THE PROTECTION PARADOX

Where, how, and when is protection enough?

WHERE

Choose the places

HOW

Make protection work

WHEN

Go beyond protection

Count conservation outcomes not just interventions.

Protecting Valle Averto means managing ecological conditions

WATER

Sluices and canal maintenance regulate levels and circulation.

HABITATS

Maintain Cladium wetlands and restore alluvial forest.

SPECIES

Control invasive plants and fish; provide nesting rafts.

FOLLOW-UP

Monitor water, vegetation and birds; maintain the interventions.

If management stopped tomorrow what would change first?

Manage ecological conditions to sustain the habitats and species we aim to protect.

The boundary of a reserve is not the boundary of its ecology

A well-chosen and well-managed reserve can still depend on processes it does not control.

WATER

Levels, salinity, nutrients and contaminants

MOVEMENT

Dispersal routes and habitat in the surrounding matrix

PEOPLE

Land use, resource rights and costs borne outside the reserve

At Valle Averto, which management problem cannot be solved inside the reserve alone?

Ecological processes extend beyond reserve boundaries and so must management.

Teaching synthesis: Margules & Pressey (2000); Saura et al. (2019); Geldmann et al. (2019); Oldekop et al. (2016).

One budget. Three decisions. No universal solution.

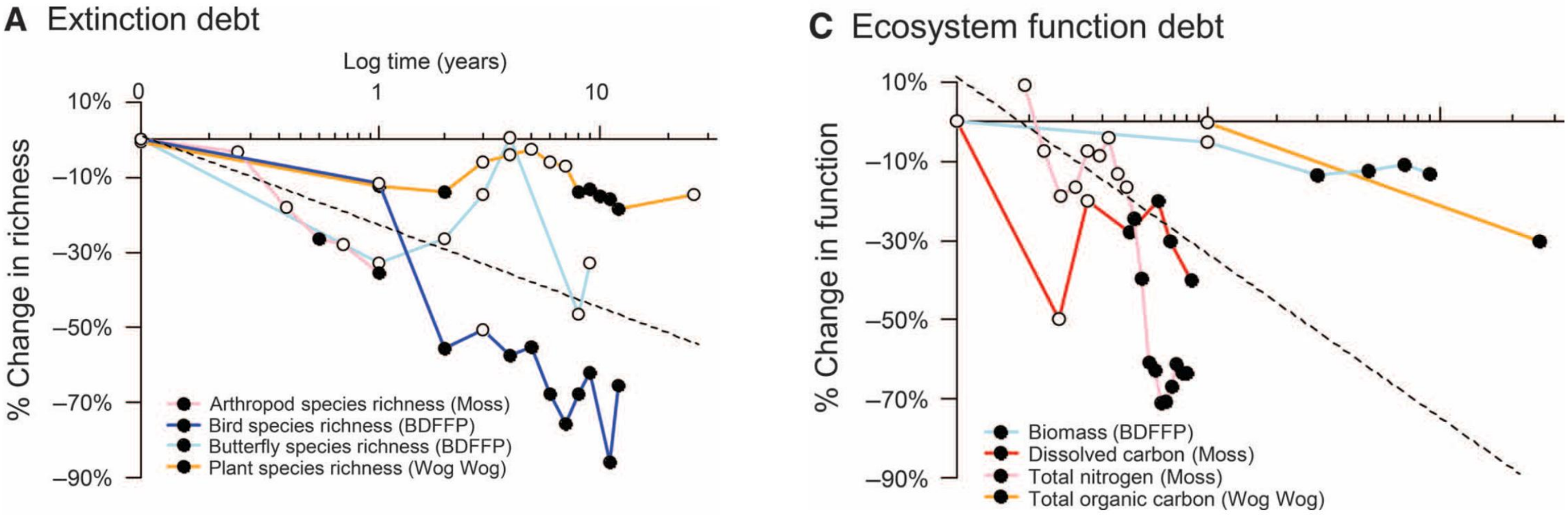
01	**WHERE**	Which sites add the most to our conservation target?
02	**HOW**	What must happen for legal protection to work?
03	**WHEN**	What should we do when habitat protection is not enough?

The unit of success is an ecological outcome, not a boundary, a release, or a planting.

Where, how and when to act are linked decisions.

Fragmentation can leave an ecological debt long after habitat loss

Long-running experiments reveal delayed losses of species and ecosystem function.



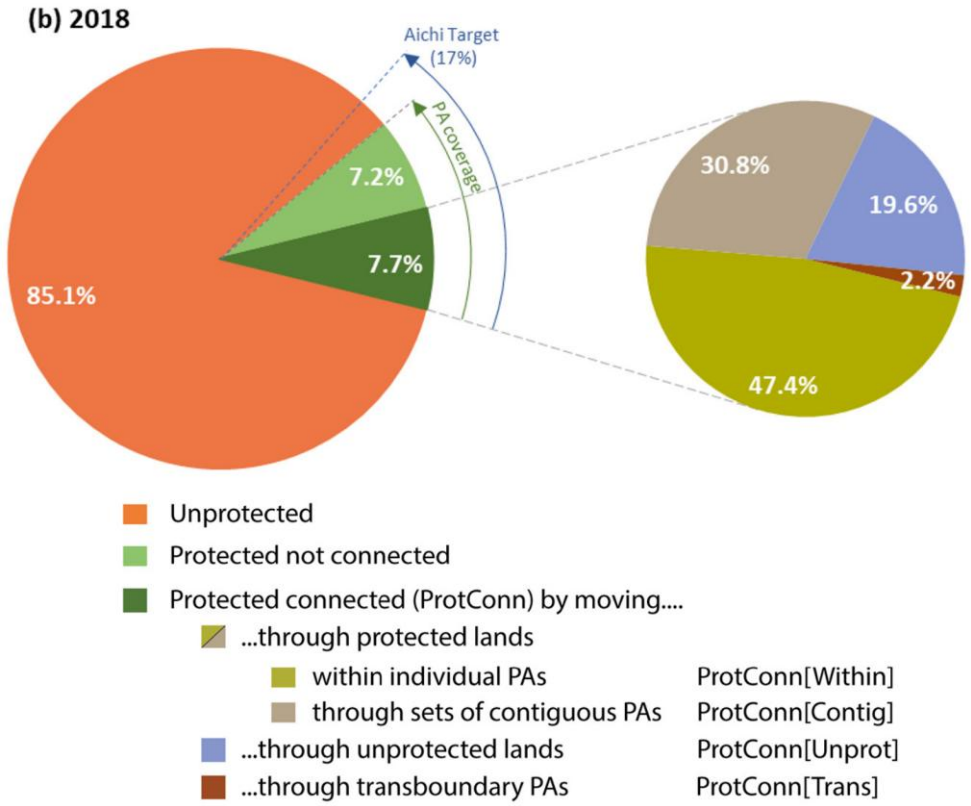
Y: change relative to less-fragmented controls. Time uses the logarithmic scale shared in the original figure.

Presence today does not guarantee persistence: fragmentation losses can arrive later.

Haddad et al. (2015) | Science Advances 1:e1500052 | Fig. 4A,C | doi:10.1126/sciadv.1500052

Protected hectares are not the same as connected habitat

A global network indicator exposes the difference between coverage and connectivity.



GLOBAL LAND, 2018

14.9%

under protection

7.7%

protected and connected under ProtConn

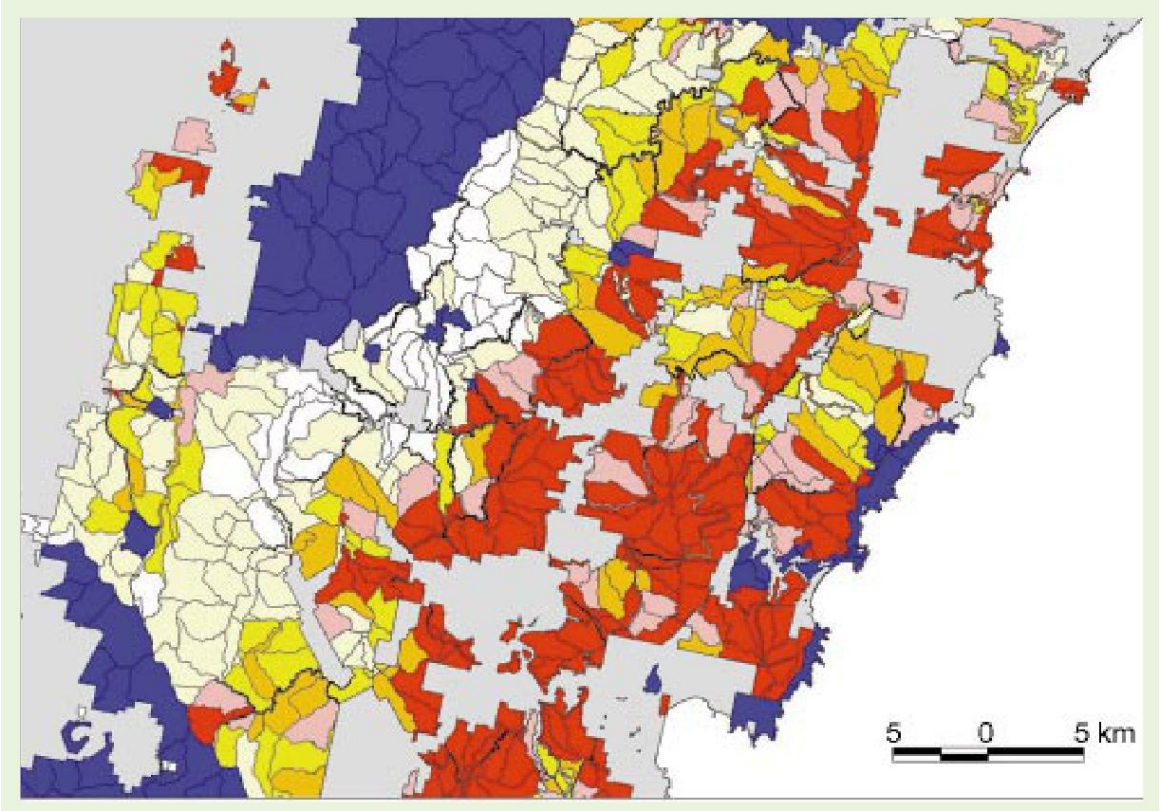
Modelled connectivity; not observed animal movement.

More protected land does not automatically mean a better-connected network.

Saura et al. (2019) | Biological Conservation 238:108183 | Fig. 5b | doi:10.1016/j.biocon.2019.07.028

The best next site fills a gap in the existing network

Conservation value is a contribution to explicit regional targets not simply local richness.



107 forest-ecosystem targets

South-coast New South Wales: contribution to targets not yet met.

- Existing reserves (blue)
- Highest contribution (red)
- Zero contribution (white)

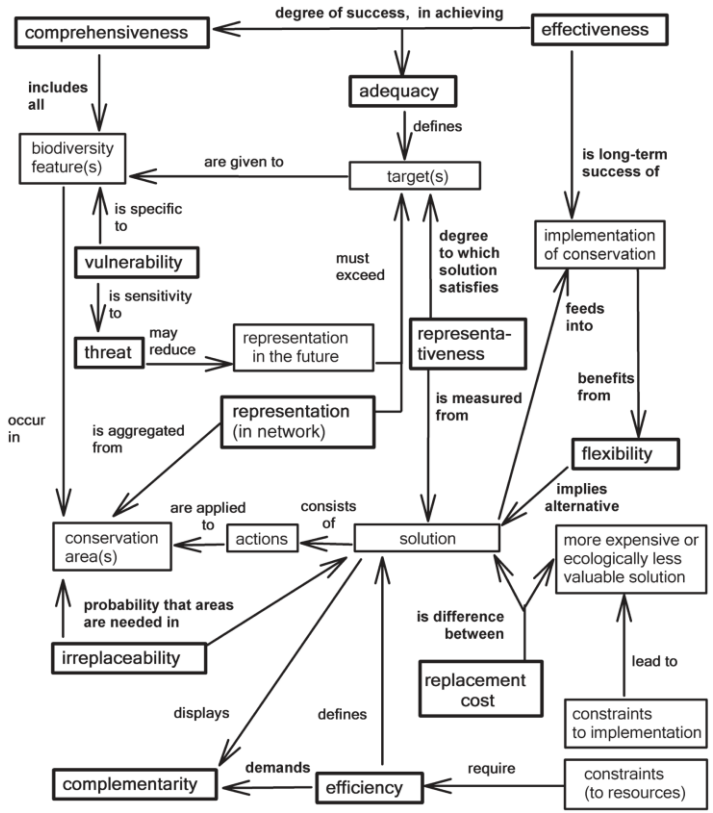
Protecting a site changes what the next site contributes.

A site's added value depends on what the existing network still lacks.

Margules & Pressey (2000) | Nature 405:243–253 | Fig. 5 | doi:10.1038/35012251

A site's priority depends on targets, threats and alternatives

These concepts are related, but they do not answer the same question.



REPRESENTATION

How much of each biodiversity feature is included?

IRREPLACEABILITY

How difficult is meeting targets without this site?

VULNERABILITY

How much could be lost under a specified threat?

EFFICIENCY

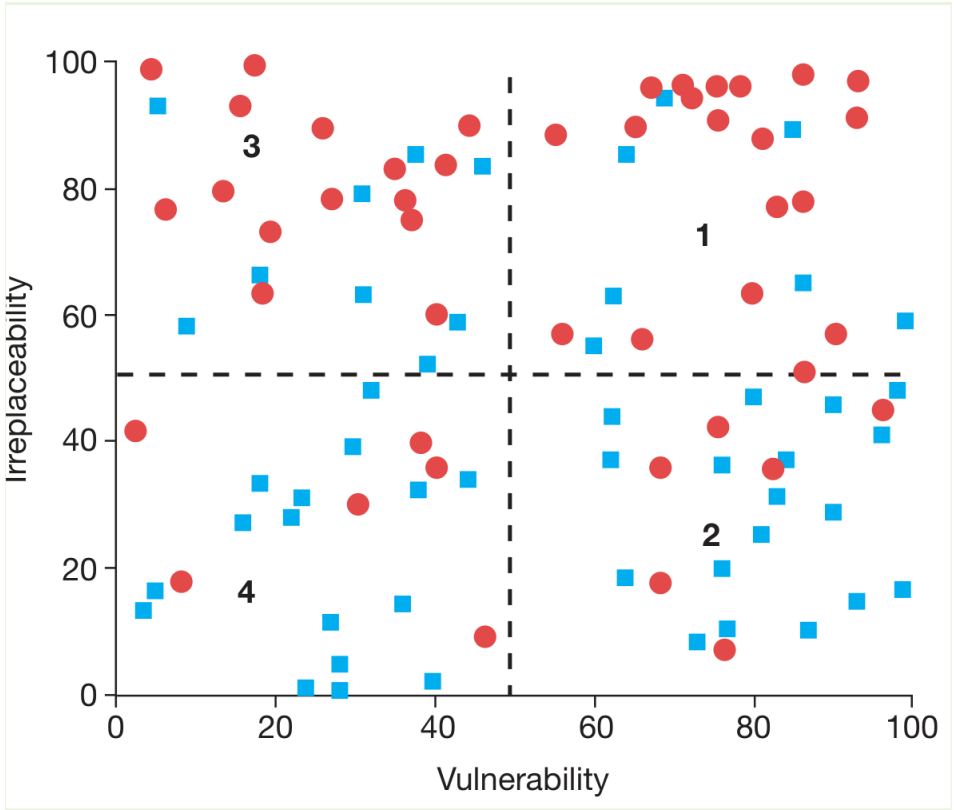
What target achievement is gained for the resources used?

The diagram is a conceptual framework, not an empirical model.

Targets, alternatives, threats and costs answer different planning questions.

Irreplaceability tells us where; vulnerability adds urgency

When protection cannot happen everywhere at once, the sequence of action matters.



Few alternatives + imminent loss

Delaying action can remove the option of achieving a target.

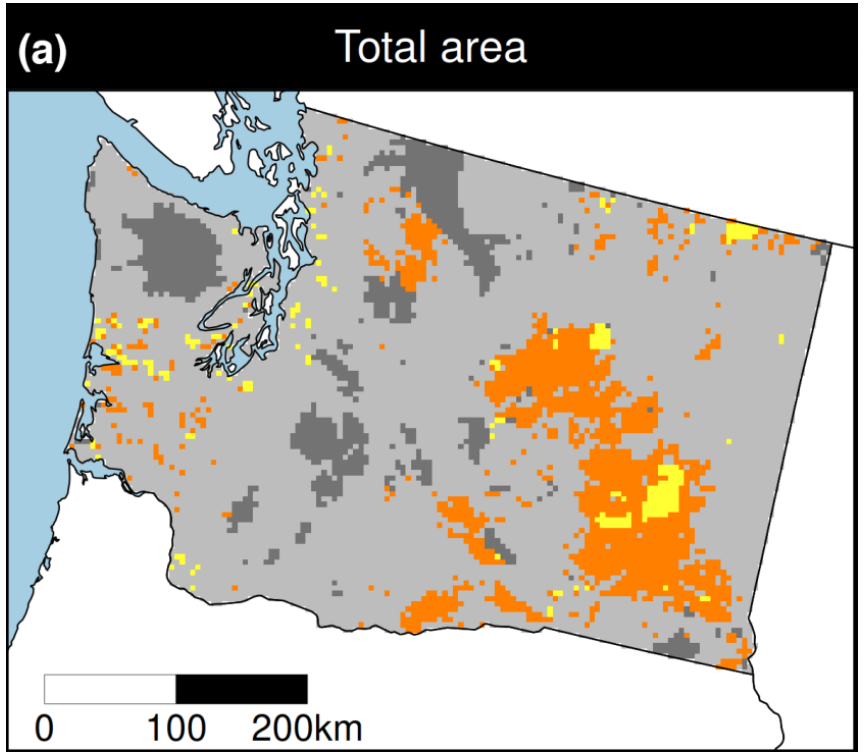
But urgency alone is not enough: can the action avert the threat?

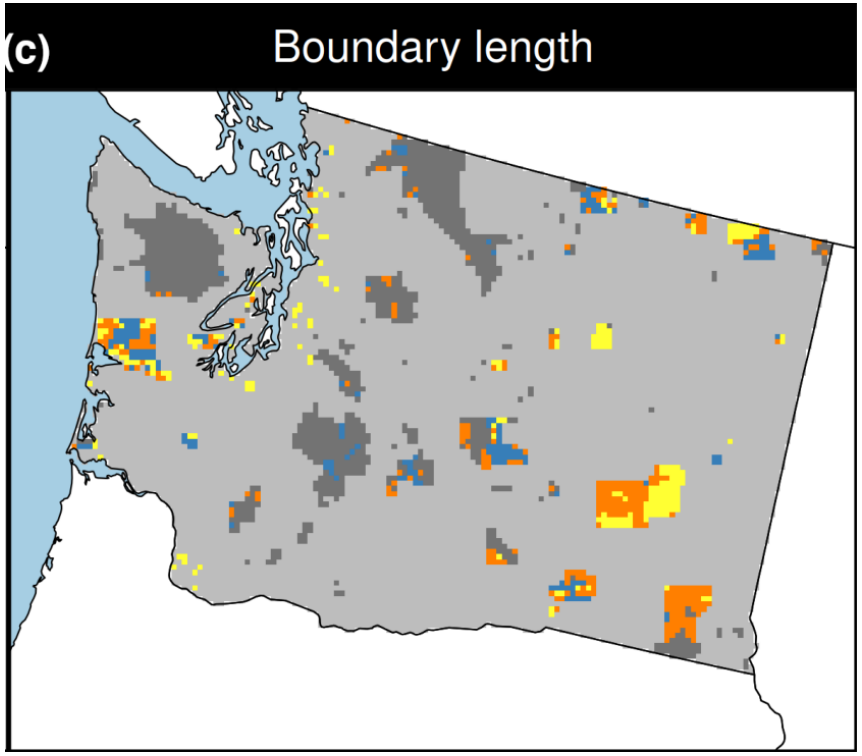
Delay can remove options when vulnerable sites have few substitutes.

Margules & Pressey (2000) | Nature 405:243–253 | Fig. 8 | doi:10.1038/35012251

The connectivity model can change the reserve network

261 bird species; the same representation targets, land-use constraints and budget.





not selected
protected
shared
unique
all

Eight approaches were compared.

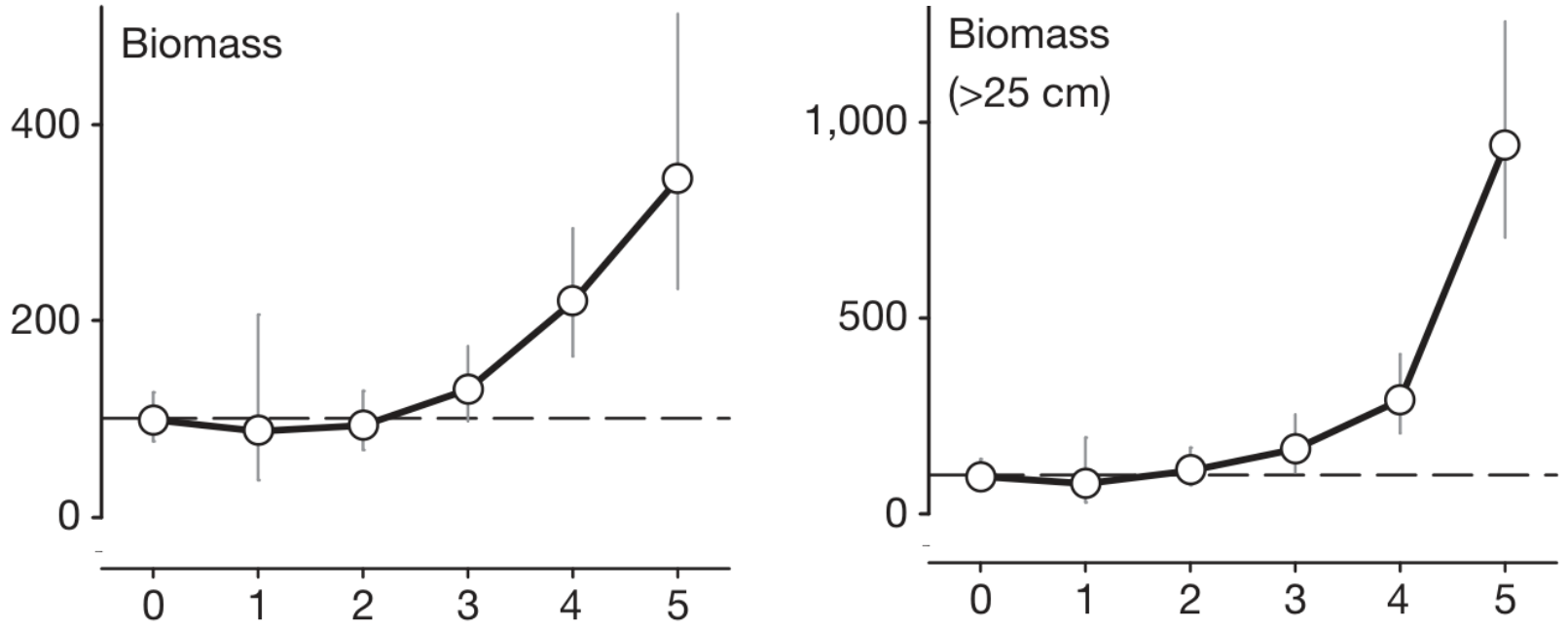
Compactness was not interchangeable with the others.

Changing connectivity assumptions can change priorities even with the same budget.

Hanson et al. (2022) | Journal of Applied Ecology 59:2507–2519 | Fig. 2a,c; full Fig. 2 in appendix | doi:10.1111/1365-2664.14251

Strong marine protection combines rules, enforcement and design

Fish biomass was highest in reserves combining four or five NEOLI features.



Number of NEOLI features (0–5) | Y: % of predicted fished-coast value

100% is the fished-site baseline not zero fish. Error bars are 95% confidence intervals.

NEOLI

No-take
fishing prohibited

Enforced
rules implemented

Old
more than 10 years

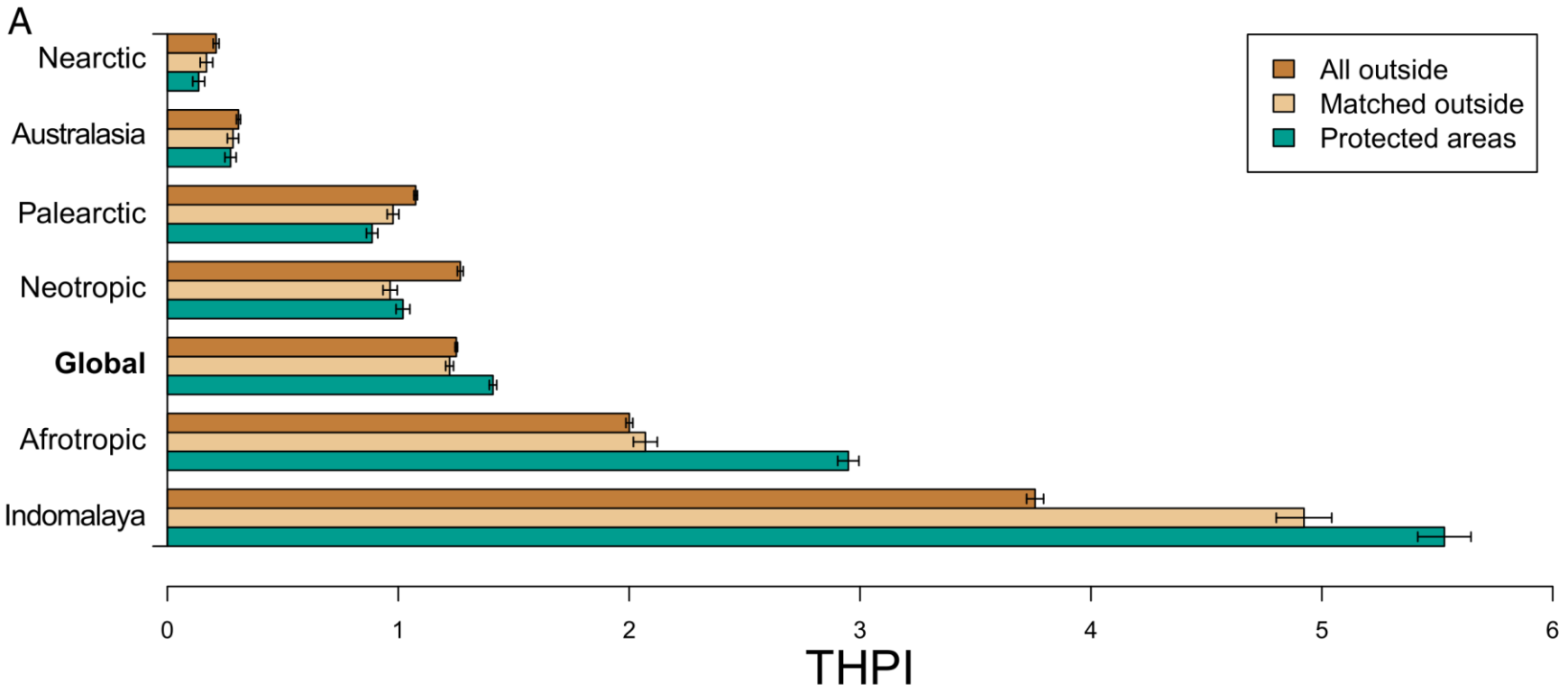
Large
more than 100 km^2

Isolated
reef bounded by sand/deep water

More NEOLI features were associated with stronger fish-biomass responses.

Protected status did not consistently slow human pressure

12,315 protected areas, 152 countries: pressure change from 1995 to 2010.



COMPARE

Protected areas vs matched outside sites

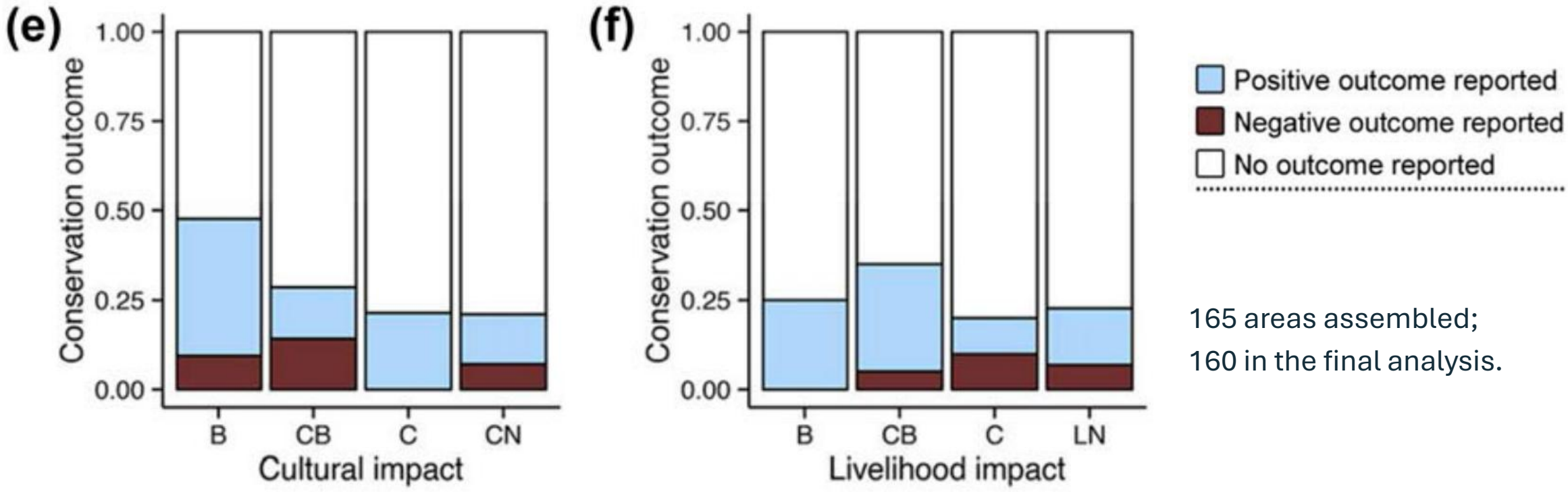
THPI measures pressure, not biodiversity.

Positive values mean pressure increased.

Judge protection against a plausible outcome without intervention.

Social benefits and ecological success can occur together

Reported cultural and livelihood benefits were associated with positive conservation outcomes.



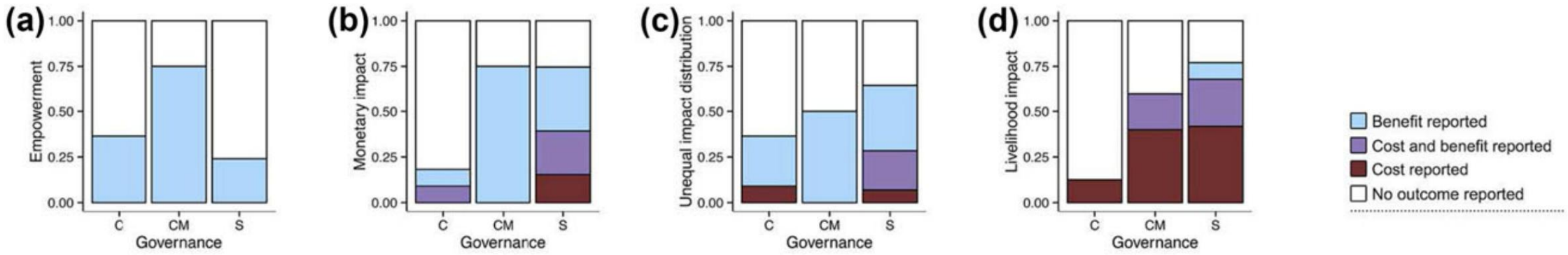
165 areas assembled;
160 in the final analysis.

B = benefits; CB = costs and benefits; C = costs; CN / LN = cultural / livelihood impacts not reported.

Social benefits can accompany conservation gains; this is not proof of causation.

Governance is associated with the distribution of costs and benefits

Co-managed areas in the sample reported more empowerment and less unequal costs.



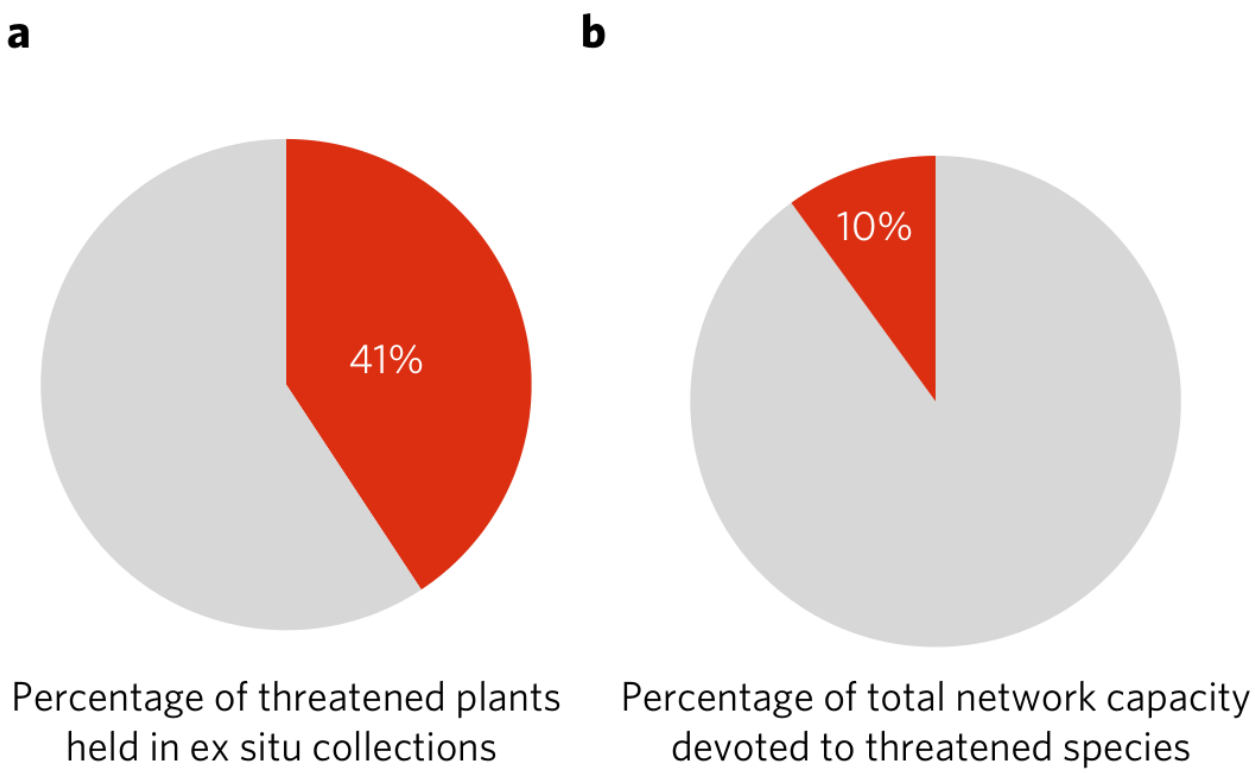
C: community-managed **CM: co-managed** **S: state-managed**

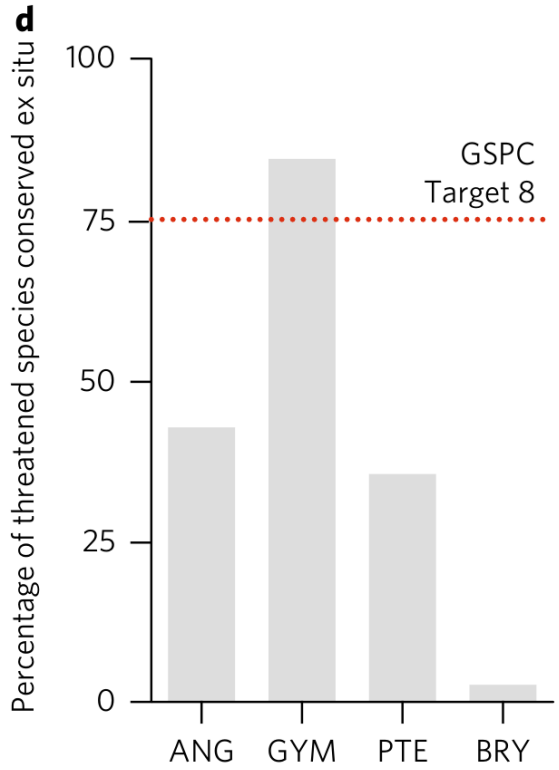
The co-managed sample was small: n = 8 for several panels, versus about 130 state-managed areas.

Co-management may bring benefits, but does not automatically remove costs.

Ex situ capacity is large but conservation priorities still have gaps

About 41% of known threatened plant species were recorded ex situ; about 10% of collection records concerned them.

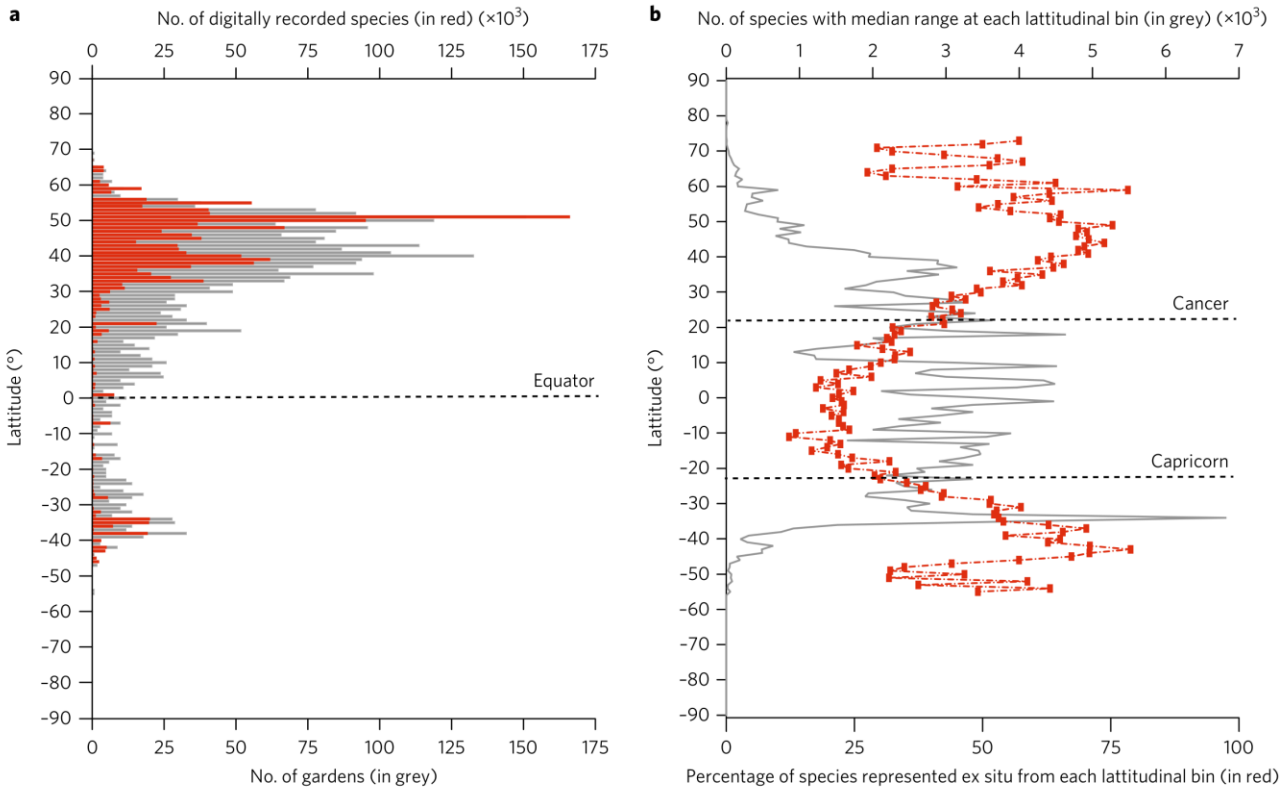




Collection presence does not prove genetic adequacy or recovery in the wild.

Tropical plant species are underrepresented in ex situ collections

The geographic distribution of collections differs from that of natural plant diversity.



RECORDED EX SITU

60%

temperate species

25%

tropical species

Within the study's filtered biogeographic dataset.

Expand collections to fill representation gaps not just to increase totals.

Conservation translocations differ in destination and purpose

Moving organisms is an intervention; establishing a persistent population is an outcome.

Conservation Translocation	Reintroduction	Release within previous native range	[8]
	Reinforcement	Release into an existing population	[8]
	Assisted gene flow	Release within native range to assist adaptation	[61]
	Pleistocene reintroduction	Release within the Pleistocene range	[55]
	Conservation introduction	Release outside the native range	[8]
	Assisted colonization	To avoid extinction	[8]
	Assisted migration	To keep up with climate change	[9]
	Ecological replacement	To restore an ecological function	[8]
	Restocking	Mostly of harvested wild populations	[62]

Within the indigenous range:
reintroduction or reinforcement.

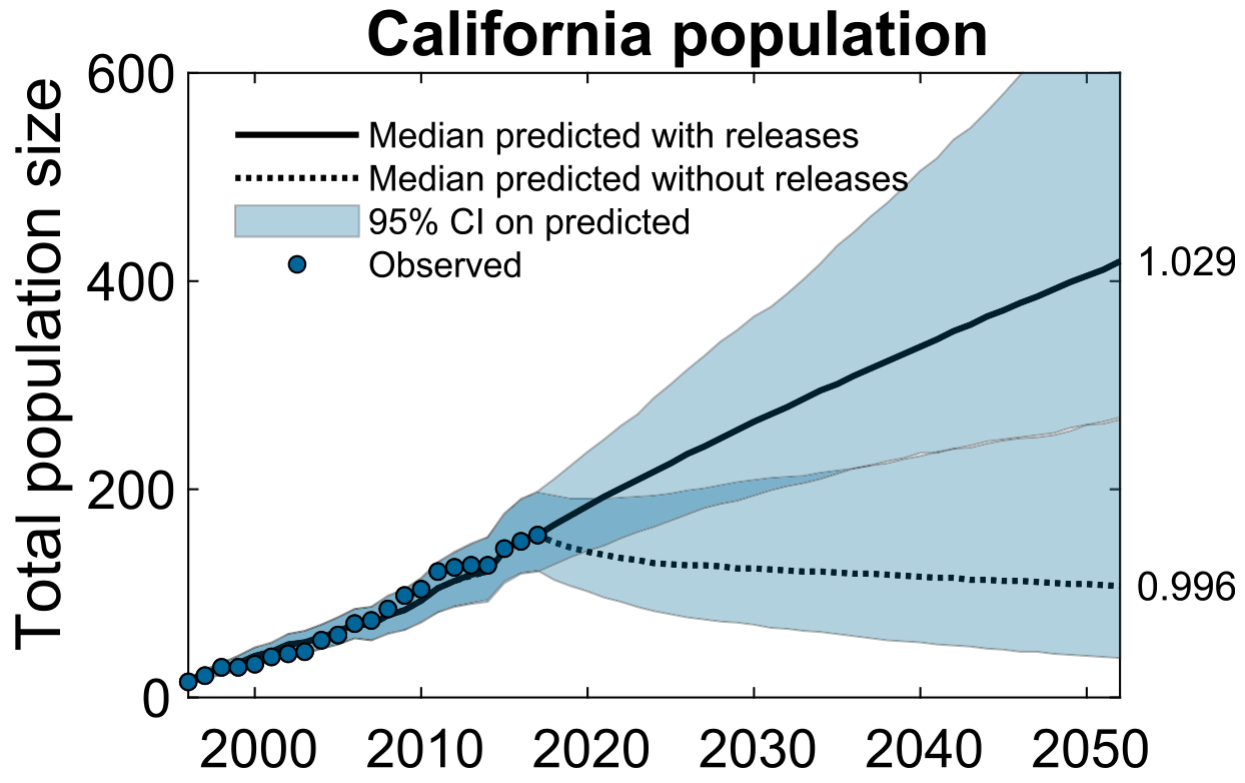
Beyond it:
conservation introduction, including assisted colonisation.

Moving organisms is an action; population persistence is the intended outcome.

Corlett (2016) | Trends in Ecology & Evolution 31:453–462 | Table 1, conservation-translocation rows | doi:10.1016/j.tree.2016.02.017

A growing reintroduced population may still depend on releases

California condors: observed recovery and projected futures are not the same evidence.



Points:
observed population

Solid line:
continued releases

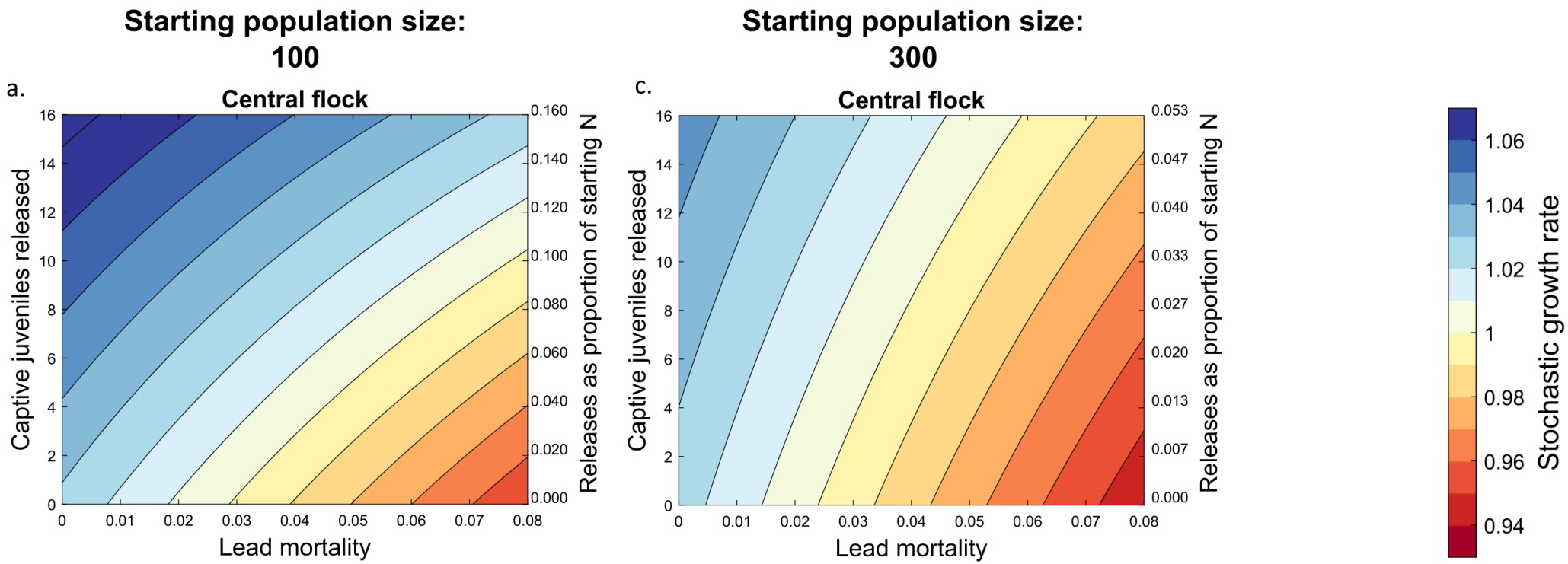
Dotted line:
releases stop

X-axis: calendar year.
Shading: model uncertainty.

Population growth is not self-sufficiency when it depends on continued releases.

Reducing the threat can outperform repeatedly adding individuals

Condor management scenarios compare lead-related mortality with annual captive releases.



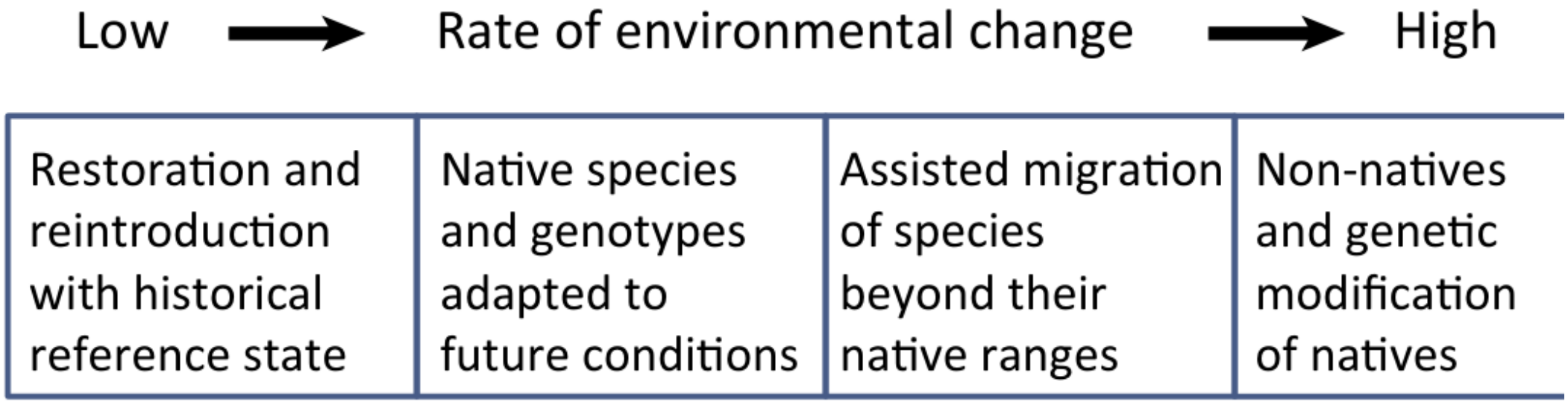
Left = lower lead mortality. Up = more releases. Colours = growth rate. Demographic benefits, not financial returns.

In the condor model, threat reduction can reduce dependence on releases.

Bakker et al. (2024) | Biological Conservation 291:110447 doi:10.1016/j.biocon.2024.110447

Climate change can alter which conservation interventions are viable

The intervention must match future conditions



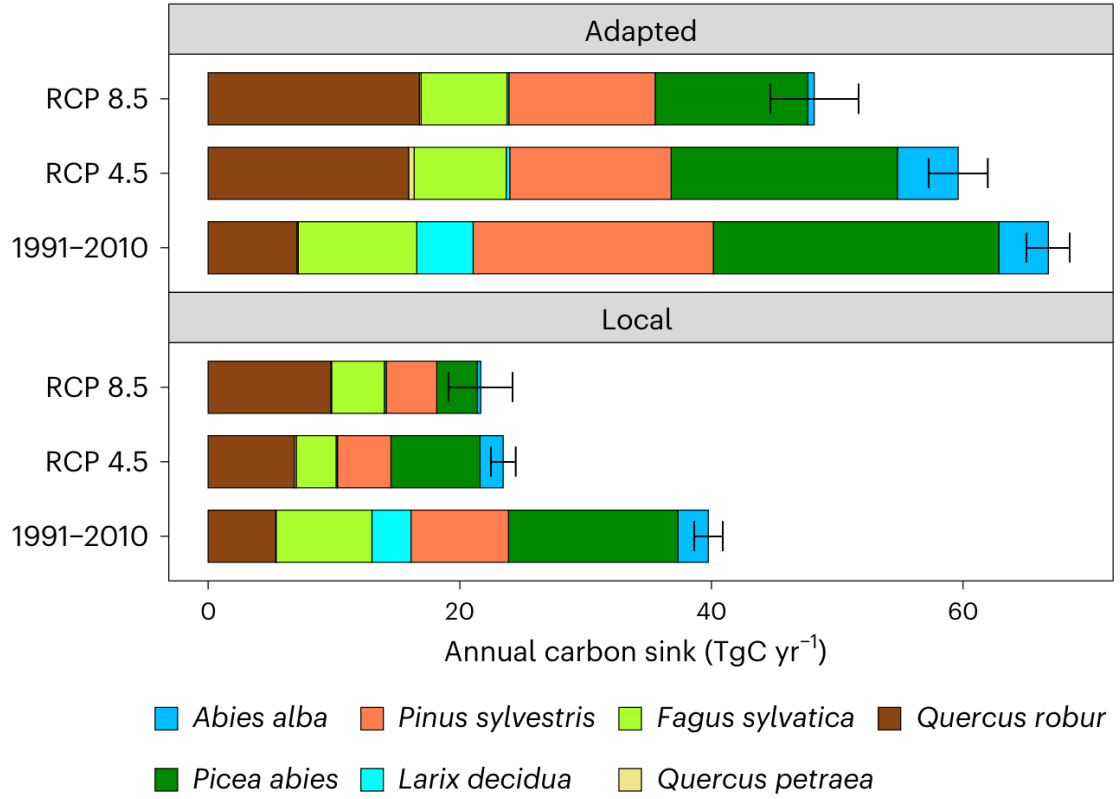
Not a measured threshold.
Not an automatic escalation rule.

Compare the risk of intervention with the risk of inaction.

Compare intervention, inaction and alternatives under future conditions.

Climate-adapted seed sources could sustain more future carbon uptake

587 provenance trials inform projections for seven European tree species.



2061–2080 SCENARIOS

48–60

Tg C yr^{-1}: adapted sources

22–23

Tg C yr^{-1}: local sources

Projected carbon gains from seed-source selection do not prove broader ecological benefits.

Choose the intervention that addresses the limiting mechanism

Different tools can be complementary. None removes the need for a clear objective.

Intervention	Ecological requirement	Feasibility and risk	Equity question
In situ management	Maintain habitat and remove the relevant threat	Sustained funding; pressures outside the site	Who bears restrictions?
Ex situ conservation	Keep representative, viable biological material	Capacity; genetic sampling; continued care	Whose diversity is represented?
Reintroduction / reinforcement	Suitable receiving habitat and viable demography	Threats; disease; welfare; long-term support	Who decides on the release?
Assisted migration	Future suitability and benefit over alternatives	Maladaptation; non-target effects; uncertainty	Who bears risks at the destination?

Match the action to the limiting mechanism, feasibility, risks and equity.

An effective conservation plan starts with an outcome—not an intervention

Eight decisions connect ecological evidence to implementation and adaptive management.

01 TARGET + DIAGNOSIS

1 What must persist—where, for whom and by when?

2 Which pressure or process limits it?

target • baseline • mechanism

02 PRIORITY + ACTION

1 Where and when should we act?

2 Which action changes the limiting mechanism?

representation • urgency • connectivity

03 FUTURE + DELIVERY

1 Will the strategy remain viable as conditions change?

2 Who decides, pays, delivers and bears the costs?

climate • feasibility • governance • equity

04 EVIDENCE + ADAPTATION

1 What ecological outcome will demonstrate success?

2 What result triggers continue, modify or stop?

indicator • counterfactual • decision trigger

TAKE-HOME **A conservation plan is a testable explanation of how action can improve persistence.**

Teaching synthesis: Margules & Pressey (2000); Kukkala & Moilanen (2013); Oldekop et al. (2016); course framework.

A defensible conservation plan must pass four tests

Ecological promise is necessary—but never sufficient.

ECOLOGICAL LOGIC

target → mechanism → expected outcome

Does the action address the bottleneck?

SPATIAL + TEMPORAL PRIORITY

representation • complementarity • urgency • connectivity

Why here—and why now?

DEFENSIBLE CONSERVATION DECISION

DELIVERY + EQUITY

feasibility • resources • governance • rights

Who can implement it—and who bears the costs?

EVIDENCE + ADAPTATION

indicator • counterfactual • uncertainty • decision trigger

What evidence would change the plan?

FINAL TEST **Do not fund a label. Fund a mechanism, test the outcome, and be ready to change course.**

Teaching synthesis: Saura et al. (2019); Edgar et al. (2014); Oldekop et al. (2016); Corlett (2016); Bakker et al. (2024).

Selected literature 1 / 2

All 12 selected papers are represented in the lecture, with original figures or the original table.

Haddad et al. (2015) — Habitat fragmentation and its lasting impact on Earth's ecosystems.

Science Advances 1:e1500052 | doi:10.1126/sciadv.1500052

Saura et al. (2019) — Global trends in protected area connectivity from 2010 to 2018.

Biological Conservation 238:108183 | doi:10.1016/j.biocon.2019.07.028

Margules & Pressey (2000) — Systematic conservation planning.

Nature 405:243–253 | doi:10.1038/35012251

Kukkala & Moilanen (2013) — Core concepts of spatial prioritisation in systematic conservation planning.

Biological Reviews 88:443–464 | doi:10.1111/brv.12008

Hanson et al. (2022) — A comparison of approaches for including connectivity in systematic conservation planning.

Journal of Applied Ecology 59:2507–2519 | doi:10.1111/1365-2664.14251

Edgar et al. (2014) — Global conservation outcomes depend on marine protected areas with five key features.

Nature 506:216–220 | doi:10.1038/nature13022

Selected literature 2 / 2

All 12 selected papers are reresented in the lecture, with original figures or the original table.

Geldmann et al. (2019) — A global-level assessment of the effectiveness of protected areas at resisting anthropogenic pressures.

PNAS 116:23209–23215 | doi:10.1073/pnas.1908221116

Oldekop et al. (2016) — A global assessment of the social and conservation outcomes of protected areas.

Conservation Biology 30:133–141 | doi:10.1111/cobi.12568

Mounce, Smith & Brockington (2017) — Ex situ conservation of plant diversity in the world's botanic gardens.

Nature Plants 3:795–802 | doi:10.1038/s41477-017-0019-3

Corlett (2016) — Restoration, Reintroduction, and Rewilding in a Changing World.

Trends in Ecology & Evolution 31:453–462 | doi:10.1016/j.tree.2016.02.017

Bakker et al. (2024) — Practical models to guide the transition of California condors from a conservation-reliant to a self-sustaining species.

Biological Conservation 291:110447 | doi:10.1016/j.biocon.2024.110447

Chakraborty et al. (2024) — Assisted tree migration can preserve the European forest carbon sink under climate change.

Nature Climate Change 14:845–852 | doi:10.1038/s41558-024-02080-5