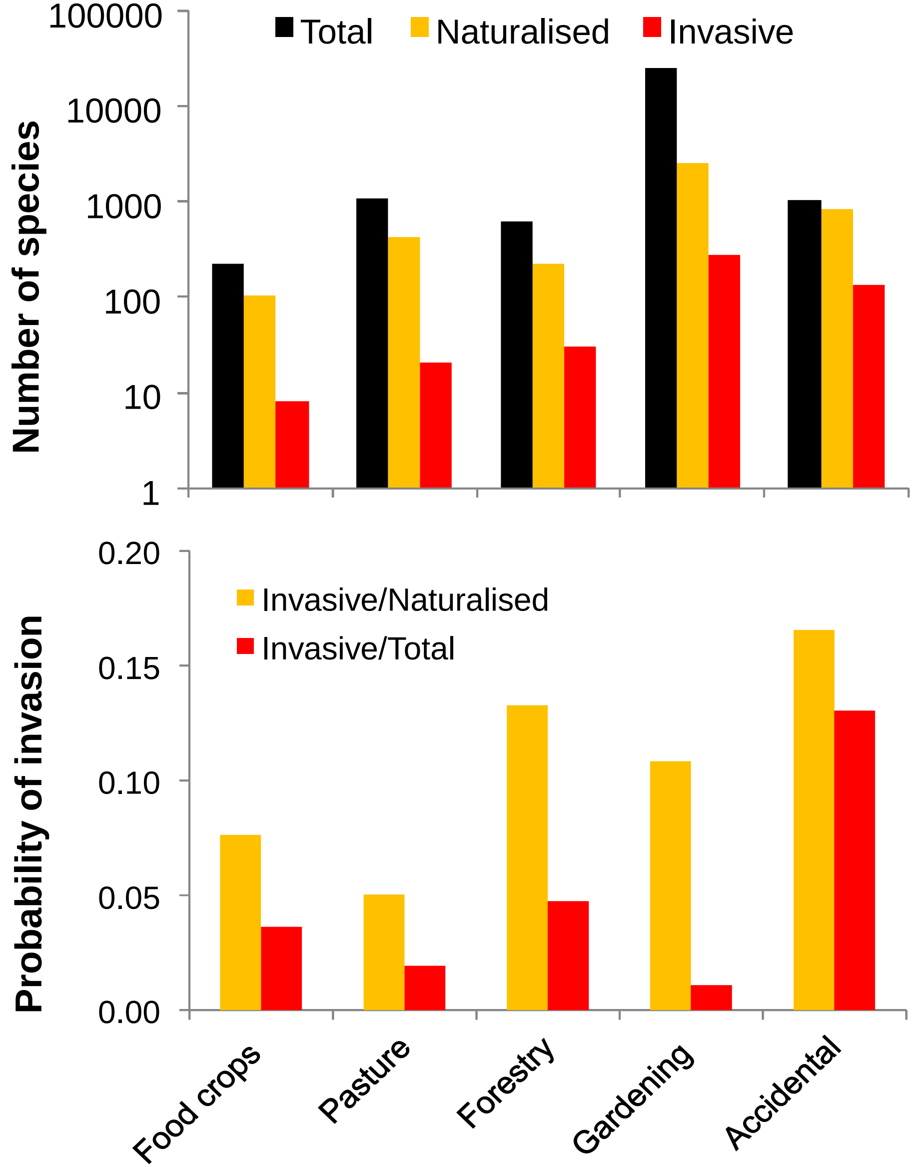
INITIAL INTRODUCTION INTO REGION

PATHWAY

- Commodity
  - Release
  - Escape
  - Contaminant
- Vector
  - Stowaway
- Dispersal
  - Corridor
  - Unaided

ARRIVAL | HABITAT | REPRODUCE | SPREAD

Pathways: silent evidence of failures



Hulme PE (2012) Weed risk assessment: a way forward or a waste of time? *Journal of Applied Ecology,* **49**, 10-19

Uncertainties in introduction effort

1. Pathways are increasingly used to describe invasions but may be more important in risk management than risk analysis

2. Pathways may not adequately capture introduction effort which may be measured by other variables e.g. import volume, area planted

3. Not capturing information on species that fail to establish can give a biased picture of risk relating to pathways

4. Integrating pathways in risk analysis will require a more quantitative framework that captures role of introduction effort on success or failure of species to become established.

Facing imperfect knowledge

Likelihood

	Little data/ knowledge	Much data/ knowledge
Much data/ knowledge	**Ambiguity** *e.g. Contending experts/fields* *Incommensurable priorities*	**Risk** *e.g. Familiar systems* *Known invasive species*
Little data/ knowledge	**Ignorance** *e.g. Unanticipated effects* *Evolution in organism*	**Uncertainty** *e.g. Complex non-linear systems* *Human element in causal models*

Consequences

Hulme PE (2011) Biosecurity: the changing face of invasion biology In: *Fifty Years of Invasion Ecology – The Legacy of Charles Elton* pp. 301-314 David M. Richardson (Ed.) Blackwells.

Risk: in the knowledge comfort zone

Understand impact	Monitor likelihood	Planned response

Ideally impacts are well known, routes of entry understood, scientific expertise available and response planned beforehand.

Ambiguity: perceptions of hazard differ

A forester engages in efforts to eradicate the velvet tree *Miconia calvescens* in Hawaii.

Don't judge species on their origins

Conservationists should assess organisms on environmental impact rather than on whether they are natives, argue **Mark Davis** and 18 other ecologists.

Complexity of defining impacts, especially on value of nature, often leads to conflicts regarding risk assessment.

Uncertainty: underestimating likelihoods

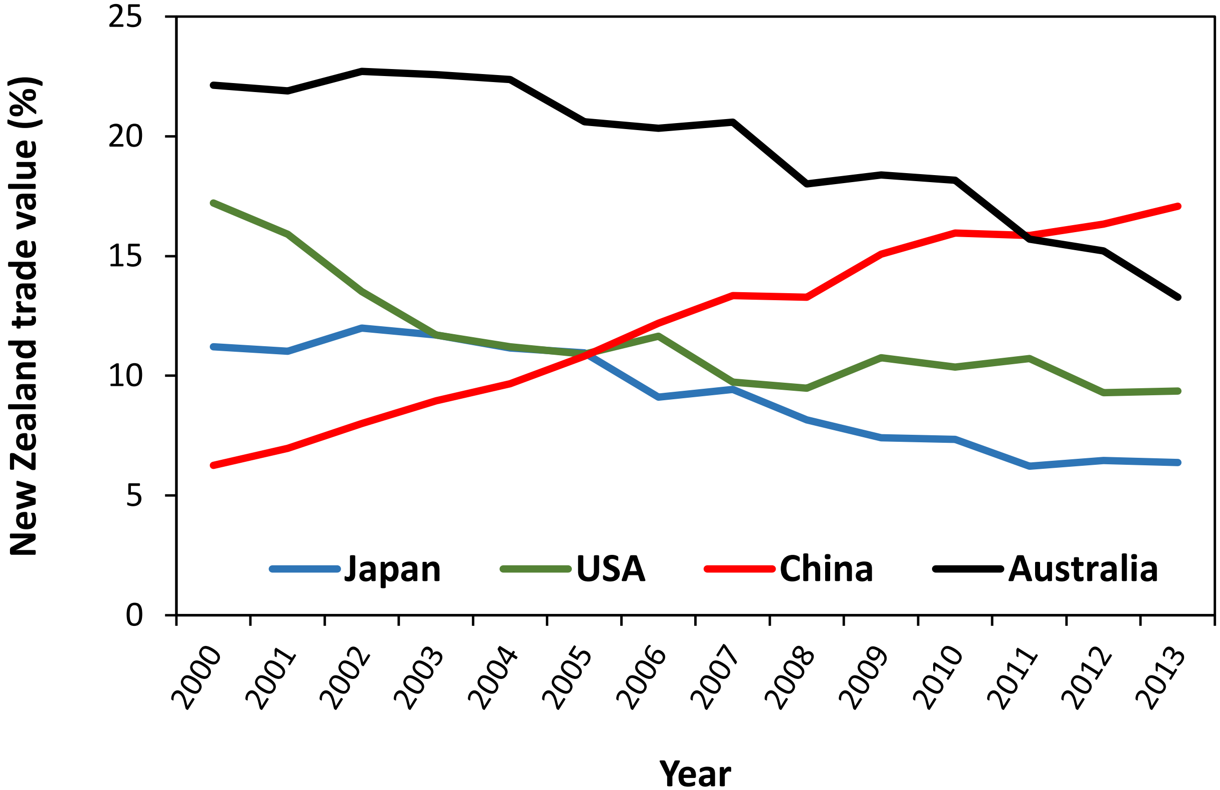
Understand impact | Limited surveillance | Difficult containment





Assessment or risks assumes good knowledge of likelihood of entry and rational behaviour of citizens and visitors.

Uncertainty: past is no guide to the future



Ignorance: Some risk are simply not known

Species “off radar”

Delay in response

Difficult containment

7, 2010 THE DOMINION POST A3

River alga still spreading

DIDYMO has been found in three more Tasman rivers – the Pearse in the Motueka Valley and Riwaka River, near Motueka, and Maruia River below Murchison. About 80 South Island waterways have been infected with the alga since it was found in the Mararoa River in 2001. Officials are urging river users to clean and dry gear after use. The Press

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Media releases

In this section:
Media releases
2014

Kauri dieback detected in Coromandel

Date: 25 March 2014
Source: Joint release from the Minister for Primary Industries and the Minister of Conservation

Contacts
Seonah Choi (Dr Sm
Phil Rennie (Mr Guy)

Test results showing the presence of *Phytophthora* taxon Agathis (PTA) or Kauri dieback disease in the Whangapoua Forest just north of Whitianga is a major concern, Conservation Minister Dr Nick Smith and Primary Industries Minister Nathan Guy say.

“This is a serious blow to our efforts to conserve kauri and protect it from this
a precautionary approach by immediately closing the affected area to reduce
will also enable time to determine the extent of the disease and our on-going
dieback in the wake of this negative news,” Dr Smith says.

Independently of existing knowledge of current and potential risks, new threats may appear with no prior history or expectation.

Addressing uncertainty, ambiguity, ignorance

Likelihood		Little data/ knowledge	Much data/ knowledge
	Much data/ knowledge	**Ambiguity** *e.g. Contending experts/fields* *Incommensurable priorities* **Qualitative approaches** e.g. Deliberation Bayesian belief networks	**Risk** *e.g. Familiar systems* *Known invasive species* **Quantitative approaches** e.g. Multivariate regression Bayesian methods
	Little data/ knowledge	**Ignorance** *e.g. Unanticipated effects* *Evolution in organism* **Horizon scanning approaches** e.g. Scenario analysis Precaution	**Uncertainty** *e.g. Complex non-linear systems* *Human element in causal models* **Semi-quantitative approaches** e.g. Scoring methods Sensitivity analysis

Consequences

Hulme PE (2011) Biosecurity: the changing face of invasion biology In: *Fifty Years of Invasion Ecology – The Legacy of Charles Elton* pp. 301-314 David M. Richardson (Ed.) Blackwells.

Conclusions

1. Paucity of information on impacts of invasive species limit the comparative assessment of different hazards and creates **ambiguity**
2. Incomplete information on introductions and the complexity of invasions lead to **uncertainty** in the likelihoods of invasion
3. Unexpected incursions challenge our ability to predict invasion risks and even the best biosecurity systems suffer from **ignorance**
4. Tools have been developed to counter ambiguity, uncertainty and ignorance but these can never be foolproof.

Many Thanks

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