When does community change require a conservation response?

From a new arrival to a defensible decision.

1 CHANGE	2 STAKES	3 TIMING	4 RESPONSE	5 OUTCOME

What would make you respond and what would change your mind?

OPENING CASE

When an invasion becomes impossible to ignore

Rugulopteryx okamurae turns an underwater community shift into a public and economic crisis.



The visible beach problem is only the surface of the invasion.

EL PAÍS — 14 JUN 2024

> “Un alga invasora implacable amenaza la biodiversidad, la pesca y el turismo en el sur de España”

THE GUARDIAN — 27 JUL 2025

> “Thousands of tons of invasive seaweed ‘overwhelming’ Spanish beaches”

≈ €3.3M / YEAR

minimum annual loss estimated for Tarifa

2,300 t removed from Tarifa beaches in 2020

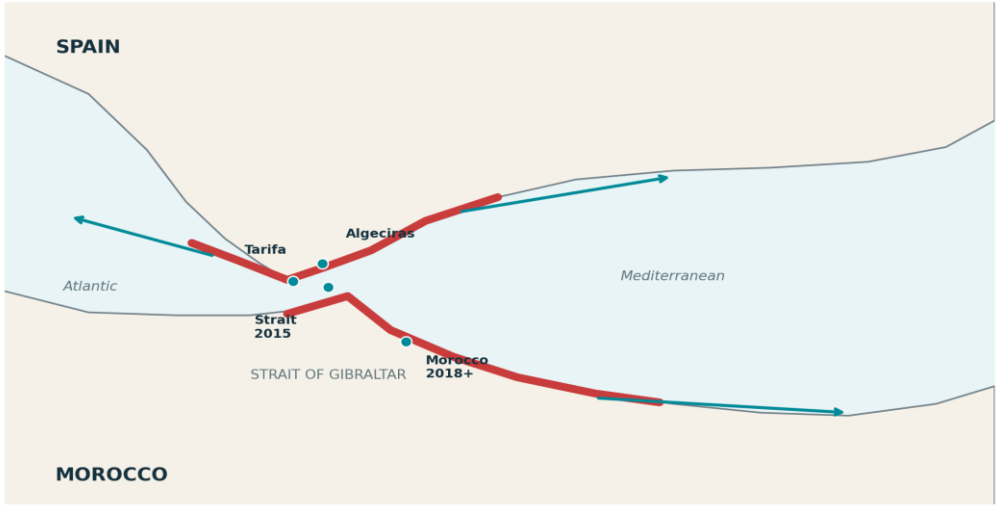
What happened below water?

CASE STUDY

Below the surface: a benthic takeover

The invasion is not just more biomass on beaches, it changes who occupies the seafloor.





2015–16: rapid establishment around the Strait; subsequent spread beyond it

WHAT CHANGED?

SPACE	Dense mats occupy rocky habitat and interact directly with resident macroalgae.
COMMUNITY	Resident sessile biota declined after the 2017 invasion peak at monitored sites.
LIVELIHOODS	Detached biomass enters fishing gear and beaches, transferring ecological change into economic cost.

So: when does community change require a conservation response?

Five questions turn community change into a conservation decision

CHANGE

What is changing?

Origin, establishment, spread and spatial scale.

STAKES

What is at risk?

Native communities, processes and people.

TIMING

Can we afford to wait?

Prevention, detection and uncertainty.

RESPONSE

Which response is justified?

Feasibility, costs and unintended effects.

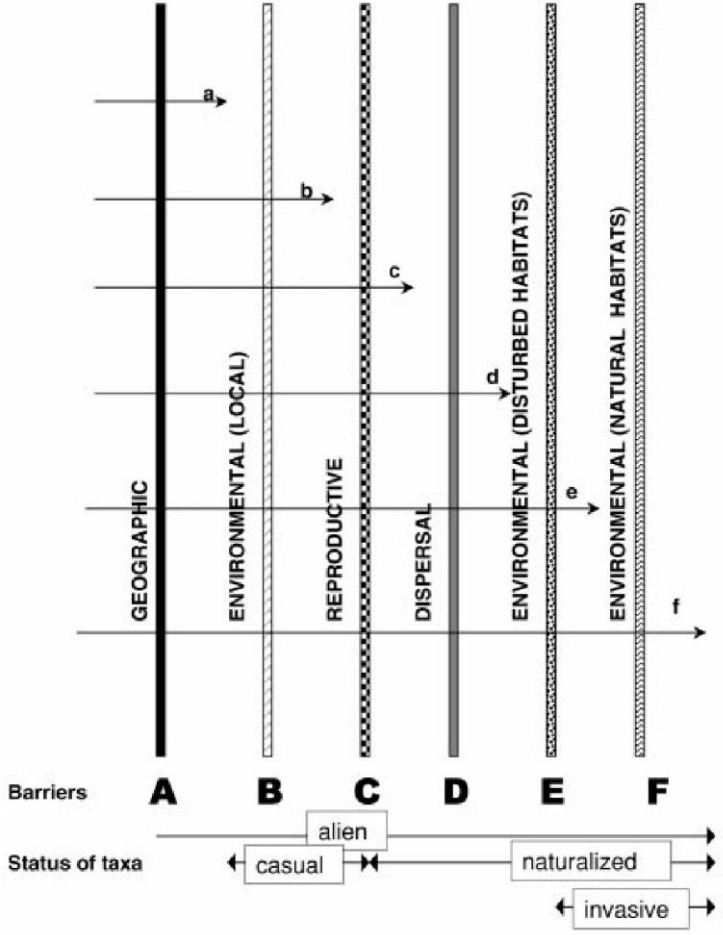
OUTCOME

Did we protect our target?

Recovery, persistence and revision.

Detection is useful only if it can trigger a sufficiently rapid response

Introduced plants must cross barriers before they spread



INTRODUCTION

Human-assisted crossing of a geographical barrier.

NATURALISATION

Self-sustaining reproduction without repeated introductions.

INVASION IN THIS PAPER

Reproductive offspring establish beyond introduction sites.

Barrier crossing is not necessarily irreversible.

Introduction, naturalization, and invasion describe different stages in this framework.

Richardson et al. (2000) | Diversity and Distributions 6:93–107 | doi:10.1046/j.1472-4642.2000.00083.x | Fig. 1

“Invasive” does not mean the same thing in every paper

Two sources use different definitions.

RICHARDSON 2000

Process-based use

A naturalized plant spreads away from its introduction site.

Harm is not built into the word “invasive”.

GIDIAS 2025

Impact-inclusive use

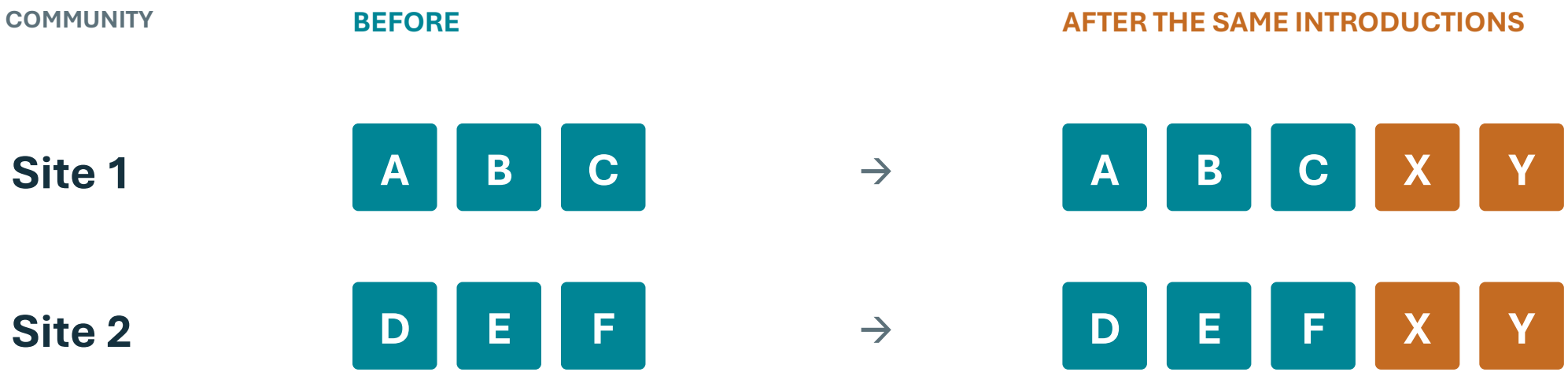
Introduced by people beyond its natural range, a species causes negative impacts on native biodiversity, ecosystem services or people.

Same term ≠ operational definition.

> **Always state whether “invasive” refers to spread, harmful impact, or both.**

Richardson et al. (2000), abstract and Table 1; Bacher et al. (2025),

Local richness can rise while communities become more alike



Local richness: 3 → 5 species per site

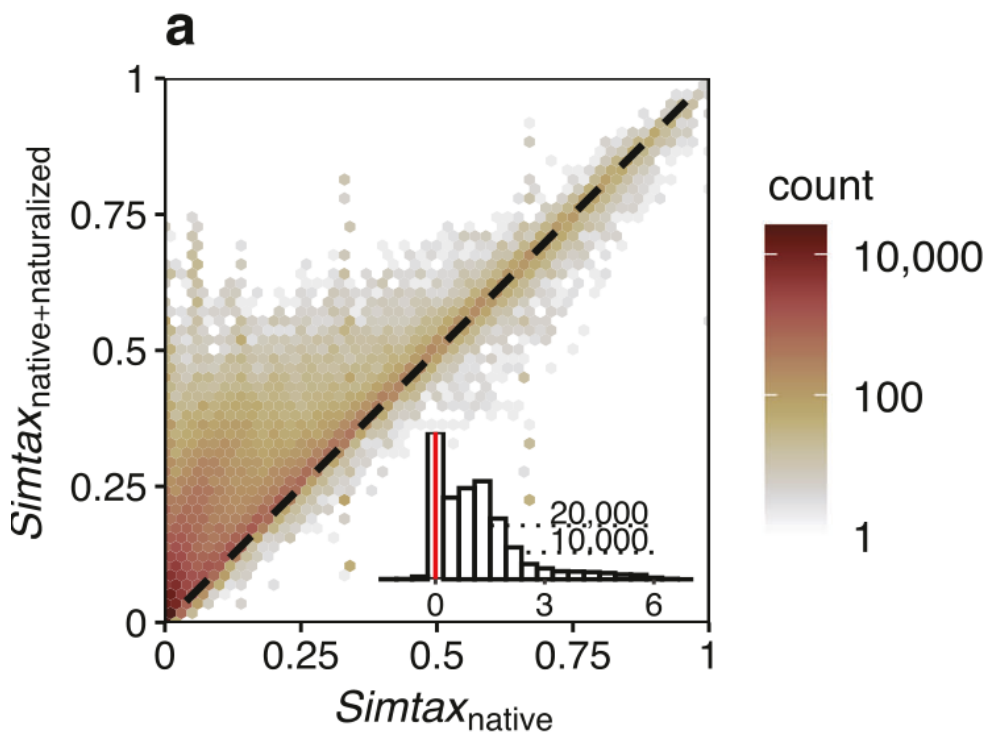
Jaccard similarity between sites: 0% → 25%

Species richness within a site and similarity between sites are different properties.

Concept: Olden et al. (2004)

Naturalized plants make many regional floras more alike

658 regions: compare the same pairs using native species only, then native + naturalised species.



PAIRWISE COMPARISONS

90.7%

of region pairs became more taxonomically similar.

READ THE DIAGONAL

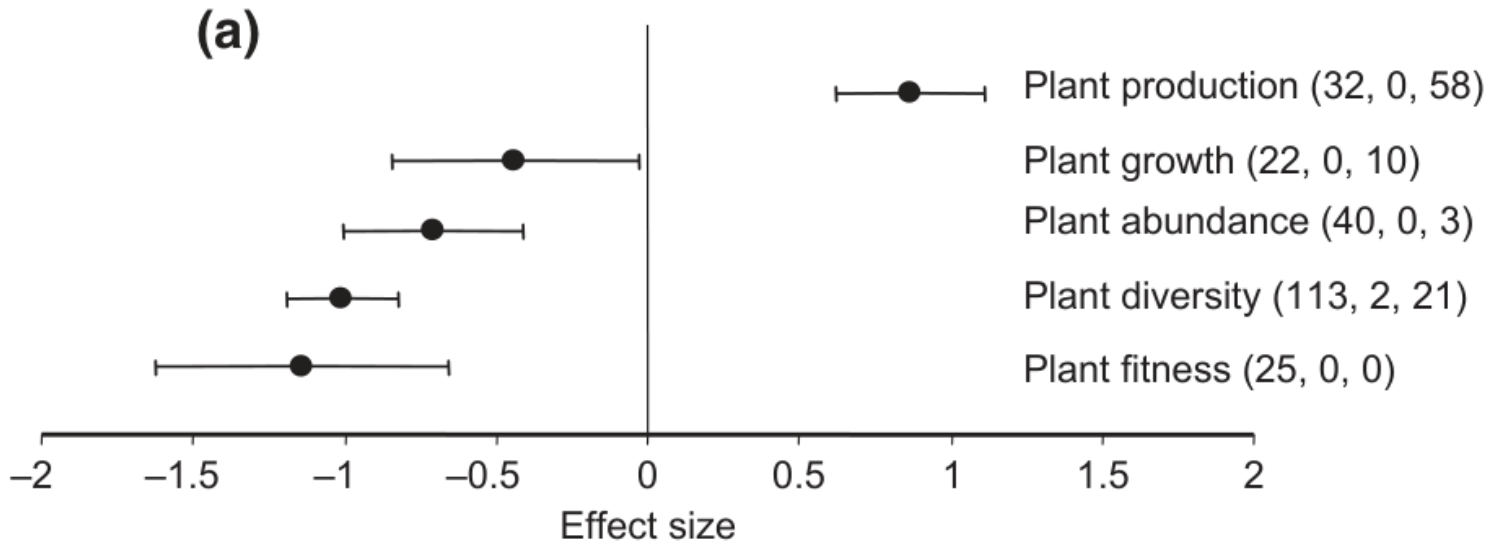
Above it: greater similarity after naturalized species are included.

Local additions can reduce regional distinctiveness without proving local extinction.

Yang et al. (2021) | Nature Communications 12:7290 | Fig. 2a | doi:10.1038/s41467-021-27603-y

More plant production can coexist with less resident diversity

Meta-analysis of 199 articles, 1,041 field cases and 135 alien plant taxa.



NEGATIVE d

Lower value in invaded plots.

POSITIVE d

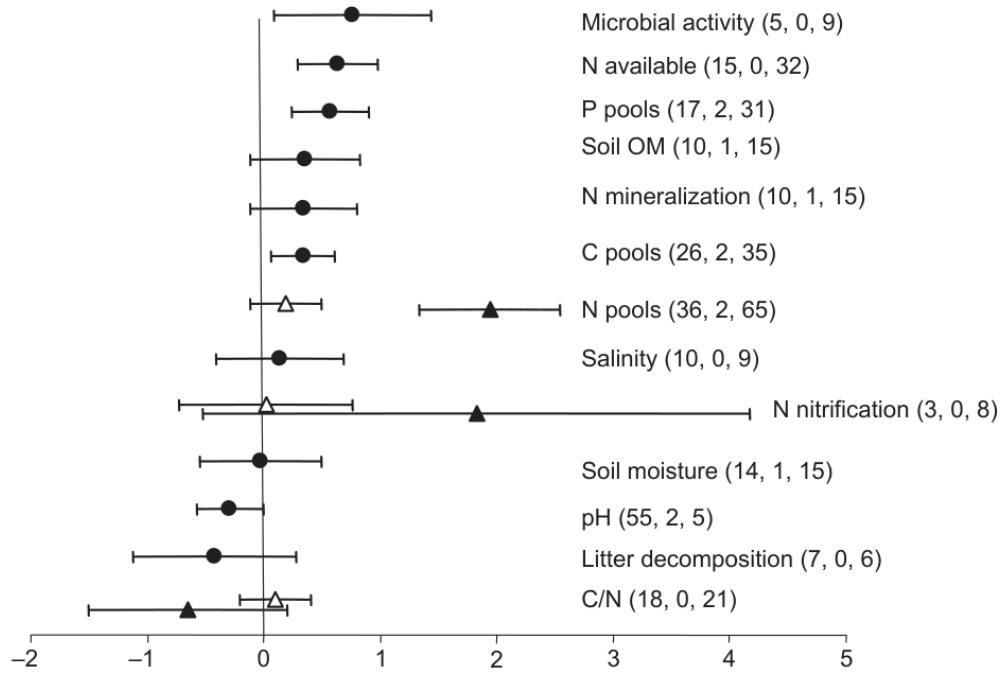
Higher value not “better”.

A larger value for one ecosystem property is not automatically a conservation gain.

Vilà et al. (2011) | Ecology Letters 14:702–708 | Fig. 1a | doi:10.1111/j.1461-0248.2011.01628.x

Ecosystem responses depend on the variable and the invader

The same meta-analysis separates nutrient pools, rates, microbial activity and other properties.



DO NOT MERGE

Pools ≠ rates
N stocks ≠ nitrification.

TRIANGLES

Filled: N-fixing invaders
Open: non-N-fixing.

ZERO CROSSED

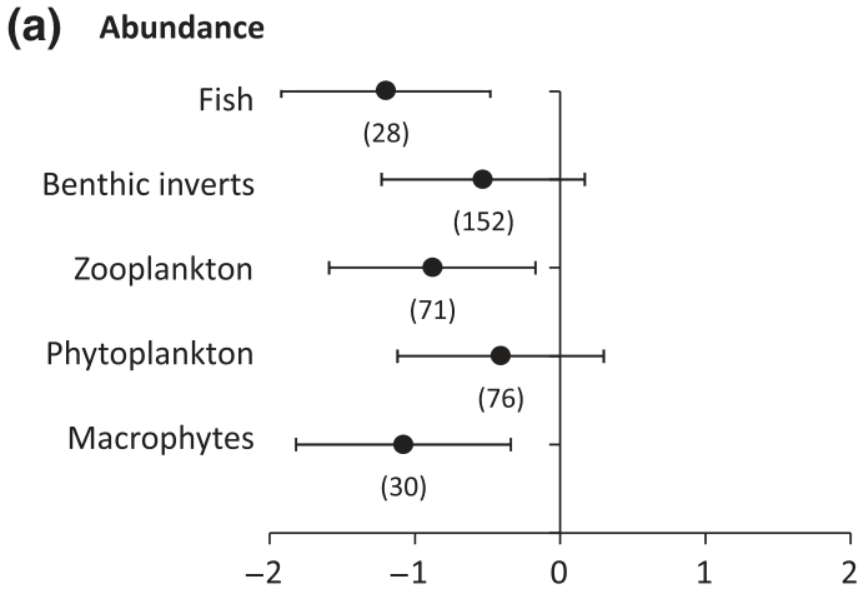
No resolved average direction for that response.

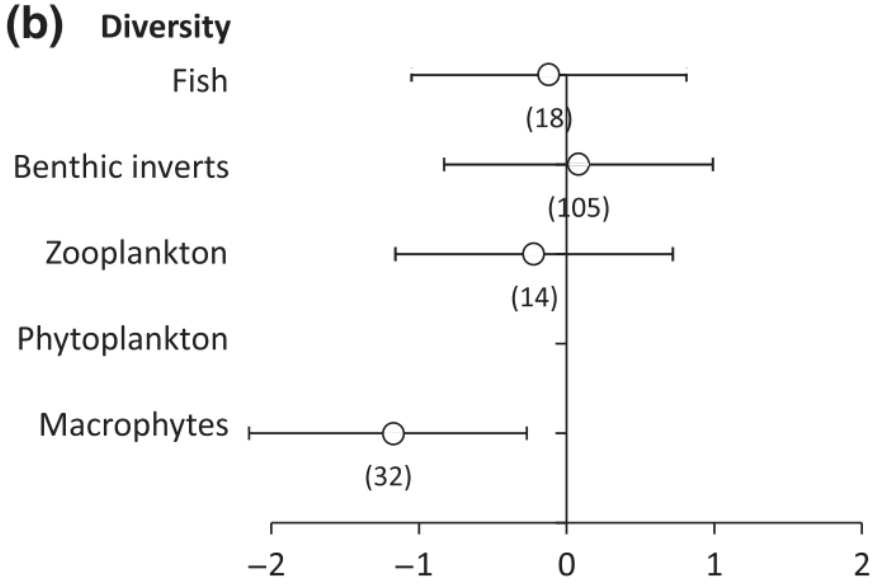
State variables and process rates answer different ecological questions.

Vilà et al. (2011) | Fig. 2; Table 1 | doi:10.1111/j.1461-0248.2011.01628.x

Diversity alone can miss major changes in abundance

151 publications, 733 cases: rivers, lakes AND estuaries





Clear mean declines in fish, zooplankton and macrophyte abundance.

Diversity responses are less uniform; macrophytes show a clear decline.

An unchanged diversity metric does not demonstrate an unchanged community.

Gallardo et al. (2016) | Global Change Biology 22:151–163 | Fig. 1a,b | doi:10.1111/gcb.13004

CAUSALITY CHECK

Is the invader driving the change or riding on it?

Correlation between exotic dominance and native decline is compatible with more than one causal story.

DRIVER

INVADER → NATIVE DECLINE

competition • predation • ecosystem engineering

The invader contributes causally to the decline.

PASSENGER

DISTURBANCE → NATIVE DECLINE
↘ EXOTIC DOMINANCE

habitat change • nutrients • fragmentation • altered disturbance

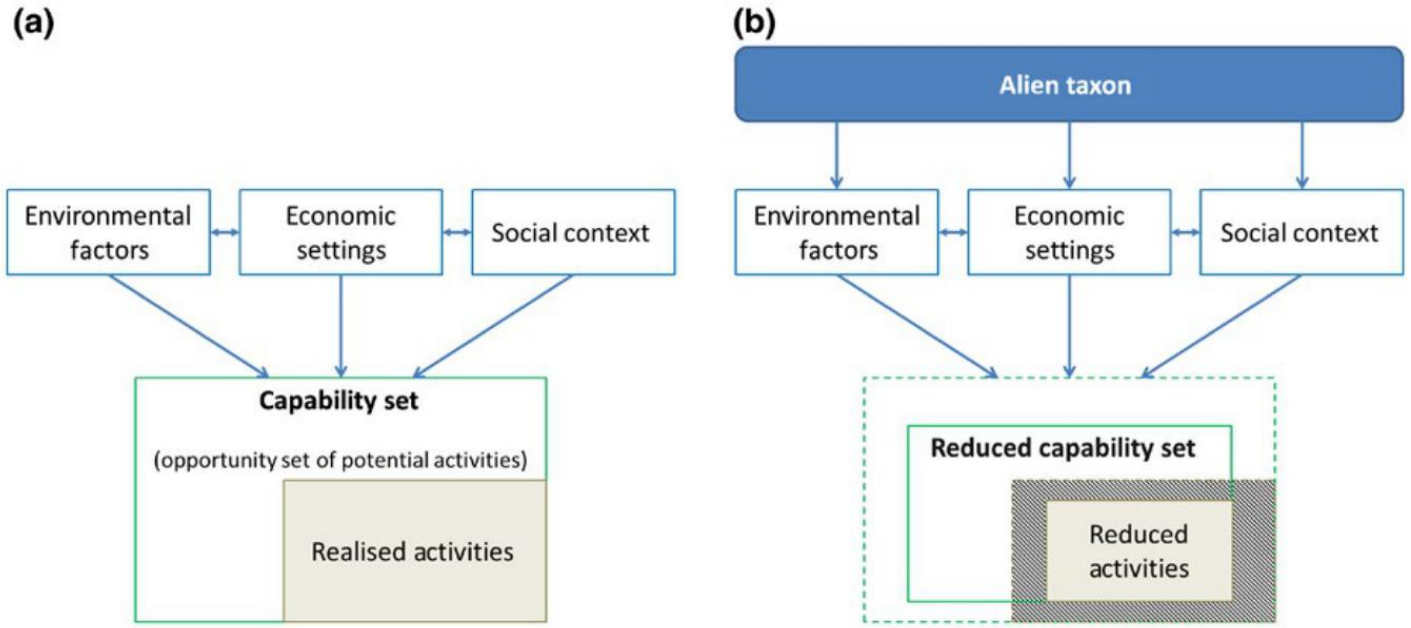
A third factor can produce both patterns.

Before removing an invader, ask whether it is the cause, a symptom, or both.

MacDougall & Turkington (2005), Ecology 86:42–55; Didham et al. (2005), Trends in Ecology & Evolution 20:470–474.

Societal impacts include constrained activities—not only money

SEICAT uses changes in people's realised activities to classify negative impacts on well-being.



MINOR

Participation becomes harder.

MODERATE

Fewer people participate.

MAJOR / MASSIVE

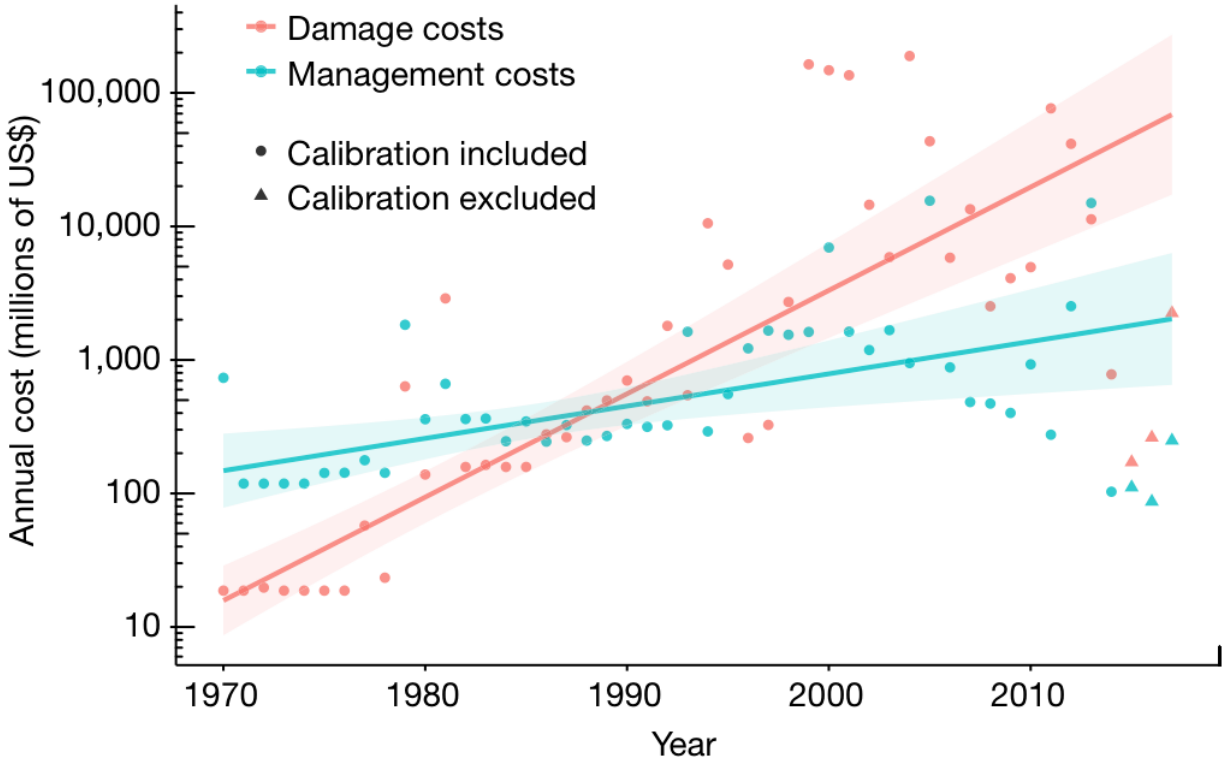
An activity disappears locally.

Assess constraints and losses; insufficient evidence is not evidence of low impact.

Bacher et al. (2018) | Methods in Ecology and Evolution 9:159–168 | doi:10.1111/2041-210X.12844 | Fig. 1; classification explained in Table 2

Reported damage costs exceeded management spending

Reported costs, 1970–2017, in 2017 US dollars



REPORTED CUMULATIVE COSTS

≈13×

damage costs vs management spending

A damage-to-spending ratio is not a measured return on investment.

Diagne et al. (2021) | Nature 592:571–576 | doi:10.1038/s41586-021-03405-6 | Fig. 2

A conservation response need not wait for visible local damage

Compare the consequences of an unnecessary intervention with the consequences of a delayed response.

RISK OF ACTING

A false alarm.
Unnecessary costs.
Effects on non-target organisms.

RISK OF WAITING

Further arrival or spread.
Losses that accumulate.
Fewer feasible response options.

A response may be prevention or targeted verification not immediate removal.

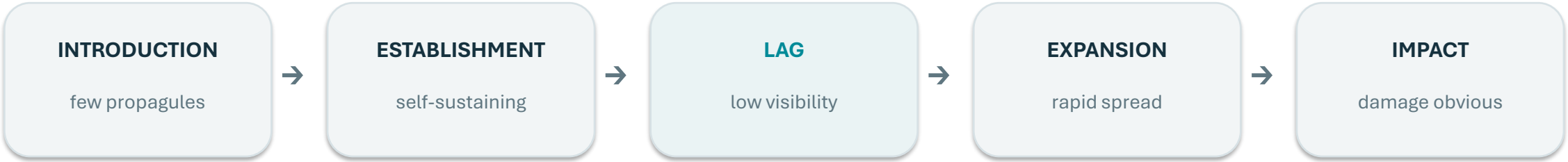
Use credible risk, uncertainty and the consequences of dela not visible damage alone.

Teaching synthesis: Keller et al. (2007); Jerde et al. (2011); Tiberti et al. (2019). Not a universal decision threshold.

LAG TIMES

The worst time to discover an invasion is when the impact becomes obvious

Introductions can remain inconspicuous for years before spread or ecological effects become easy to see.



LOWER COST / MORE OPTIONS ← prevention + early detection **FEWER OPTIONS / HIGHER COST**

A lag is not proof that “nothing is happening.” Detection, propagule pressure and context matter before impacts become obvious.

Waiting for visible damage can convert a preventable problem into permanent management.

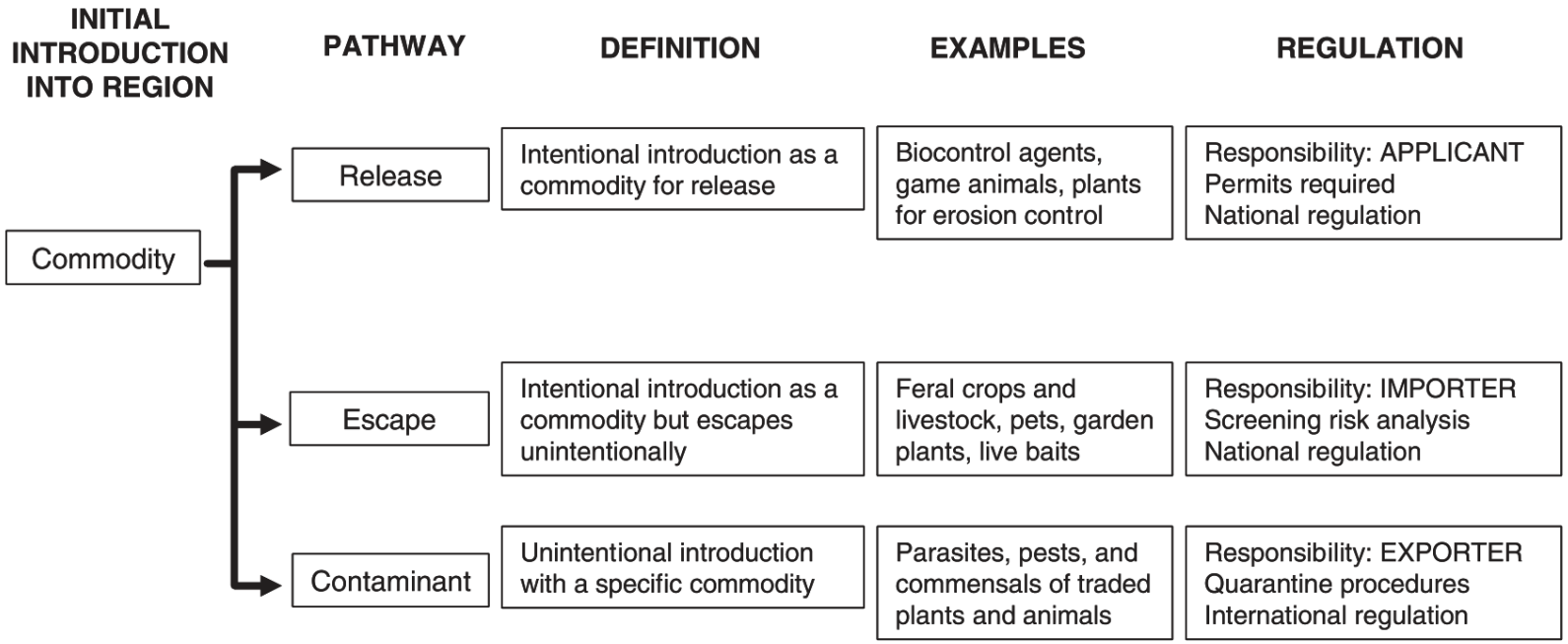
Simberloff (2010), Invasive species, in Conservation Biology for All, Chapter 7.

The organism is not the only thing that travels

PROPAGULE PRESSURE

More individuals or repeated introductions can raise the establishment probability.

Release, escape and contamination are different pathways associated with traded organisms.



Manage the pathway that brings the organism not only the organism itself.

Hulme et al. (2008) | Journal of Applied Ecology

Not every new arrival crosses a border in a shipment

Transport, new corridors and spread from an already invaded neighbour create different entry routes.

INITIAL INTRODUCTION INTO REGION	PATHWAY	DEFINITION	EXAMPLES	REGULATION
Vector	Stowaway	Unintentional introduction attached to or within a transport vector	Hull fouling, ballast water/soil/sediment organisms	Responsibility: CARRIER Quarantine procedures International regulation
Dispersal	Corridor	Unintentional introduction via human infrastructures linking previously unconnected regions	Lessepsian migrants, Ponto-Caspian aliens in the Baltic	Responsibility: DEVELOPER Environmental impact laws International regulation
	Unaided	Unintentional introduction through natural dispersal of alien species across political borders	Potentially all alien taxa capable of dispersal	Responsibility: POLLUTER 'Polluter Pays' International regulation

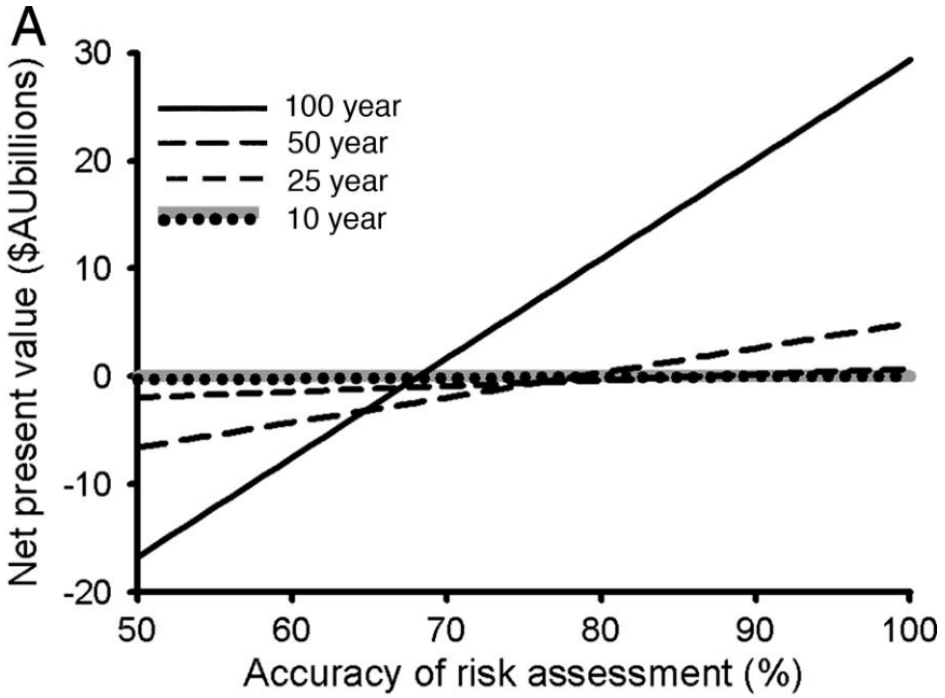
Unintentional here means spread from an alien population introduced elsewhere

Prevention must also address transport networks and secondary spread.

Hulme et al. (2008)

Imperfect screening can still prevent costly mistakes

Australian ornamental-plant trade: a model compares screening with allowing all proposed imports.



READ THE AXES

X: screening accuracy
Y: net benefit of screening

READ THE LINES

Different policy horizons:
10, 25, 50 and 100 years.

READ THE ZERO

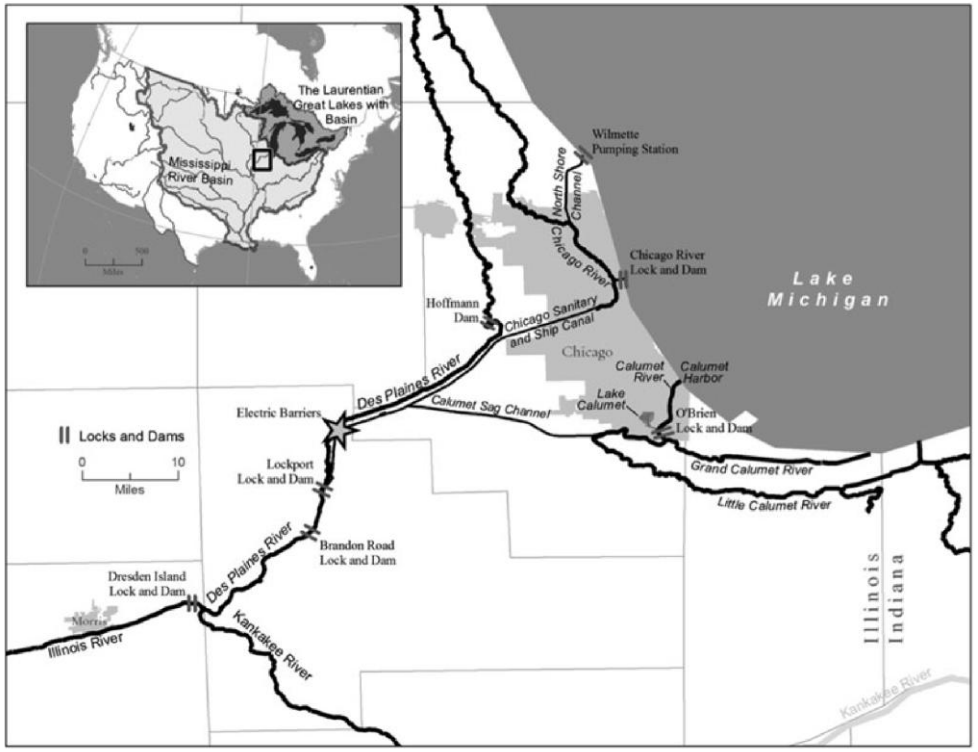
Above zero: screening has higher modelled net benefits.

Prevention need not be perfect to be worthwhile, but assumptions and time horizons matter.

Keller, Lodge & Finnoff (2007)

A canal can connect ecosystems and invasion pathways

Historical study system: Chicago waterways link the Mississippi and Great Lakes basins.



THE CONNECTION

Artificial waterways link two large drainage basins.

THE BARRIER

The star marks the electric barrier studied in the paper.

THE QUESTION

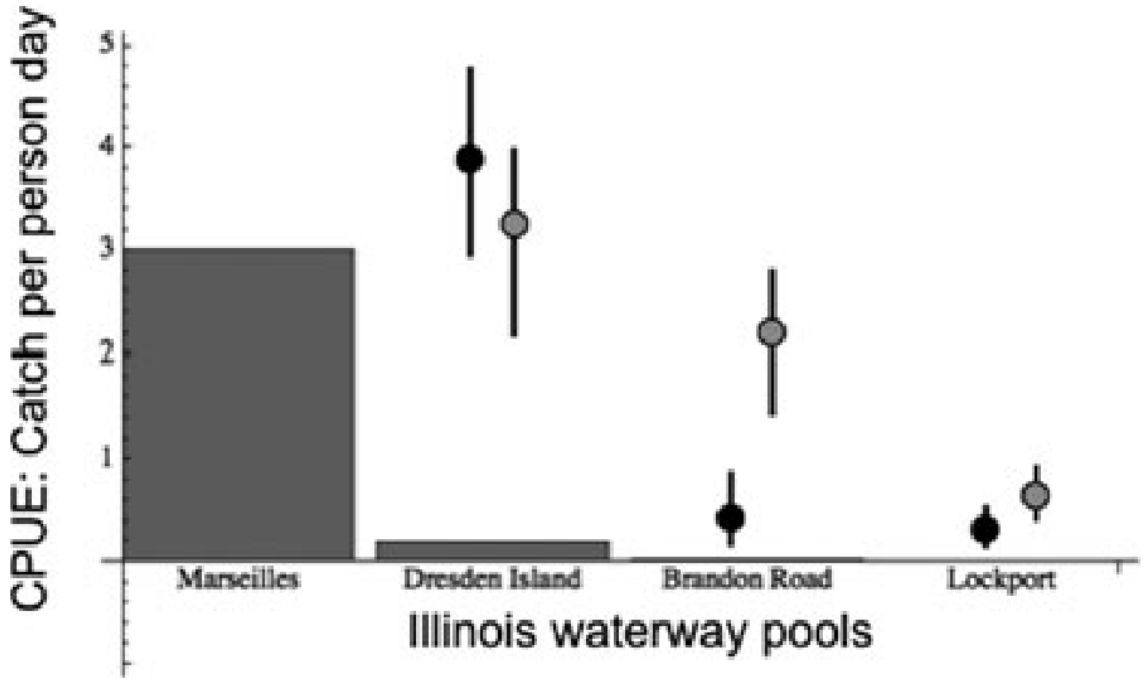
Can low-density fish be detected before routine capture?

Place surveillance where pathways create a plausible route of arrival.

Jerde et al. (2011

No captured fish does not necessarily mean no fish

eDNA surveillance detected target DNA where electrofishing produced no carp record.



BARS

Electrofishing records per person-day.

DOTS

eDNA positives / person-day.
Black: bighead; grey: silver.

An early signal can justify investigation without proving abundance or establishment.

Jerde et al. (2011) | Fig. 3; Methods and Discussion | doi:10.1111/j.1755-263X.2010.00158.x

Choose the objective before choosing the tool

PREVENTION

Reduce the chance of a new arrival.
Match the action to the route.

EARLY DETECTION + RESPONSE

Find a credible signal early.
Specify who verifies and responds.

ERADICATION

Remove the target from a defined area.
Verify absence and prevent return.

CONTAINMENT / IMPACT CONTROL

Limit spread or reduce a specified impact.
Judge success against that objective.

Different goals need different evidence of success.

Synthesis: Hulme (2008); Keller (2007); Jerde (2011); Tiberti (2019); Carrion (2011); Schaffner (2020).

Non-chemical removal still had non-target costs

A proposed response must consider non-target costs as well as the expected conservation benefit.

Table 2 Number of non-target species accidentally captured in four high altitude lakes (DJO, DRE, LEY, NER) treated for alien brook trout eradication between 2013 and 2017

	DJO	DRE	LEY	NER	2013	2014	2015	2016	2017	Total
Amphibians										
Common frog *Rana temporaria*	29	27	–	–	0	16	7	28	5	56
Birds										
Dipper *Cinclus cinclus*	–	23	13	–	0	6	18	8	4	36
Mallard *Anas platyrhyncos*[a]	–	5	–	–	0	0	5	0	0	5
Black redstart *Phoenicurus ochruros*	–	–	1	–	0	0	1	0	0	1
Mammals										
Water shrew *Neomys* sp.	–	5	–	–	0	3	1	0	1	5

[a]All ducklings

NON-CHEMICAL ≠ HARMLESS

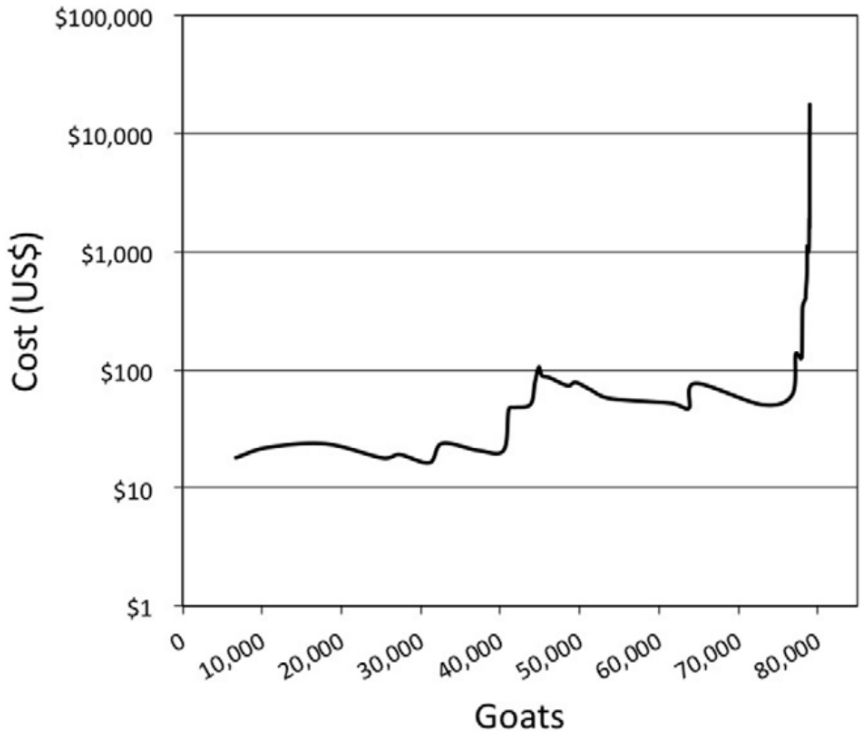
Deaths occurred; population effects were not quantified.

Measure collateral harm separately from the benefits of removing the invader.

Tiberti et al. (2019) | Biological Invasions 21:875–894 | doi:10.1007/s10530-018-1867-0 | Table 2; Results p. 883

The last individuals can be the most expensive to remove

Santiago Island, Galápagos: the cost per goat rose sharply near the end of the eradication campaign.



COST PER GOAT

US$10–100

for most removals

>US$10,000

for the final animals

Removing most individuals is not the same as completing eradication.

Carrion et al. (2011) | PLOS ONE 6:e18835 | doi:10.1371/journal.pone.0018835 | Fig. 1

Eradication is not a method. It is a commitment to the last individual

Four conditions distinguish an ambitious removal campaign from a defensible eradication plan.

1 RESOURCES

Can you fund the expensive final 1%?

2 AUTHORITY

Can everyone who controls access cooperate?

3 BIOLOGY

Do you know where the target is vulnerable?

4 REINVASION

Can you stop it from coming straight back?

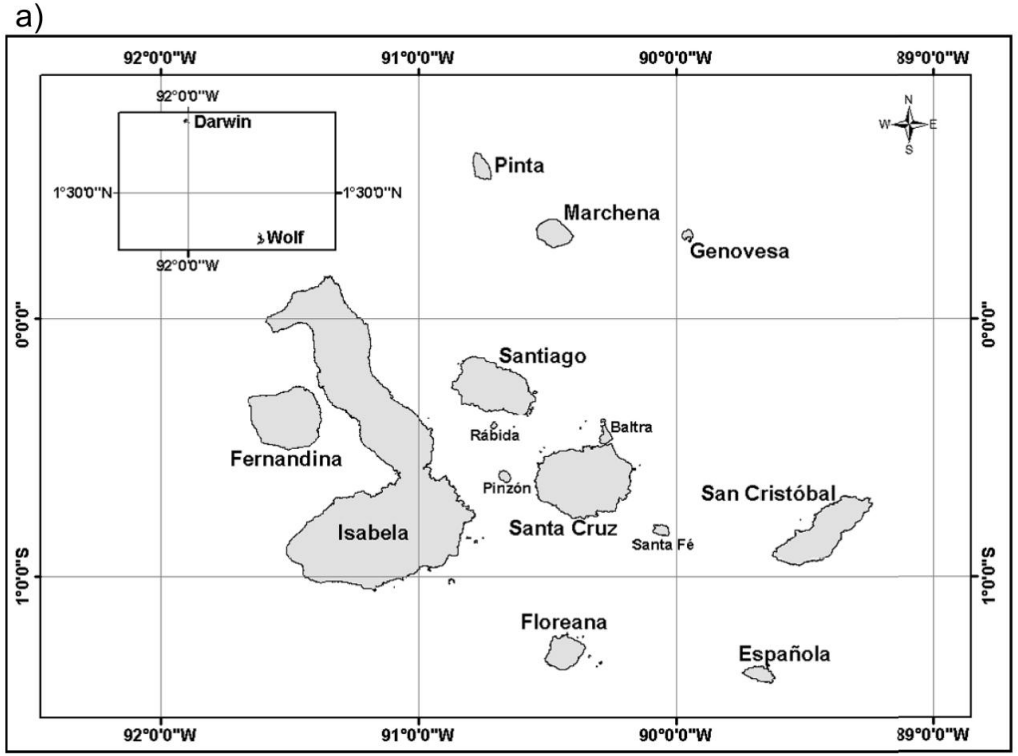
Fail one condition and the population can rebound.

Define feasibility before choosing eradication and design post-eradication prevention from day one.

Simberloff (2010), Conservation Biology for All, Chapter 7, section 7.3.2 Monitoring and eradication.

Eradication must be protected against reintroduction

Galápagos: island-scale operations sit inside an archipelago-wide social and management system.



AT PUBLICATION

Feral goats remained on 3 islands.

DOCUMENTED RISK

At least 9 intentional reintroductions after eradication.

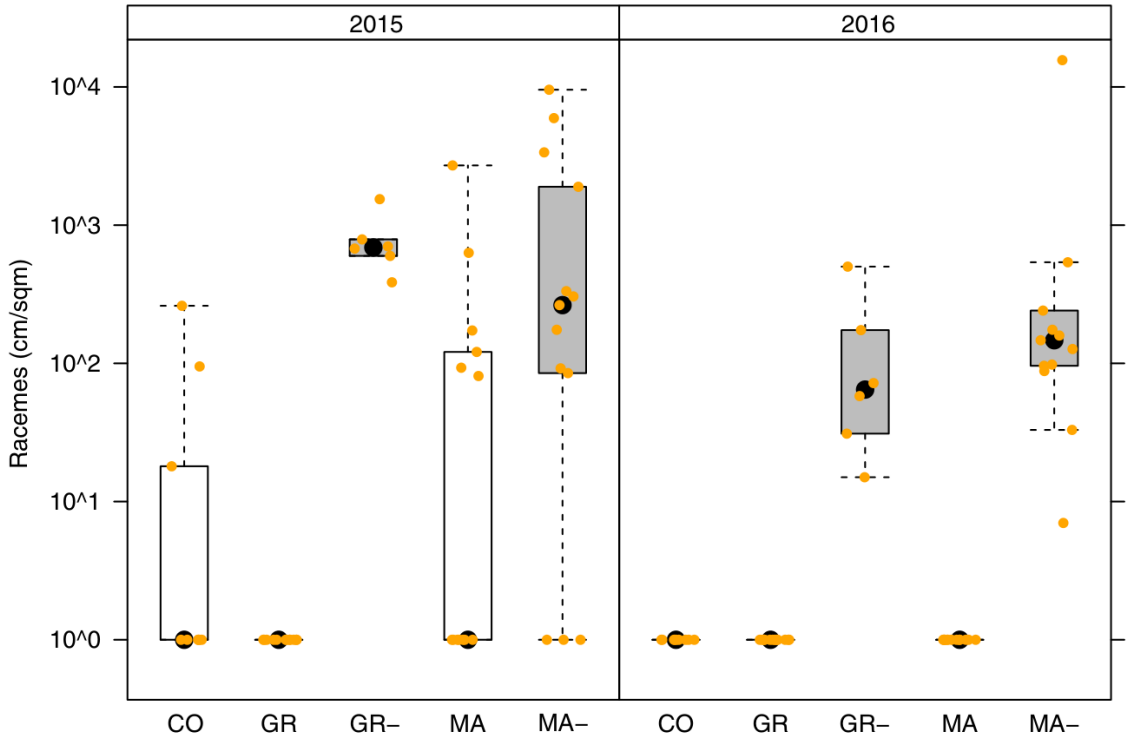
Removal + monitoring + education + governance

A completed removal still needs prevention, surveillance and durable governance.

Carrion et al. (2011) | PLOS ONE 6:e18835 | doi:10.1371/journal.pone.

An introduced herbivore reduced ragweed's pollen-production proxy

Northern Italy, 2015–2016: compare beetle-present plots with insecticide-exclusion plots.



WHAT IS MEASURED?

Raceme length per m^2.

"–" AFTER SITE NAME

Beetle excluded.
Higher flower output.

WHAT IS NOT SHOWN

Eradication, universal safety or decades of control.

Reducing an impact is different from eradicating its source.

Schaffner et al. (2020) | Nature Communications 11:1745 | Fig. 3 | doi:10.1038/s41467-020-15586-1

Long-term management starts with a result worth maintaining

Compare strategies by their objective, stopping rule and continuing obligations.

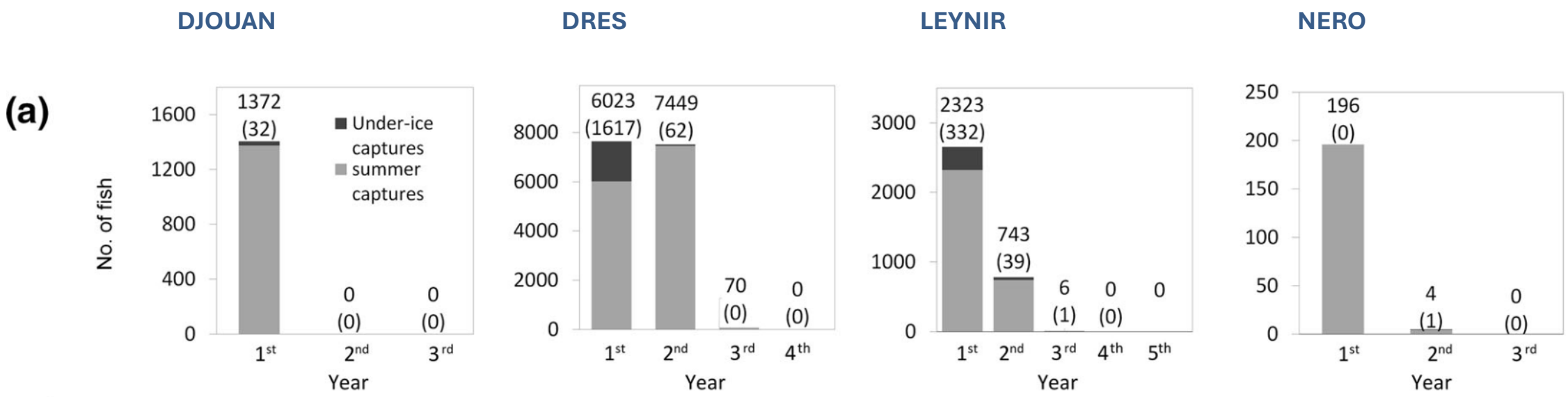
STRATEGY	RESULT TO EVALUATE	WHAT CONTINUES?
Eradication	Target absent from a defined area.	Surveillance and prevention of reintroduction.
Containment	Spread beyond the managed area is limited.	Boundary surveillance and repeated response.
Impact reduction	A defined ecological or social impact is reduced.	Track target, impact, non-target effects and changing conditions.

Specify what must stay low, what must recover and what will trigger renewed action.

Synthesis from Hulme (2008), Tiberti (2019), Carrion (2011) and Schaffner (2020); no universal numeric threshold.

Zero captures need sustained, effective search effort

Annual fish captures fell, but eradication required sustained checking after the last fish was caught.



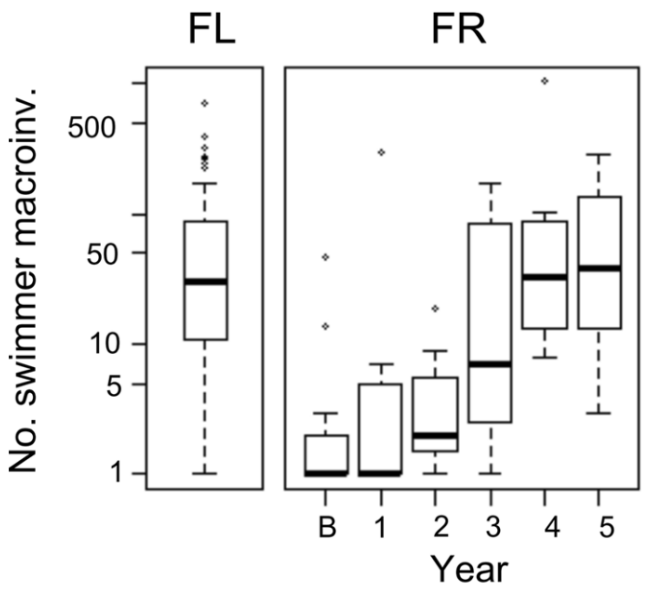
Study rule: 1 year with no captures at maintained effort, followed by further monitoring.

> **A decline in captures is not, by itself, evidence that the population is gone.**

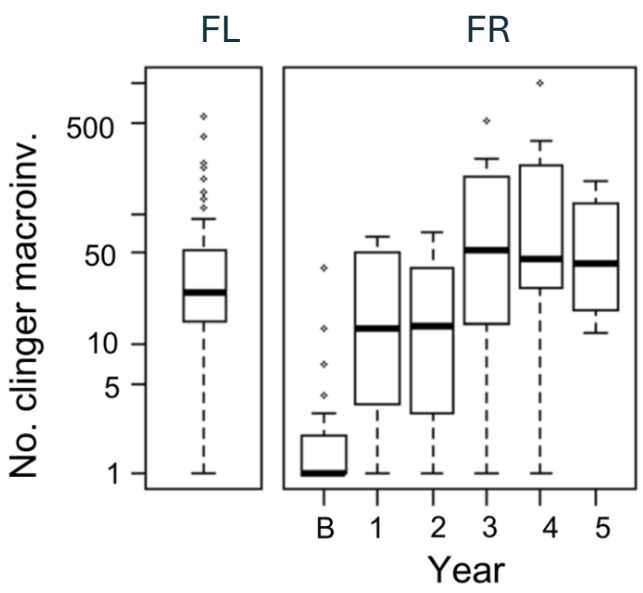
Tiberti et al. (2019) | Biological Invasions 21:875–894 | doi:10.1007/s10530-018-1867-0 | Fig. 1a; Methods and Discussion

Sensitive invertebrates moved towards fishless reference levels

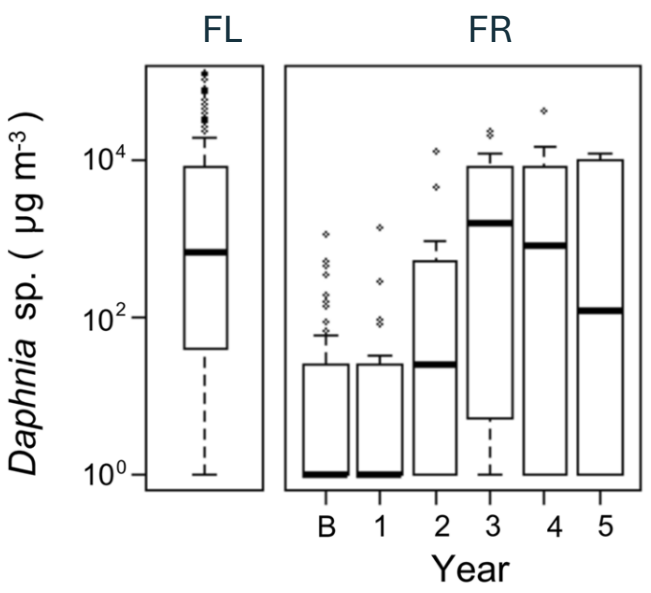
SWIMMERS



CLINGERS



DAPHNIA



B = pre-removal observations; years 1–5 = 2013–2017. Y-axes are logarithmic.

Follow native biological responses, not just the number of invaders removed.

Tiberti et al. (2019) | Biological Invasions

TRADE-OFF

What if removing the invader also removes habitat for an endangered n

San Francisco Bay turns a simple “remove the invasive” story into a conflict between legitimate conservation goals.

GOAL A

REMOVE HYBRID SPARTINA

Restore tidal-marsh structure and reduce invasive spread

NOT A BINARY CHOICE

stage removal + restore alternative habitat

GOAL B

PROTECT RIDGWAY’S RAIL

The endangered bird had come to use invasive Spartina as nesting habitat

The management target is not “native purity.” It is the best achievable outcome across explicit conservation goals.

Conservation actions can conflict. Sequence, transition habitat and monitoring can matter as much as the final goal.

Lampert et al. (2014), Science 344:1028–1031. Hybrid Spartina eradication and endangered California Ridgway’s rail.

Respond to threats to conservation goals

When does community change require a conservation response?

1 CHANGE	Describe the change, its cause and its spatial scale.
2 STAKES	Specify the native feature, process or human activity at risk.
3 TIMING	Compare the consequences of acting and waiting.
4 RESPONSE	Choose a feasible action; assess costs and non-target risks.
5 OUTCOME	Test the result against the goal, then maintain or revise the response.

A credible threat can justify a response before local damage becomes visible.