BIOECONOMY SCIENCE INSTITUTE
Manaaki Whenua Landcare Research

The impact of mammalian browsers on carbon storage

Duane Peltzer, Jennifer Bufford, Sarah Richardson, Peter Bellingham

Biological invasions are a major component of global change

- Most mammals and half our flora are non-native species
- An ecological view of ‘impact’ is $\int$(distribution, abundance, effect)

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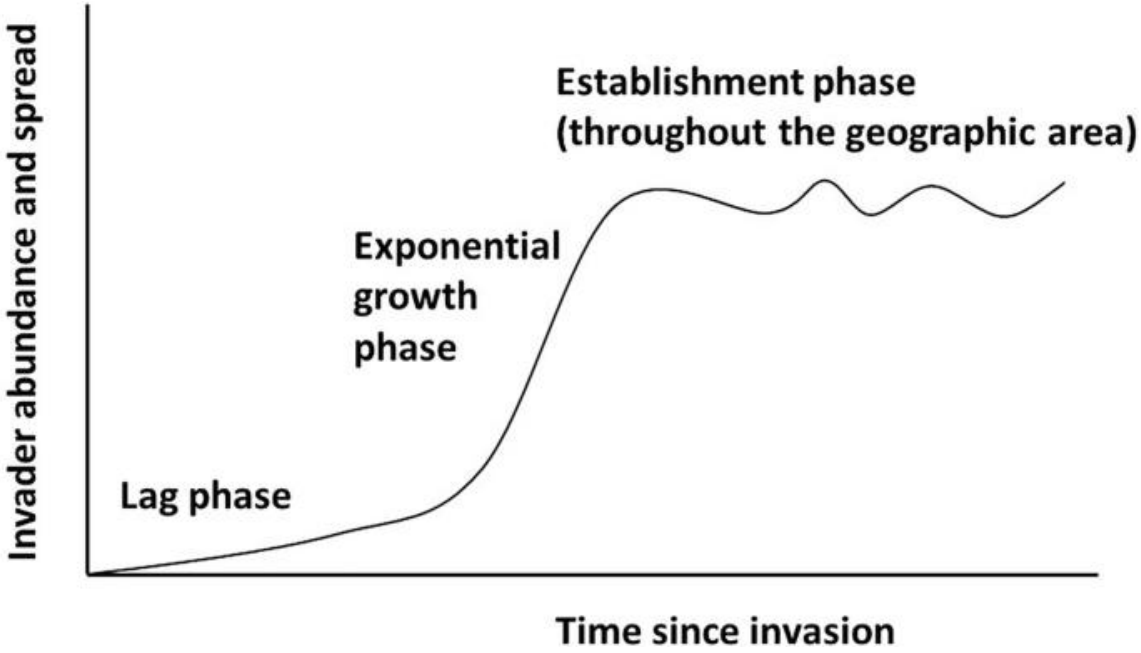
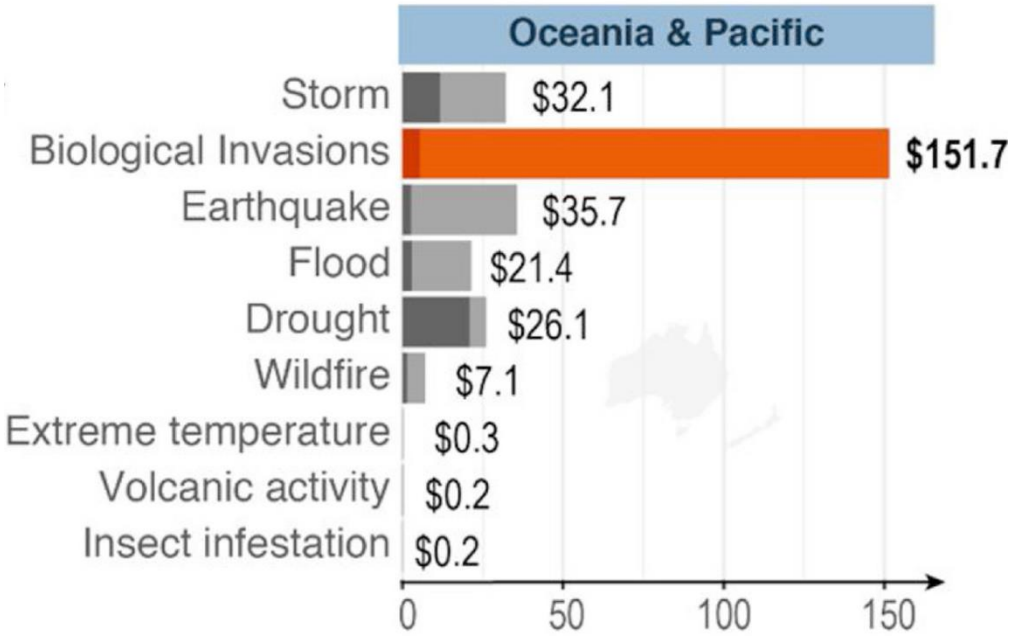
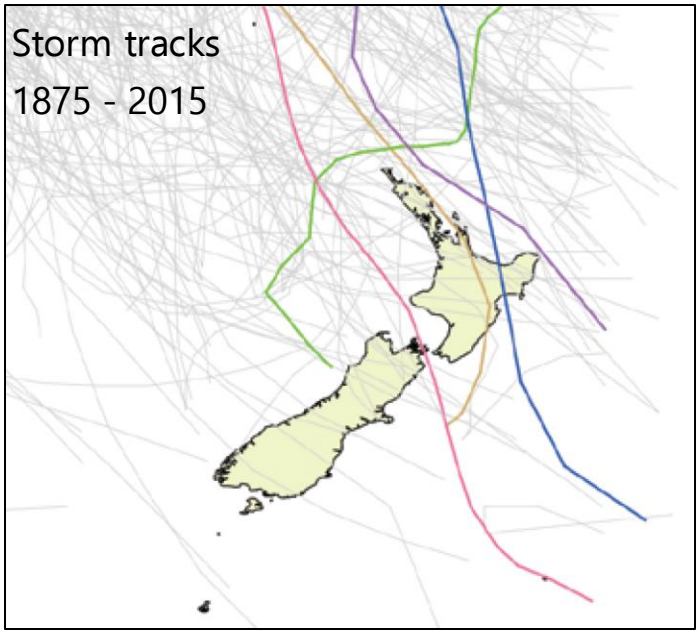


Invaders caused $152 Billion USD damage (1980-2019) for NZ/Australia region



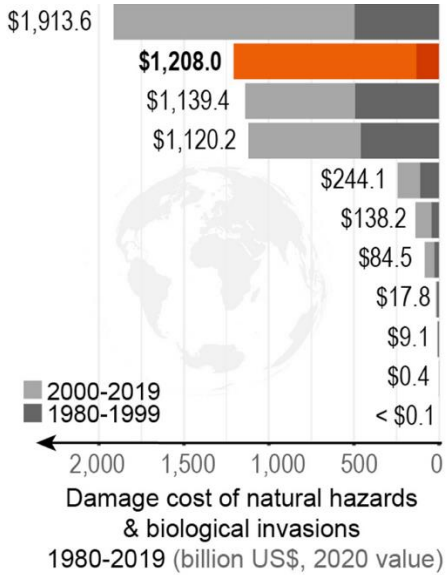


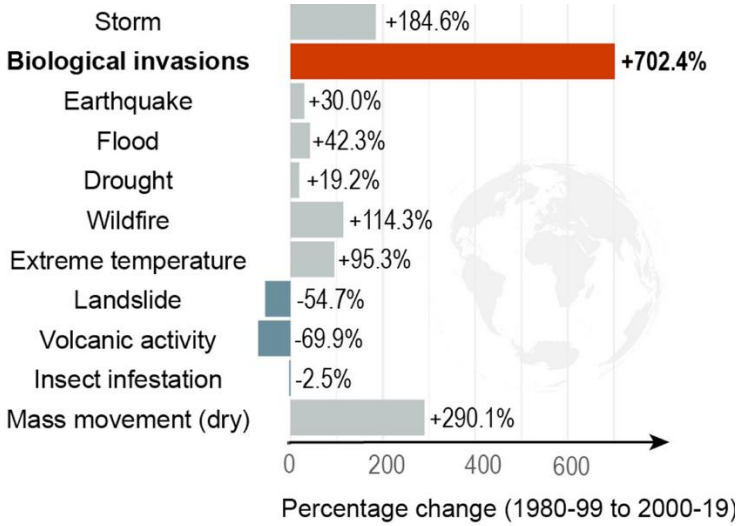
Turbelin et al. 2023 Perspect. Ecol. Cons. 21:143

Wyse et al. 2018 NZJE 42:87

Biological invasions are the fastest growing hazard

Invaders caused $152 Billion USD damage (1980-2019) for NZ/Australia region





Turbelin et al. 2023 Perspect. Ecol. Cons. 21:143

THE BIG KILL

New Zealand's crusade to rid itself of mammals.

BY ELIZABETH KOLBERT

Rats and other invasive mammals are destroying New Zealand's native fauna. A quarter of native birds are extinct. The kiwi is threatened. What can be done? "Conservation is all about killing things," a volunteer coördinator said.

PHOTOGRAPH BY STEPHEN DUPONT

THE NEW YORKER

Why do we manage biological invaders?

- To eradicate, contain or reduce abundance of populations

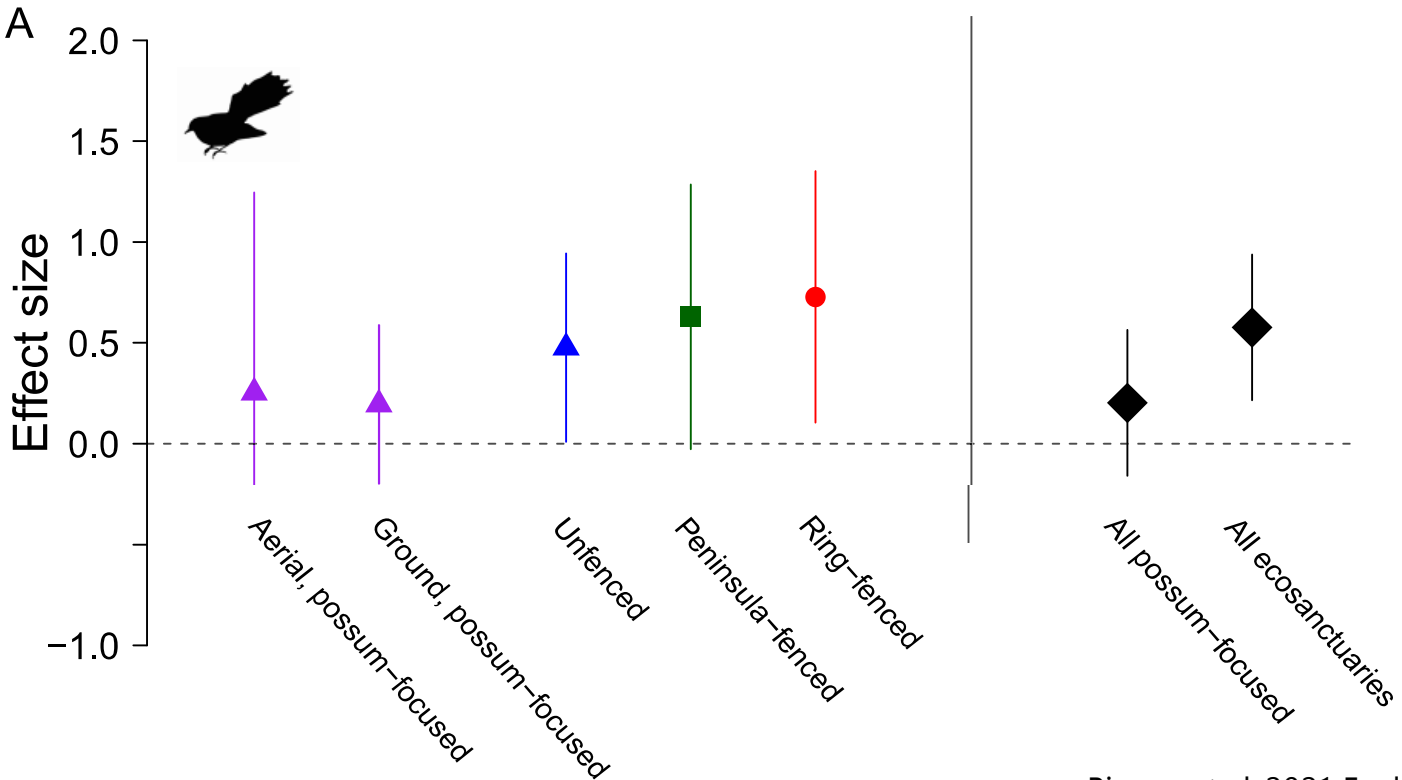
Why do we manage biological invaders?

- To eradicate, contain or reduce abundance of populations

What outcomes are sought?

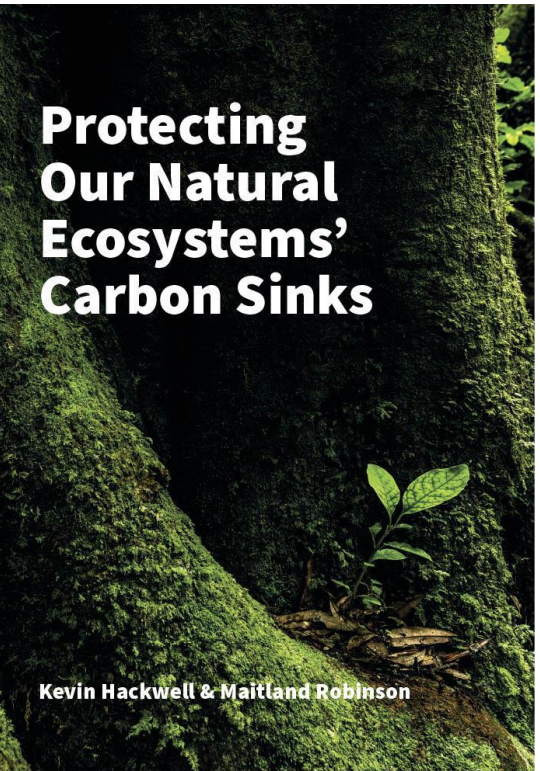
- Biodiversity including vulnerable sites or species
- Disease management
- Safeguard economic activity
- Ecosystem condition (composition, structure, functions)
- Carbon

Bird (and plant) diversity increases with intensive long-term (>7 yr) possum, rat and mustelid control



Binney et al. 2021 Ecol. Monographs e01439

Q: Does management of mammal browsers increase C sequestration of indigenous forests?



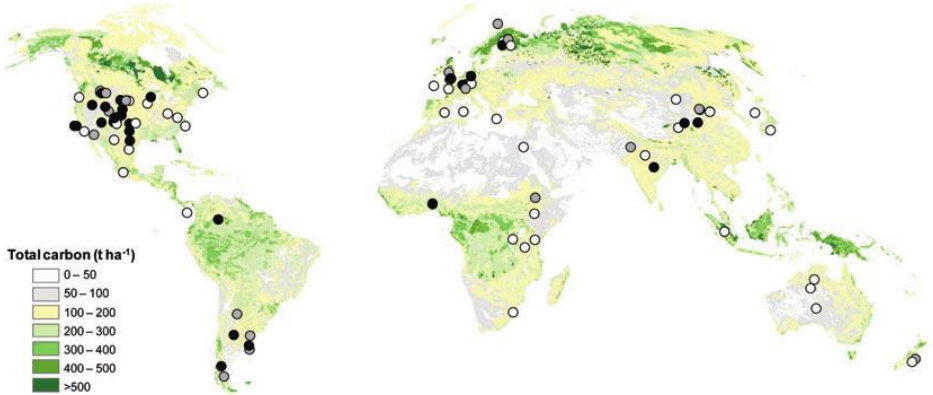
Some propose major gains are likely. AI.

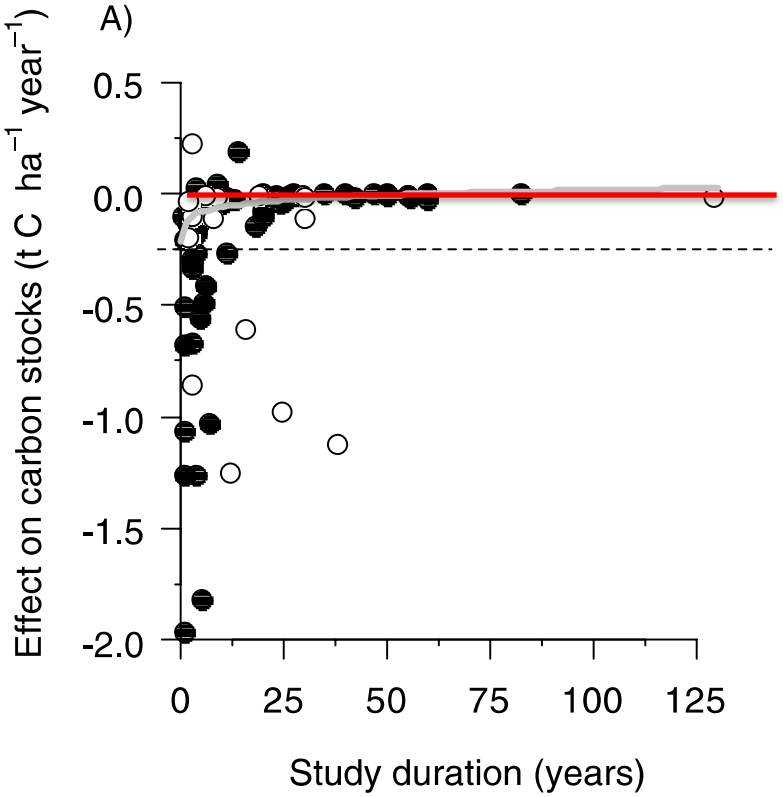
Most scientific/peer-reviewed studies demonstrate no or small effects.

Can decision makers be confident in C gains from management interventions?

Take home: some science principles required to claim management like **attribution** and **permanence** aren't met.

- Browser impacts can be positive or negative, and vary among species and systems.

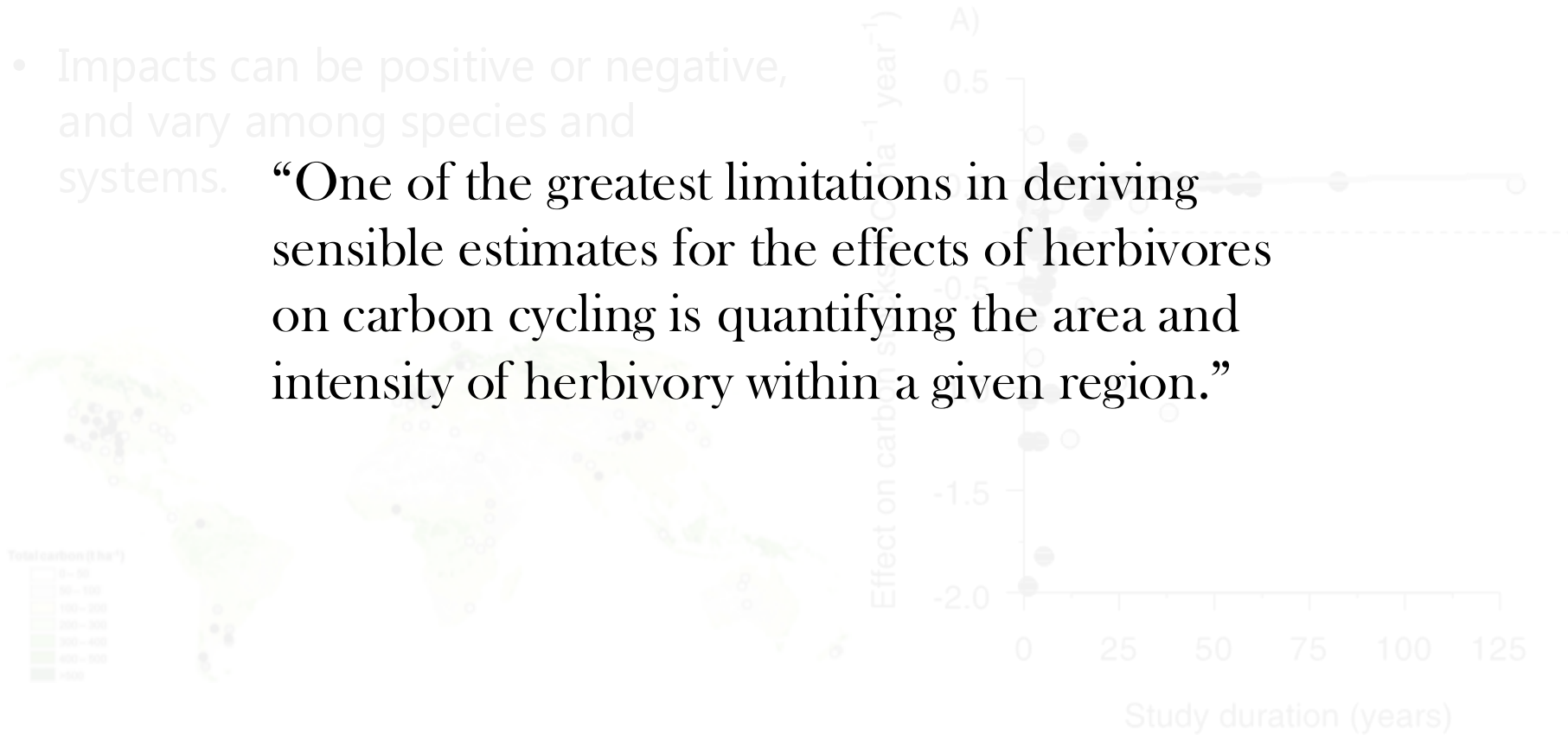




Tanentzap & Coomes 2012 Biol. Rev. 87:72

- Impacts can be positive or negative, and vary among species and systems.

"One of the greatest limitations in deriving sensible estimates for the effects of herbivores on carbon cycling is quantifying the area and intensity of herbivory within a given region."



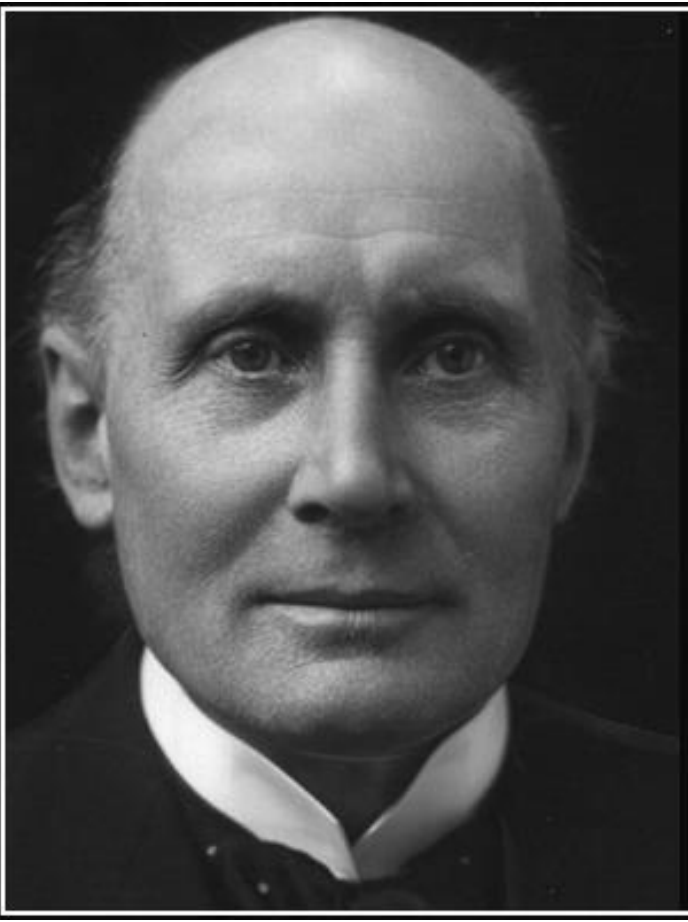
Tanentzap & Coomes 2012 Biol. Rev. 87:72

Most studies (2010-2020 period) measure responses of birds or plant species to management, but not carbon

Table 2. Number of peer-reviewed journal publications classified by invasive species and biodiversity response categories.

Invasive species	Biodiversity response				
	Bird	**Invertebrate**	**Plant**	**Other**	**Total**
Mammal predator	60	6	0	24	90
Mammal herbivore	0	0	29	1	30
Weed	2	6	10	3	21
Other	4	1	4	5	14
Total	66	13	43	33	155

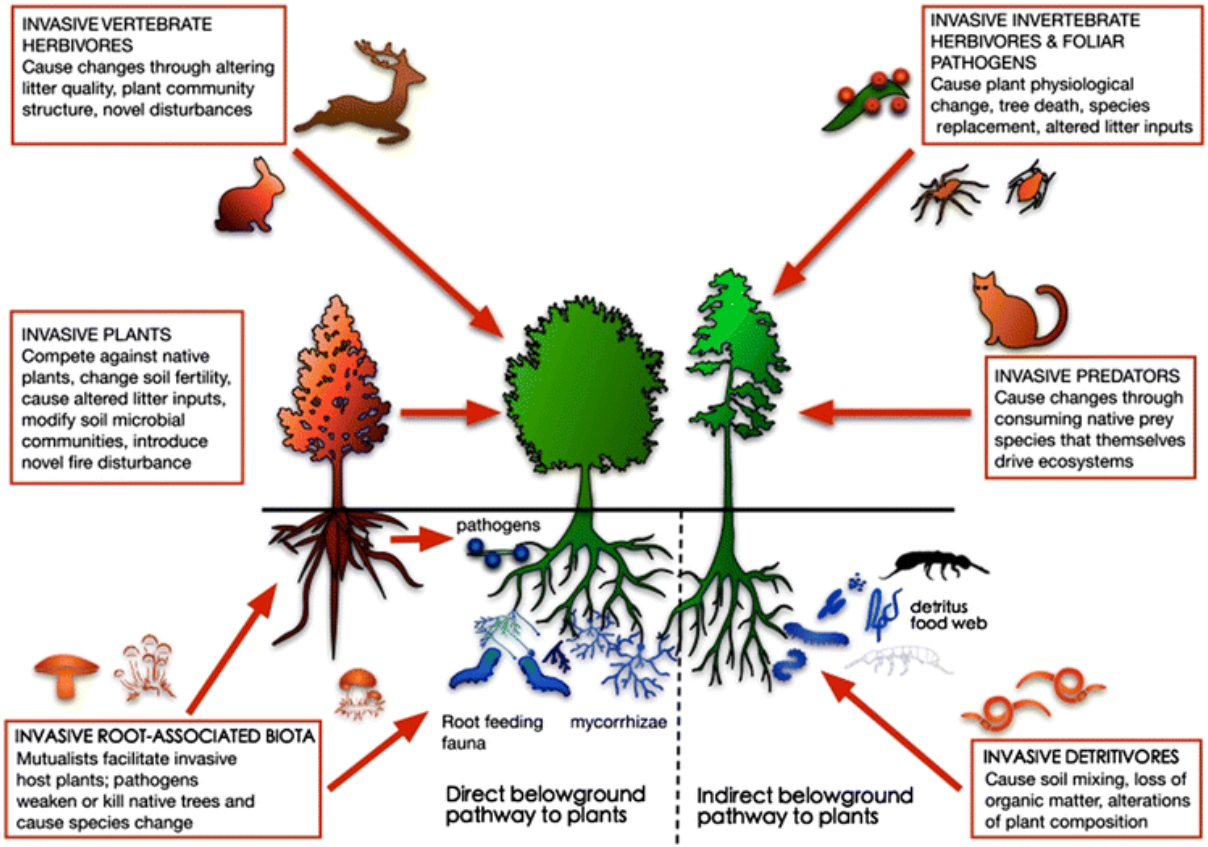
Allen et al. 2023 NZ J Ecology 47:3503



Seek simplicity but distrust it.

— Alfred North Whitehead —

Animal effects depend on other ecosystem processes

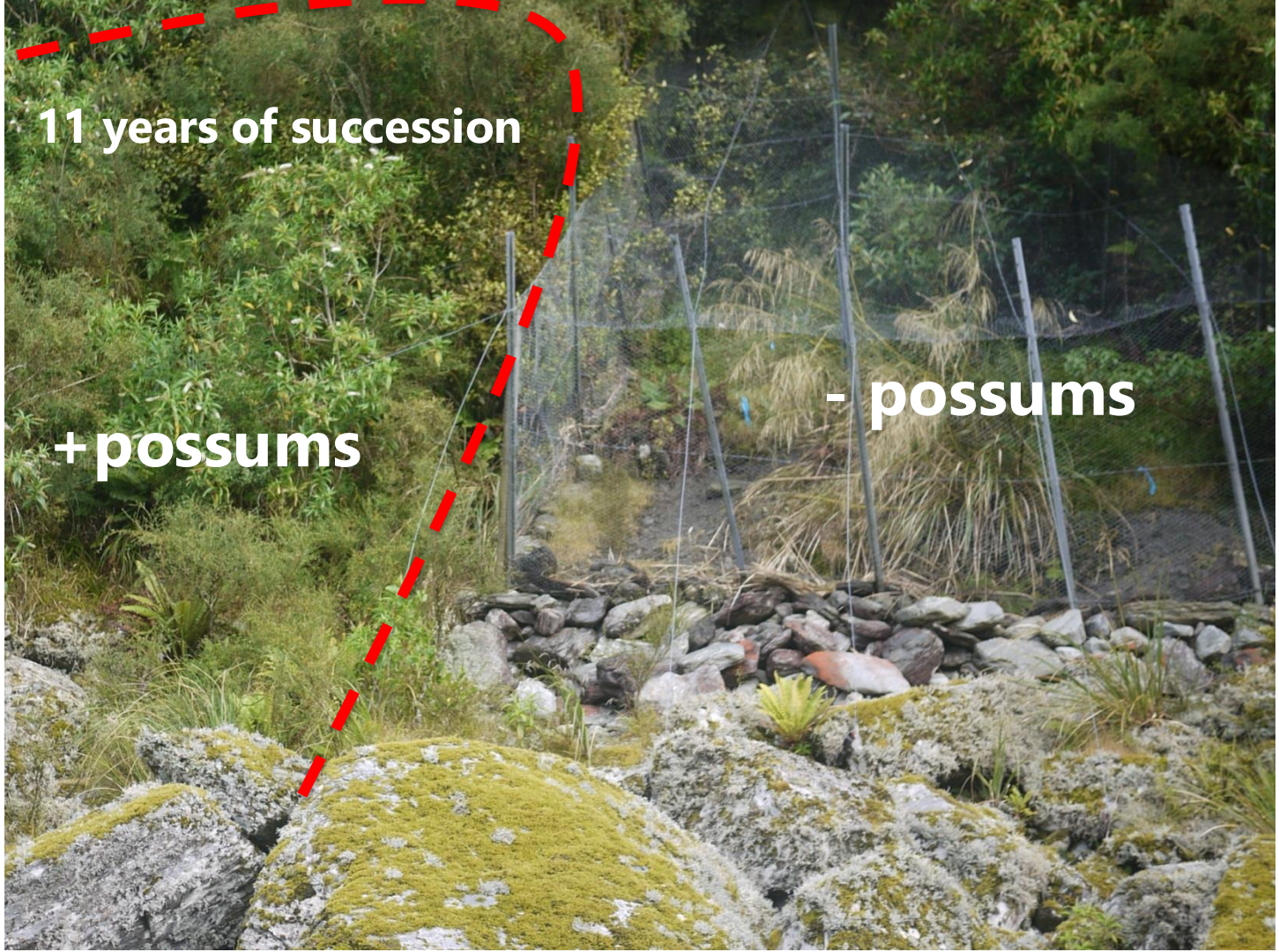


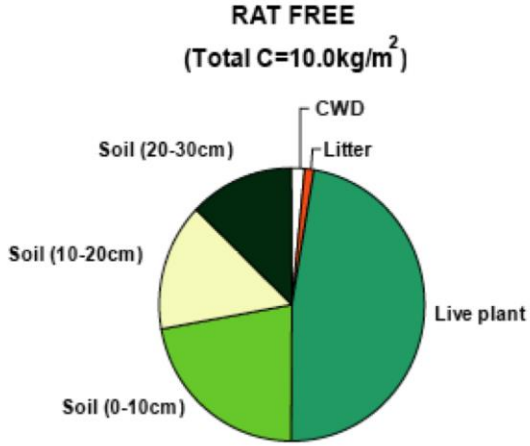
Wardle & Peltzer 2017 Biol. Inv. 19:3301

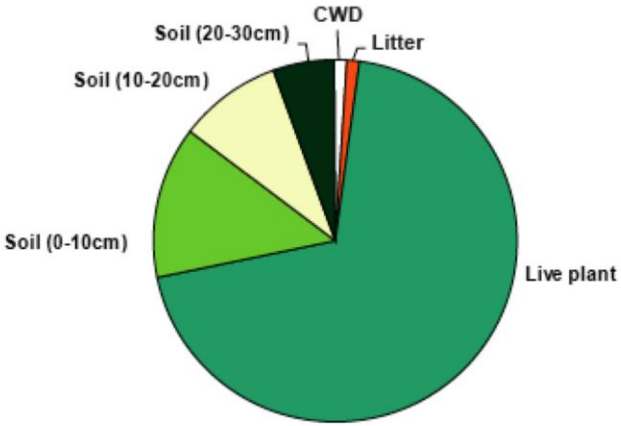
A New Zealand example…

Kokatahi River (Westland) succession experiment excluding possums for 11 years

Prediction:
Removal of possums that eliminate palatable woody will retard succession


11 years of succession
+possums
- possums





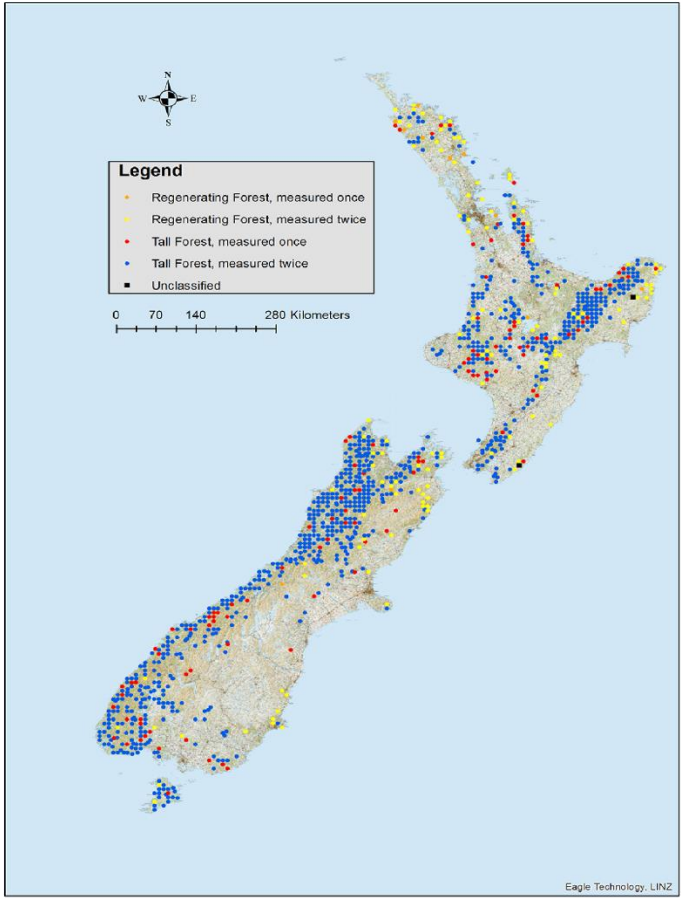
Wardle et al. 2007 Biol Lett 3: 479.

Prediction:
Removal of possums will retard succession

Instead:
Possums removed competitive herbs and grasses: woody succession was more rapid when possums are present.

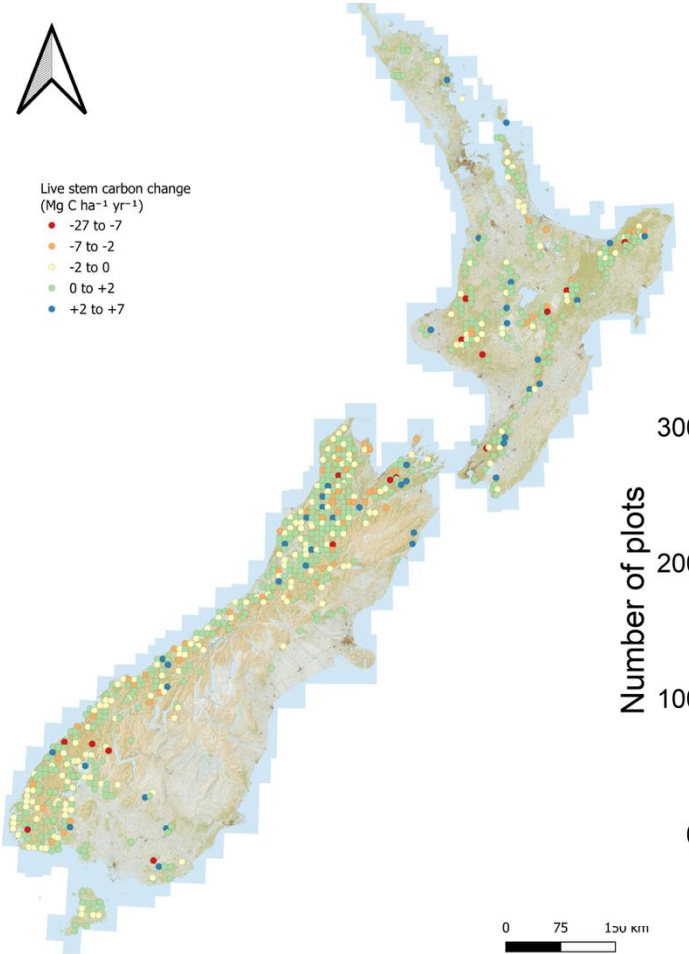
Bellingham et al. 2016 J. Ecol. 104:1505

Indigenous forest plots are used to estimate forest C nationally

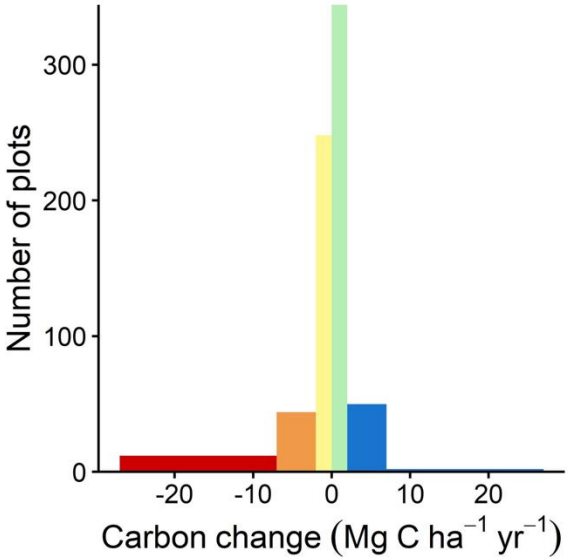


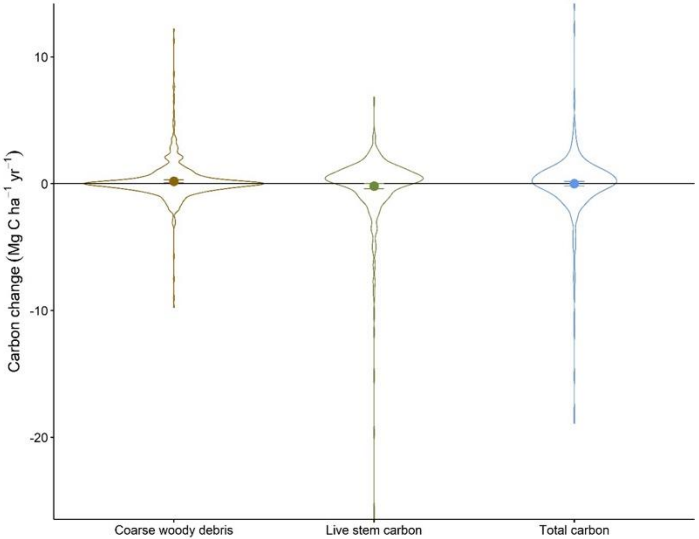
- Coomes et al. 2002 designed system based on NVS.
- Holdaway et al. 2017 (874 plots): old growth forest biomass +0.28 $tC \cdot ha^{-1}$ yr^{-1}; regenerating forests +2.78 tC ha^{-1} yr^{-1}.
- Paul et al. 2021 (1036 plots): No change in total C stocks (227.0 ± 14.4 $tC \cdot ha^{-1}$ vs 227.2 ± 14.5 $tC \cdot ha^{-1}$ for 2002-2007, 2009-2014).

Most recent remeasurement yields similar results



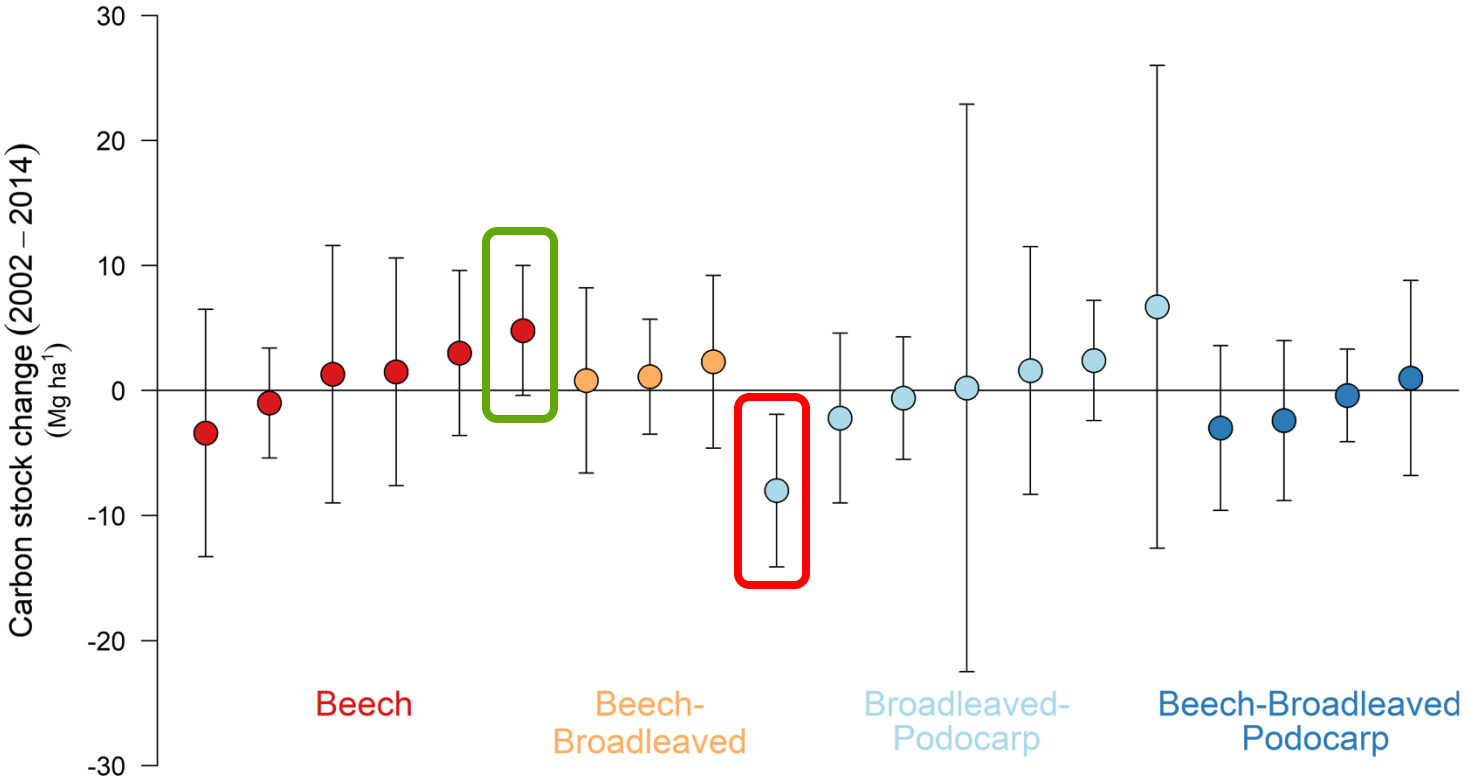
Mean change of -0.0005 Mg C ha^{-1} yr^{-1}





Bufford et al. 2025 LC4613 Report for DOC

Carbon stock changes differ among forest-types



Paul et al. 2021 Forest Ecosyst. 8:34

Infer browser effects from diet selection

Preferred

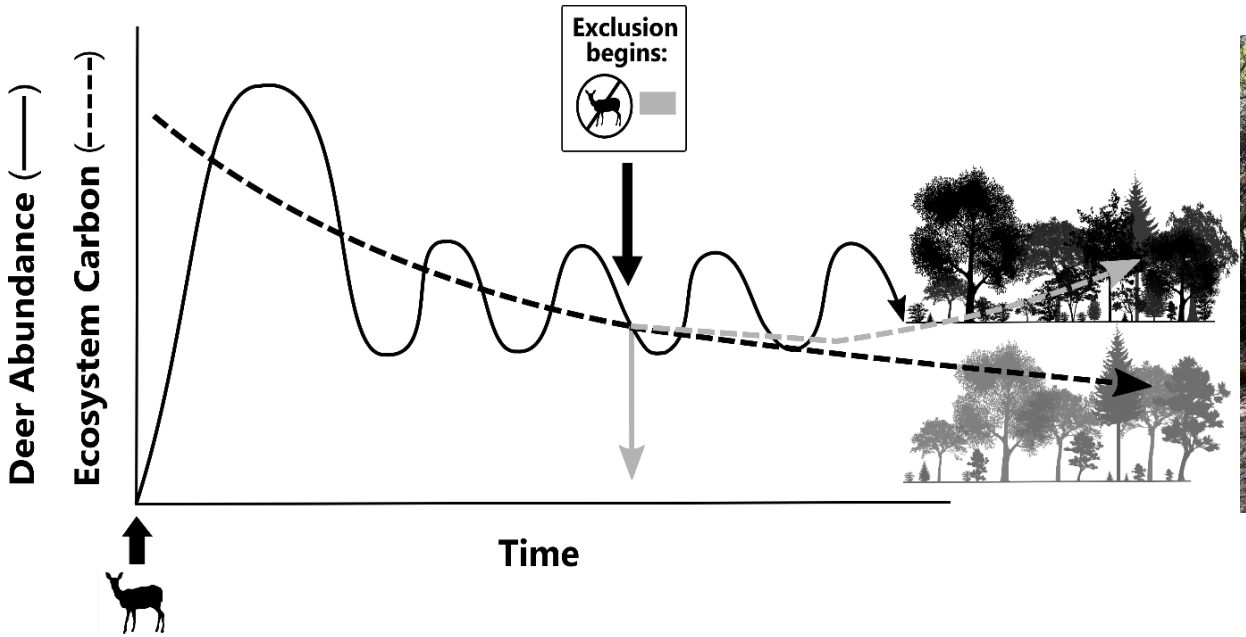
Not selected

Avoided

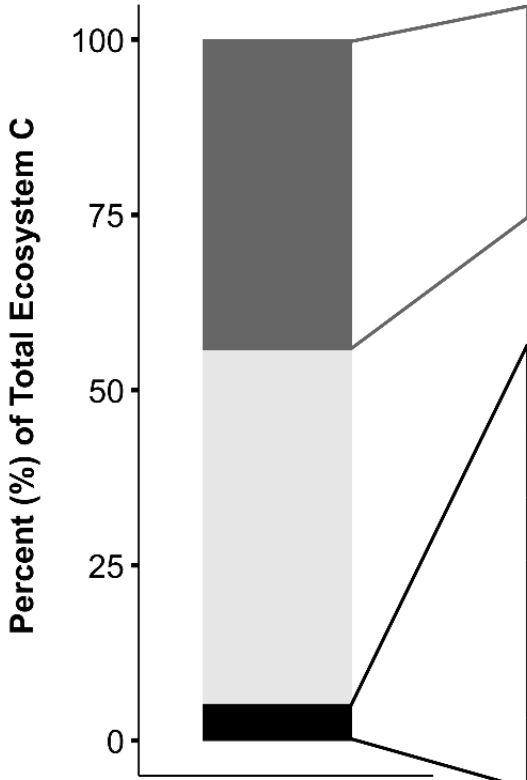
- Deer and possum diet partly overlap
- Possum omnivory and diet selection is problematic

Nugent et al. 2001; Forsyth et al. 2002; Peltzer et al. 2014

A ‘best case scenario’ is exclusion



No difference in total ecosystem C with ungulate exclusion



C pools	Exclosure	Control
Large trees[1]	103.43 ± 19.30 a	127.07 ± 29.17 a
Roots (Large trees)	20.69 ± 3.86 a	25.41 ± 5.83 a

[1]DBH ≥ 30 cm

C pools	Exclosure	Control
Small trees[2]	9.97 ± 1.77 a	5.85 ± 1.05 b
Roots (Small trees)	1.99 ± 0.36 a	1.17 ± 0.21 b
Saplings[3]	0.91 ± 0.10 a	0.54 ± 0.11 b
Roots (Saplings)	0.18 ± 0.02 a	0.11 ± 0.02 b
CWD[4]	4.42 ± 1.10 b	7.81 ± 1.89 a

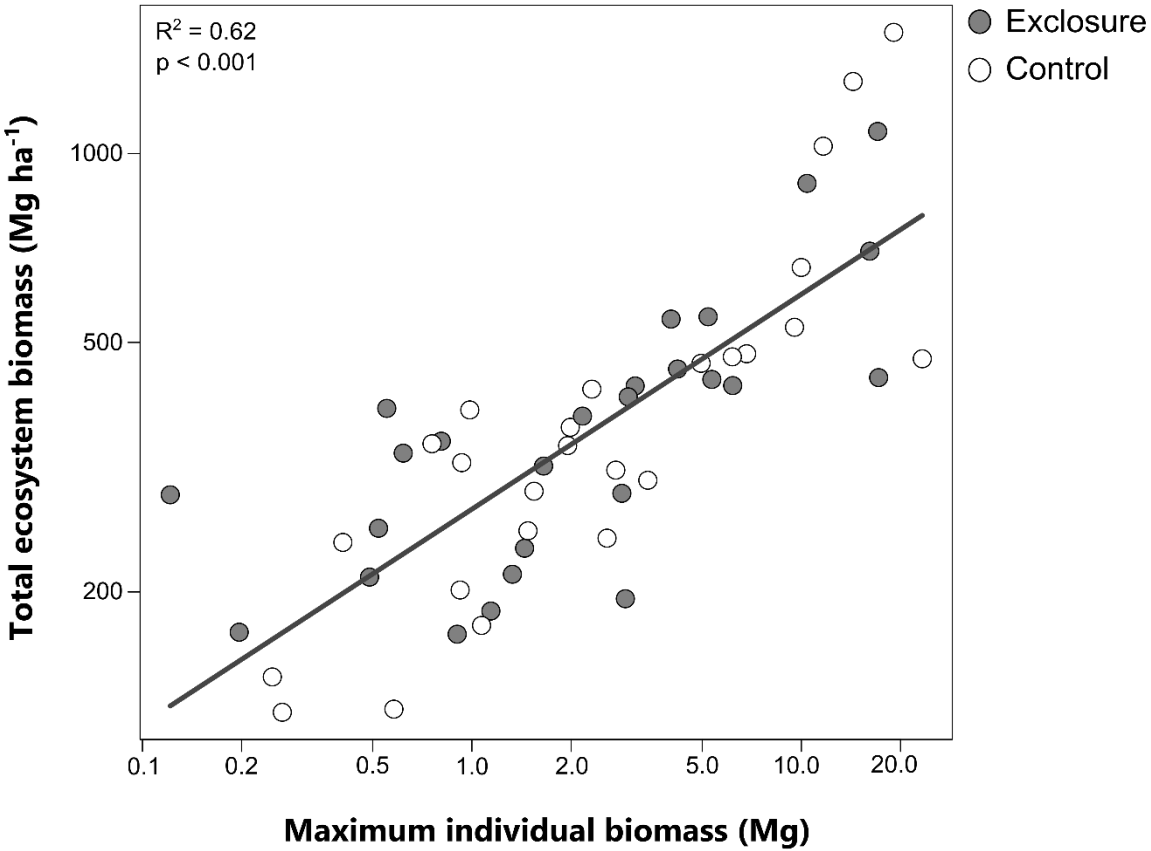
[2]DBH < 10 cm and ≥ 2.5 cm

[3]DBH < 2.5 cm

[4]coarse woody debris

Allen et al. 2023 Ecol Appl 33:e2836

Large trees drive total carbon

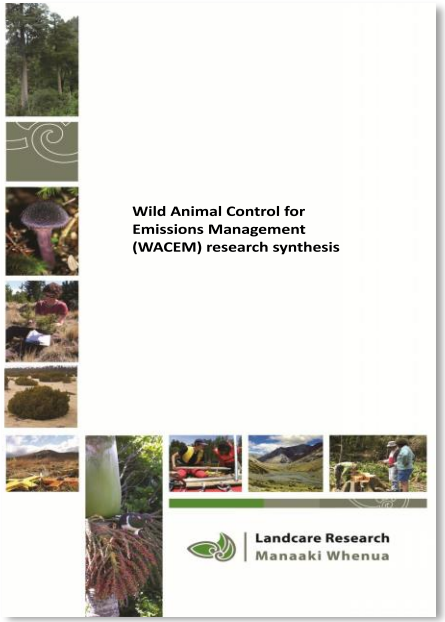


Wild Animal Control for Emissions Management (WACEM) research synthesis

INVESTIGATION NO.: DOC4424

FE Carswell, RJ Holdaway, NWH Mason, SJ Richardson, LE Burrows, RB Allen, DA Peltzer

Landcare Research



Major recommendations:

- Most C gains are through succession or reforestation
- Challenging to show C gains that can be attributable to 'wild animal' control because gains are small compared to sink size or disturbance impacts
- Focus on animal control in broadleaved-hardwood successions, and restoration of successions in relatively wet (1000mm/yr), warm (>9°C MAT) areas.

Science-based principles for Natural Climate Solutions

- Recent review of science principles
- Separate from policy or market considerations
- Principles treated like criteria
- Rank by **confidence** (IPBES)
- Helps to guide decision makers across scales

Ellis et al. 2024 Nature Comm. 15: 547

Prioritised schedule of science principles for NCS's

Measureable: reliable quantification of cumulative effectiveness.
Validated: cross-checked against standards or available methods.
Additional: attributable net change in C from baseline.
Permanent: durable removal (minimum 50 years?).

Material: scaling up and magnitude of effects on C.
Scalable: robustness of measurements across scales.
Leakage: perverse or negative outcomes are avoided.
Transparent: data, analyses and assumptions are accessible.

Peltzer et al. 2025 LC Report 2526-0025 for MfE

Prioritised schedule of science principles for NCS's

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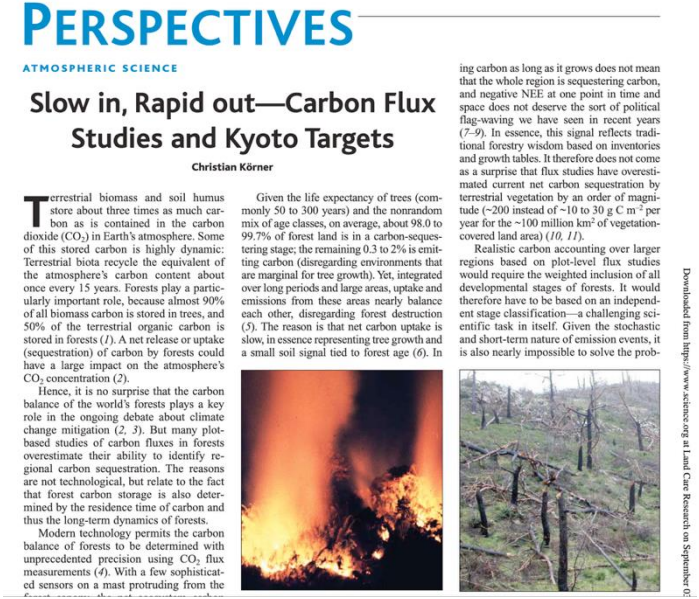
Material: scaling up and magnitude of effects on C.
Scalable: robustness of measurements across scales.
Leakage: perverse or negative outcomes are avoided.
Transparent: data, analyses and assumptions are accessible.
Sustainable: biodiversity or co-benefits accrue.

Additionality/attribution and permanence require work

Additional: attributable net change in C from baseline.
Permanent: durable removal (minimum 50 years?).



PERSPECTIVES

ATMOSPHERIC SCIENCE

Slow in, Rapid out—Carbon Flux Studies and Kyoto Targets

Christian Körner

Terrestrial biomass and soil humus store about three times as much carbon as is contained in the carbon dioxide (CO_2) in Earth's atmosphere. Some of this stored carbon is highly dynamic: Terrestrial biota recycle the equivalent of the atmosphere's carbon content about once every 15 years. Forests play a particularly important role, because almost 90% of all biomass carbon is stored in trees, and 50% of the terrestrial organic carbon is stored in forests (*1*). A net release or uptake (sequestration) of carbon by forests could have a large impact on the atmosphere's CO_2 concentration (*2*).

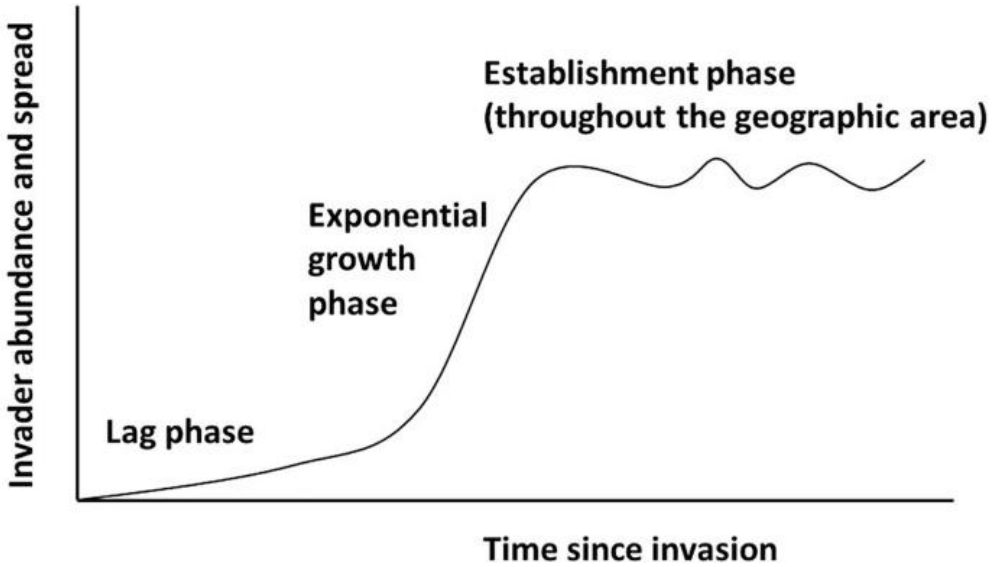
Hence, it is no surprise that the carbon balance of the world's forests plays a key role in the ongoing debate about climate change mitigation (*2, 3*). But many plot-based studies of carbon fluxes in forests overestimate their ability to identify regional carbon sequestration. The reasons are not technological, but relate to the fact that forest carbon storage is also determined by the residence time of carbon and thus the long-term dynamics of forests.

Modern technology permits the carbon balance of forests to be determined with unprecedented precision using CO_2 flux measurements (*4*). With a few sophisticated sensors on a mast protruding from the

Given the life expectancy of trees (commonly 50 to 300 years) and the nonrandom mix of age classes, on average, about 98.0 to 99.7% of forest land is in a carbon-sequestering stage; the remaining 0.3 to 2% is emitting carbon (disregarding environments that are marginal for tree growth). Yet, integrated over long periods and large areas, uptake and emissions from these areas nearly balance each other, disregarding forest destruction (*5*). The reason is that net carbon uptake is slow, in essence representing tree growth and a small soil signal tied to forest age (*6*). In

ing carbon as long as it grows does not mean that the whole region is sequestering carbon, and negative NEE at one point in time and space does not deserve the sort of political flag-waving we have seen in recent years (*7–9*). In essence, this signal reflects traditional forestry wisdom based on inventories and growth tables. It therefore does not come as a surprise that flux studies have overestimated current net carbon sequestration by terrestrial vegetation by an order of magnitude (~200 instead of ~10 to 30 g C m^{-2} per year for the ~100 million km^2 of vegetation-covered land area) (*10, 11*).

Realistic carbon accounting over larger regions based on plot-level flux studies would require the weighted inclusion of all developmental stages of forests. It would therefore have to be based on an independent stage classification—a challenging scientific task in itself. Given the stochastic and short-term nature of emission events, it is also nearly impossible to solve the prob-

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Deer on loose in Christchurch suburb, one hits car

8:55 pm on 22 September 2024

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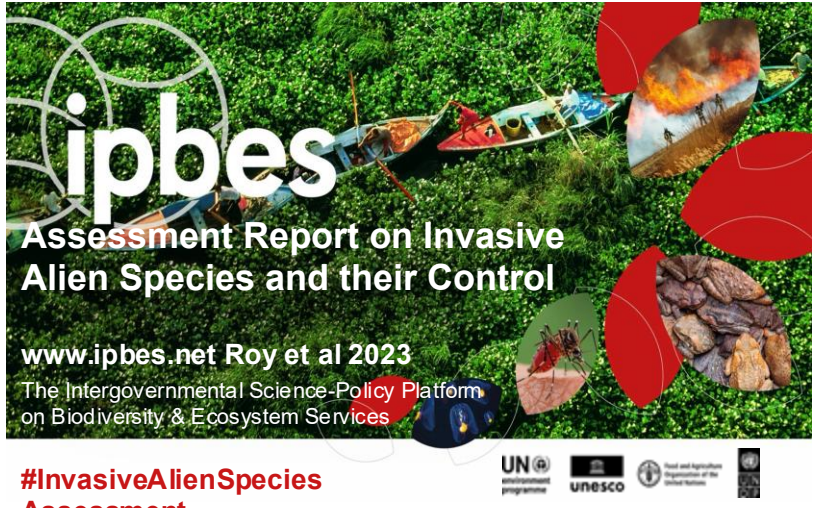
Maia Ingoe, Journalist
@MaiaIngoe maia.ingoe@rnz.co.nz

A deer spotted in a Halswell backyard. Photo: Supplied / Nik Mason

Federated Farmers call for national pest strategy

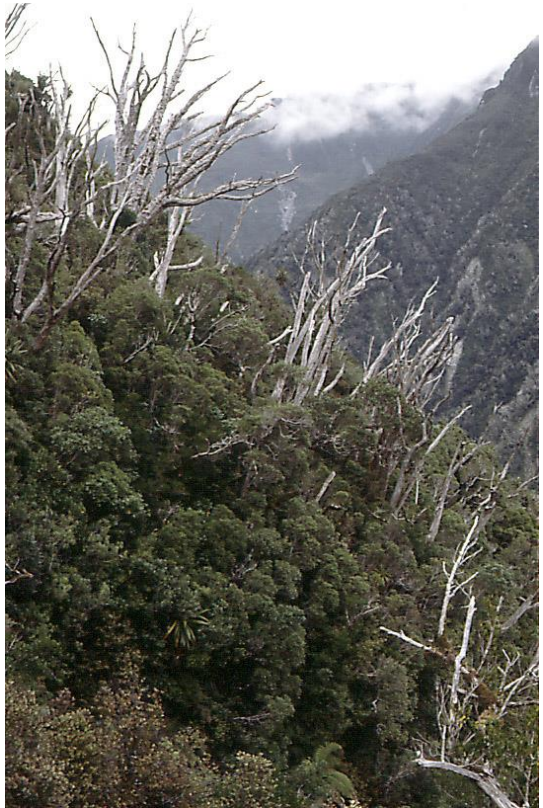
05/09/2025

Federated Farmers is calling for a national pest strategy, saying a rising numbers of feral animals are hammering farm pasture, fences and native bush.



#InvasiveAlienSpecies Assessment

Summary



- The case for managing browsers for C outcomes is weak, but is far stronger for biodiversity goals
- Huge variation occurs among forest-types
- Additionality and permanence are problematic
- Quality evidence is essential for understanding when and where interventions are having the desired outcomes.