

Embracing scale-dependence to achieve synthesis

Jonathan Chase



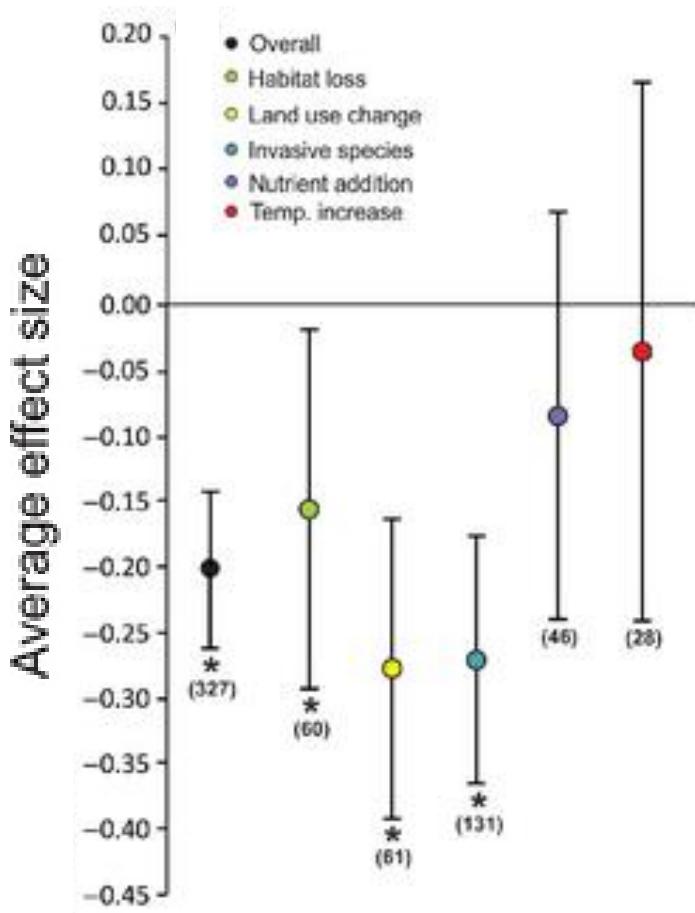
MARTIN-LUTHER-UNIVERSITÄT
HALLE-WITTENBERG



German Centre
for Integrative
Biodiversity Research



We know that biodiversity is declining.....and this is bad



Murphy and Romanuk 2013

REVIEW

doi:10.1038/nature11148

Biodiversity loss and its impact on humanity

Bradley J. Cardinale¹, J. Emmett Duffy², Andrew Gonzalez³, David U. Hooper⁴, Charles Perrings⁵, Patrick Venail¹, Anita Narwani¹, Georgina M. Mace⁶, David Tilman⁷, David A. Wardle⁸, Ann P. Kinzig⁵, Gretchen C. Daily⁹, Michel Loreau¹⁰, James B. Grace¹¹, Anne Larigauderie¹², Diane S. Srivastava¹³ & Shahid Naeem¹⁴

LETTER

doi:10.1038/nature11118

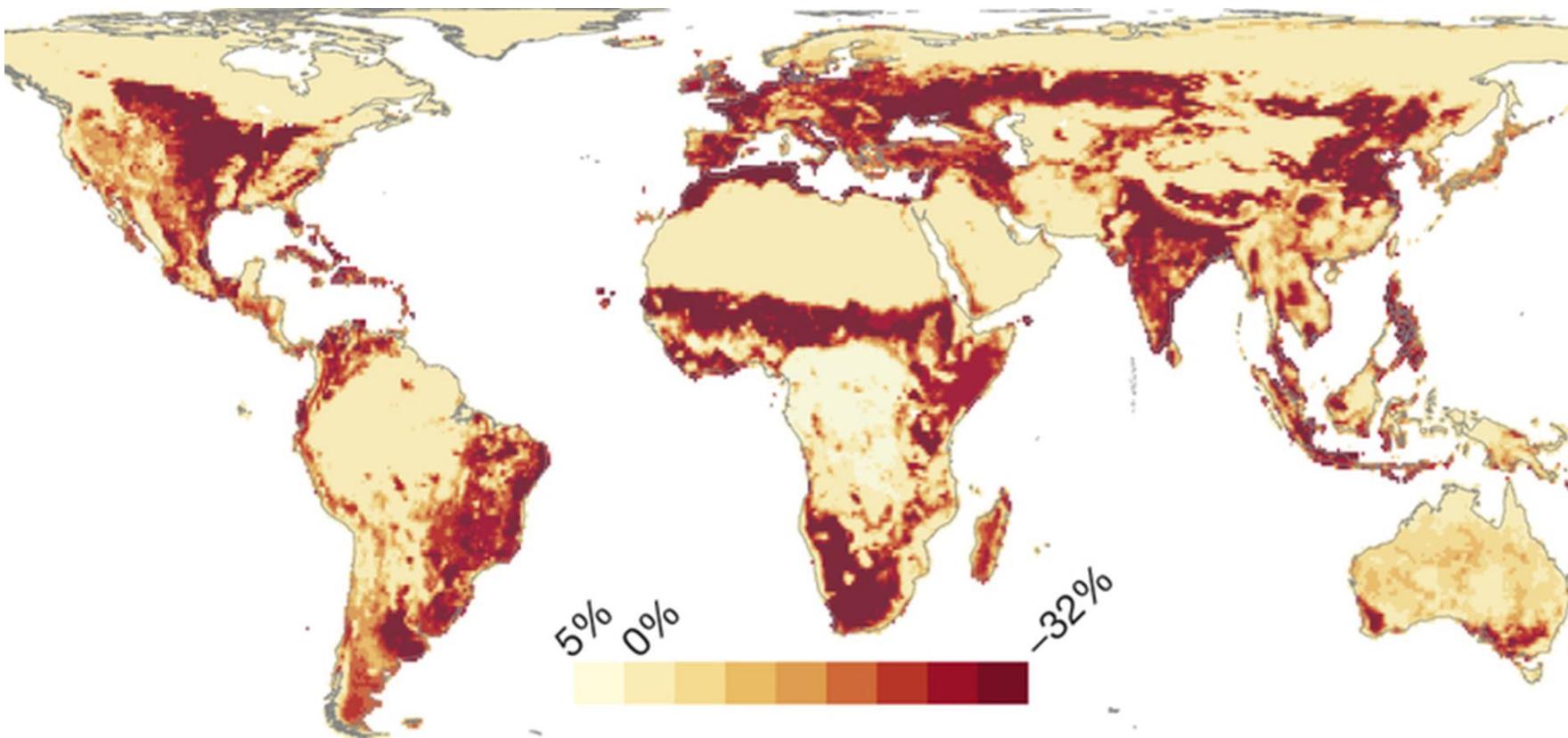
A global synthesis reveals biodiversity loss as a major driver of ecosystem change

David U. Hooper¹, E. Carol Adair^{2,3}, Bradley J. Cardinale⁴, Jarrett E. K. Byrnes², Bruce A. Hungate⁵, Kristin L. Matulich⁶, Andrew Gonzalez⁷, J. Emmett Duffy⁸, Lars Gamfeldt⁹ & Mary I. O'Connor^{2,10}

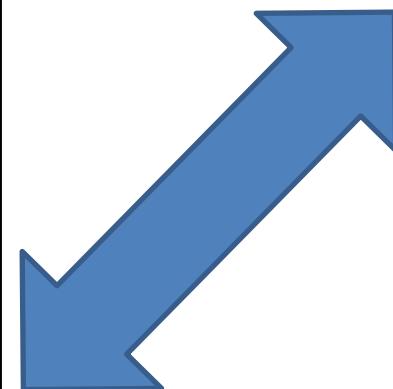
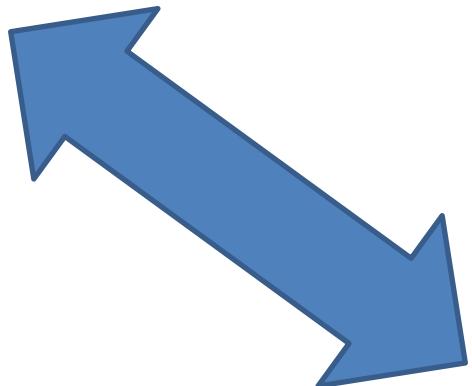
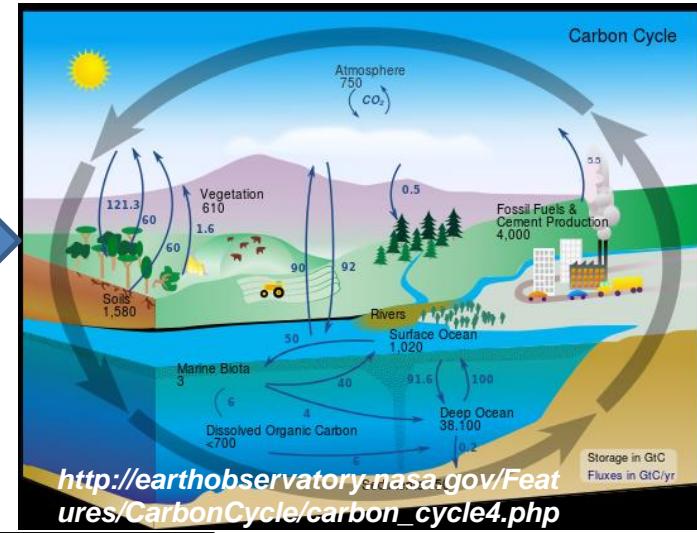
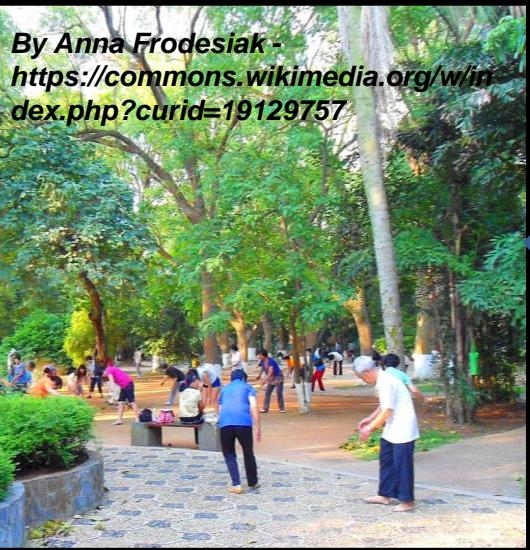
The Functions of Biological Diversity in an Age of Extinction

Shahid Naeem,^{1*} J. Emmett Duffy,² Erika Zavaleta³

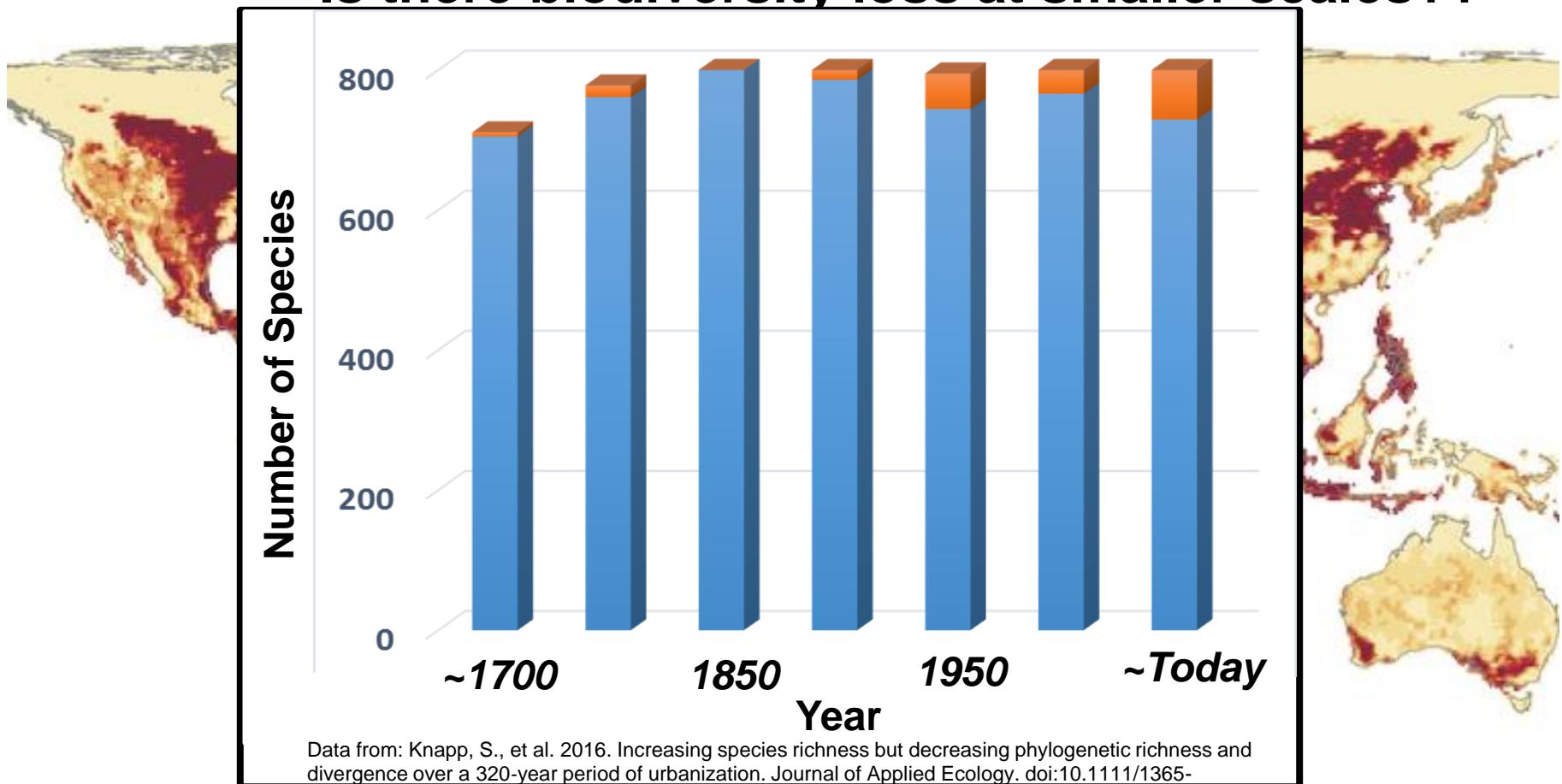
Land-use change and local biodiversity--PREDICTS



Reprinted by permission from Macmillan Publishers Ltd: Newbold, T., et al. 2015. Global effects of land use on local terrestrial biodiversity. *Nature*, 520: 45-50.



Is there biodiversity loss at smaller scales??



Data from: Knapp, S., et al. 2016. Increasing species richness but decreasing phylogenetic richness and divergence over a 320-year period of urbanization. *Journal of Applied Ecology*. doi:10.1111/1365-2664.12826

Reprinted by permission from Macmillan Publishers Ltd: Newbold, T., et al. 2015. Global effects of land use on local terrestrial biodiversity. *Nature*, 520: 45-50.



Photos by Jonathan Chase

WORLD VIEW

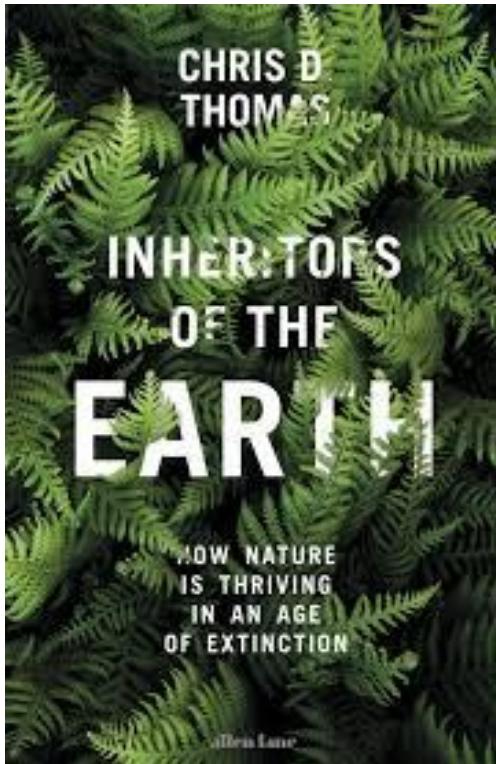
A personal take on events

PHIL ROBERTS



The Anthropocene could raise biological diversity

Humanity has wrought an age of ecological transformations. It is time to rethink our irrational dislike of invading species, argues Chris D. Thomas.



On average, less than one native species dies out for each introduced species that arrives. Britain, for instance, has gained 1,875 established non-native species without yet losing anything to the invaders.

Is diversity really declining?

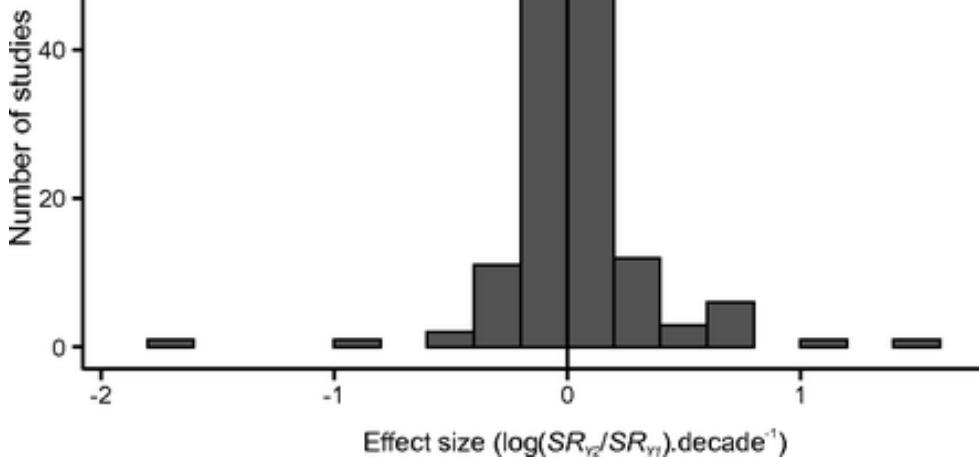
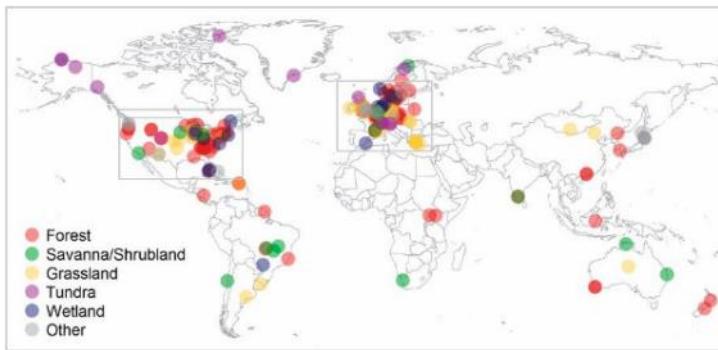
PNAS

Global meta-analysis reveals no net change in local-scale plant biodiversity over time

Mark Vellend^{a,1}, Lander Baeten^{b,c}, Isla H. Myers-Smith^{a,d}, Sarah C. Elmendorf^e, Robin Beauséjour^a, Carissa D. Brown^a, Pieter De Frenne^a, Kris Verheyen^a, and Sonja Wipf^f

^aDépartement de Biologie, Université de Sherbrooke, Sherbrooke, QC, Canada J1K 2R1; ^bDepartment of Forest and Water Management, Forest and Nature Lab, Ghent University, BE-9090 Melle-Gontrode, Belgium; ^cDepartment of Biology, Terrestrial Ecology Unit, Ghent University, BE-9000 Gent, Belgium; ^dSchool of GeoSciences, University of Edinburgh, Edinburgh EH9 3JW, United Kingdom; ^eNational Ecological Observatory Network, Boulder, CO 80301; and ^fWSL Institute for Snow and Avalanche Research SLF, CH-7260 Davos, Switzerland

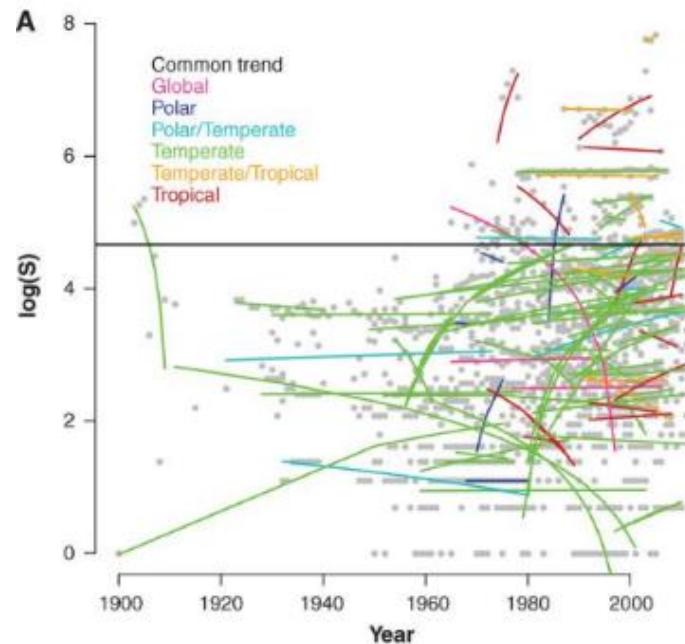
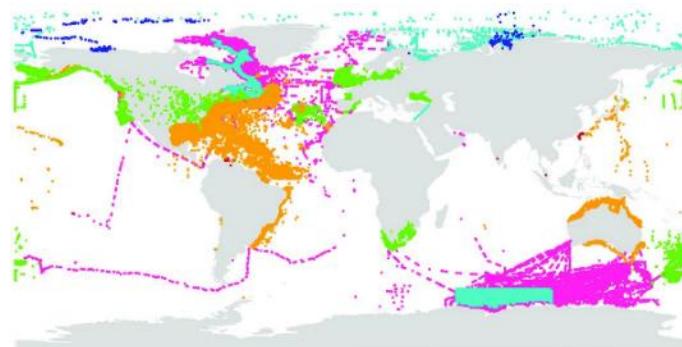
Edited by Peter M. Kareiva, The Nature Conservancy, Seattle, WA, and approved October 1, 2013 (received for review July 9, 2013)



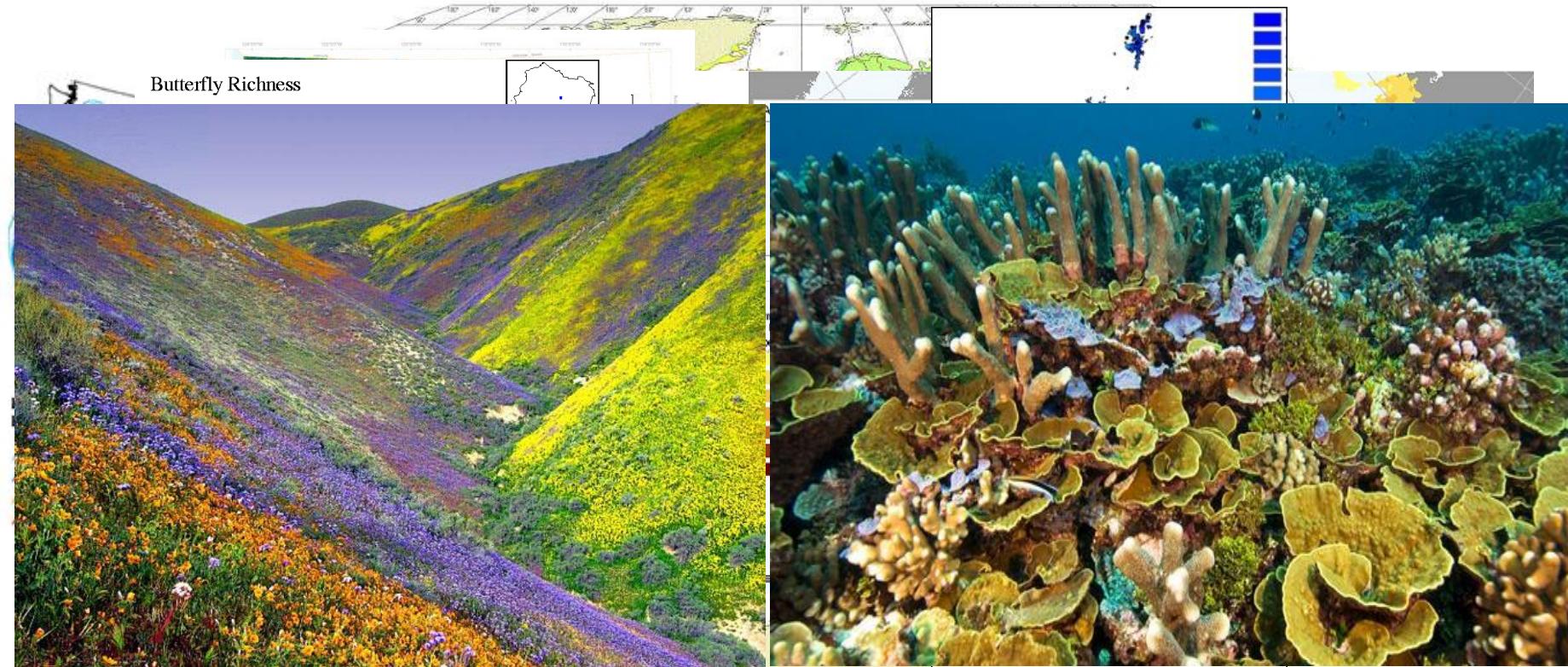
18 APRIL 2014 VOL 344 SCIENCE www.sciencemag.org

Assemblage Time Series Reveal Biodiversity Change but Not Systematic Loss

Maria Dornelas,^{1,*} Nicholas J. Gotelli,² Brian McGill,³ Hideyasu Shimadzu,^{1,4} Faye Moyes,¹ Caya Sievers,¹ Anne E. Magurran¹



GLOBAL BIODIVERSITY: SPECIES NUMBERS OF VASCULAR PLANTS



Map Source:
London Thematic Mapper (Bath 9 Row 60-61, July 14, 1992)
Supervised Classification

© 1996 Center for Conservation Biology - Stanford University
Standard Parallels 36°N and 36°S
Scale 1: 130,000,000
www.conbio.stanford.edu/

Map produced August 1996

of species per $10,000\text{km}^2$

DZ 1 (<100)	DZ 5 (1000 - 1500)	DZ 9 (4000 - 5000)
DZ 2 (100 - 200)	DZ 6 (1500 - 2000)	DZ 10 (>5000)
DZ 3 (200 - 500)	DZ 7 (2000 - 3000)	Capeensis floristic regions
DZ 4 (500 - 1000)	DZ 8 (3000 - 4000)	

sea surface temperature:

>29°C

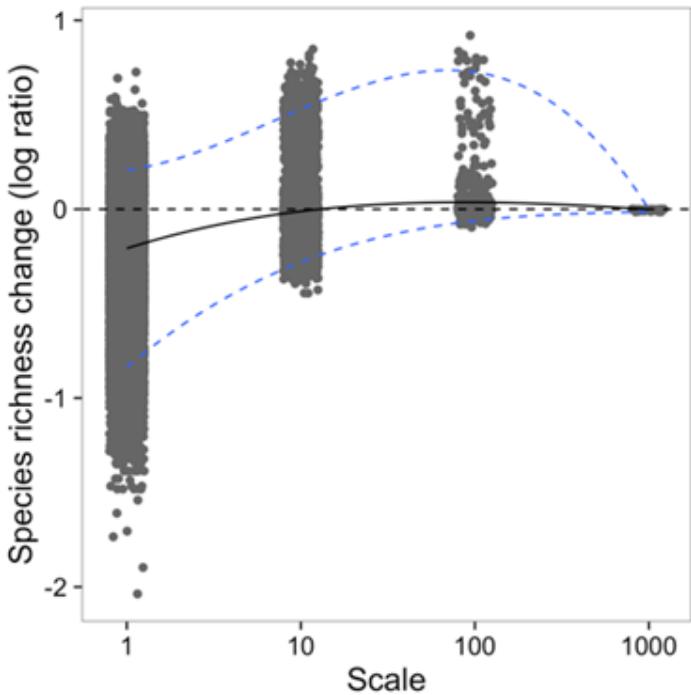
>27°C

cold currents

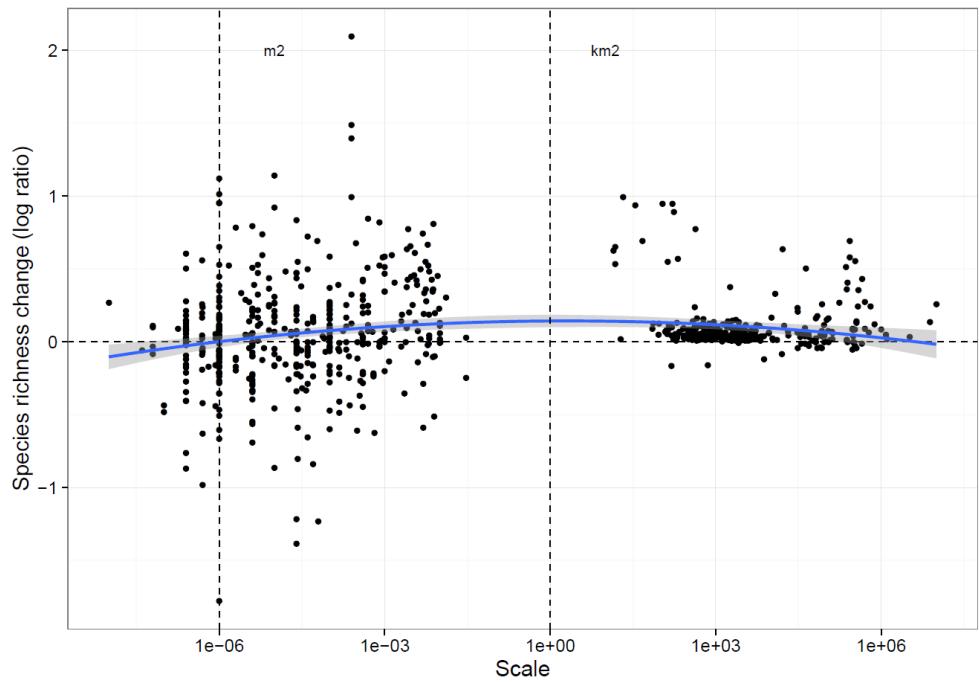
W. Barthott, N. Biedinger, G. Braun
F. Feig, G. Kier, W. Lauer & J. Mutke 1997
modified after
W. Barthott, W. Lauer & A. Pielke 1996
Department of Botany and Geography
University of Bonn
German Aerospace Research Establishment, Cologne
Cartography: M. Gref
Department of Geography
University of Bonn

Biodiversity crisis?—Scale matters

Theoretical Expectations



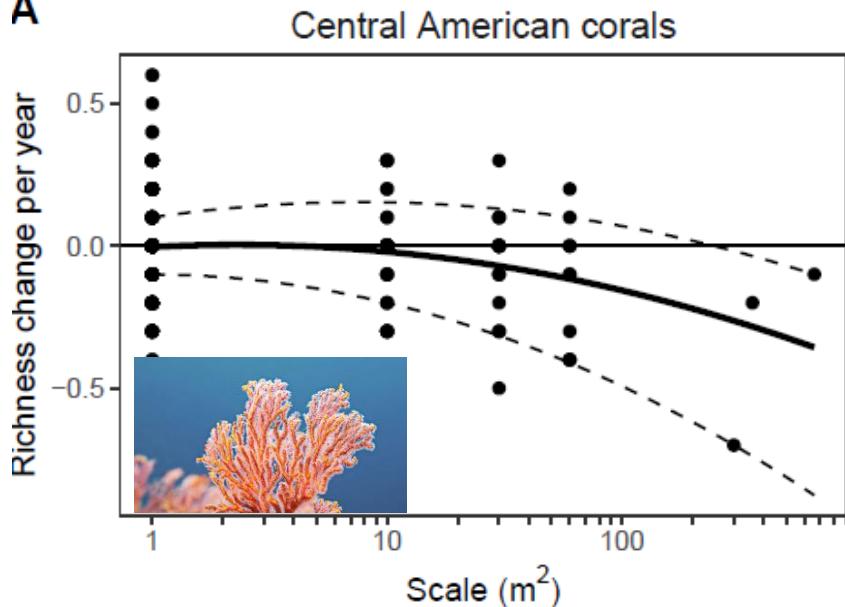
Meta-analytical results (plants only)



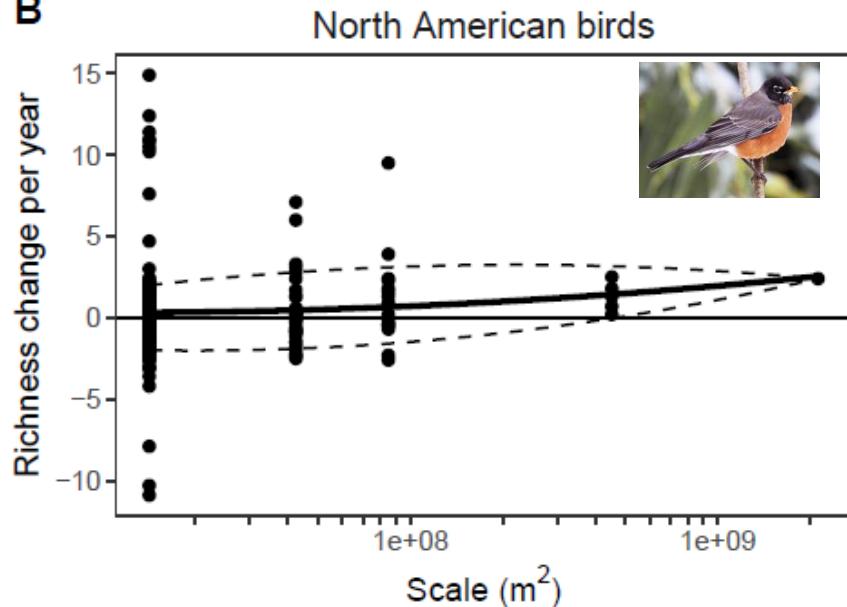
And species richness is a terrible indicator....

Change through time

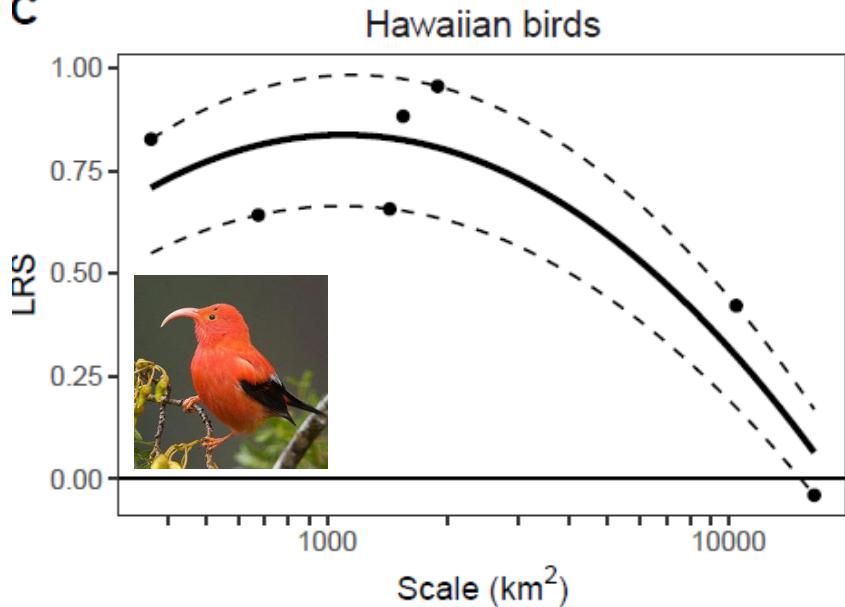
A



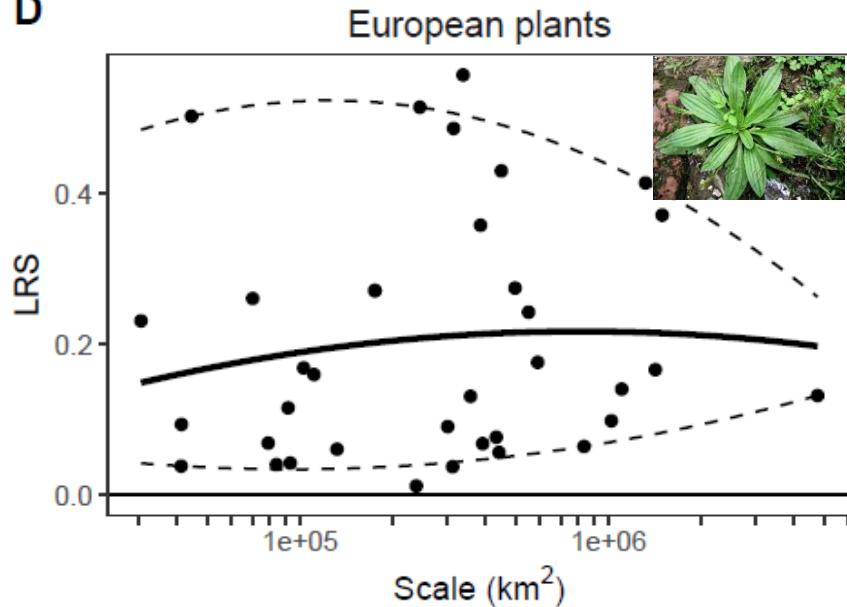
B



C



D



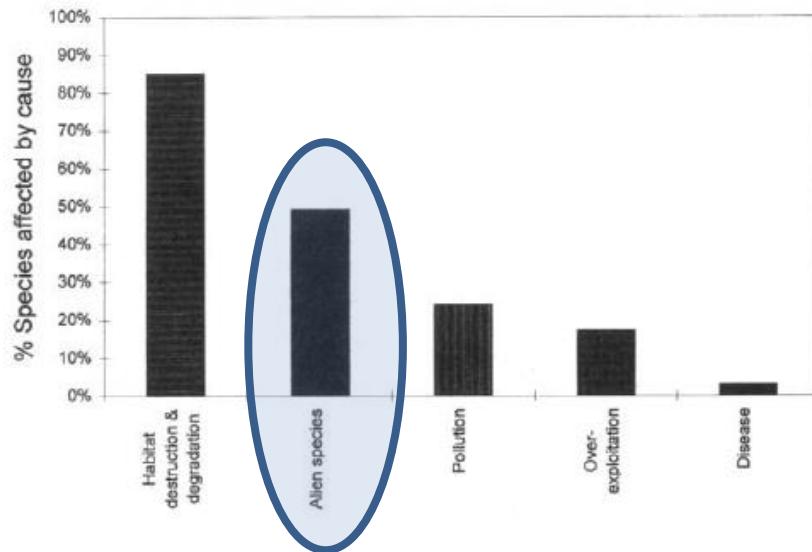
Alien species are the “second greatest threat” to global biodiversity



Quantifying Threats to Imperiled Species in the United States

Assessing the relative importance of habitat destruction, alien species, pollution, overexploitation, and disease

David S. Wilcove, David Rothstein, Jason Dubow, Ali Phillips, and Elizabeth Losos



“ Habitat loss is the single greatest threat to biodiversity, followed by the spread of alien species ”

Wilcove et al. 1998 BioScience

ECOSYSTEMS AND HUMAN WELL-BEING

Biodiversity Synthesis

A Report of the Millennium Ecosystem Assessment

Synthesis Team Co-chairs
ANASTHISIA KUMAR DULAMALPAGI, SHABUD NÄREM

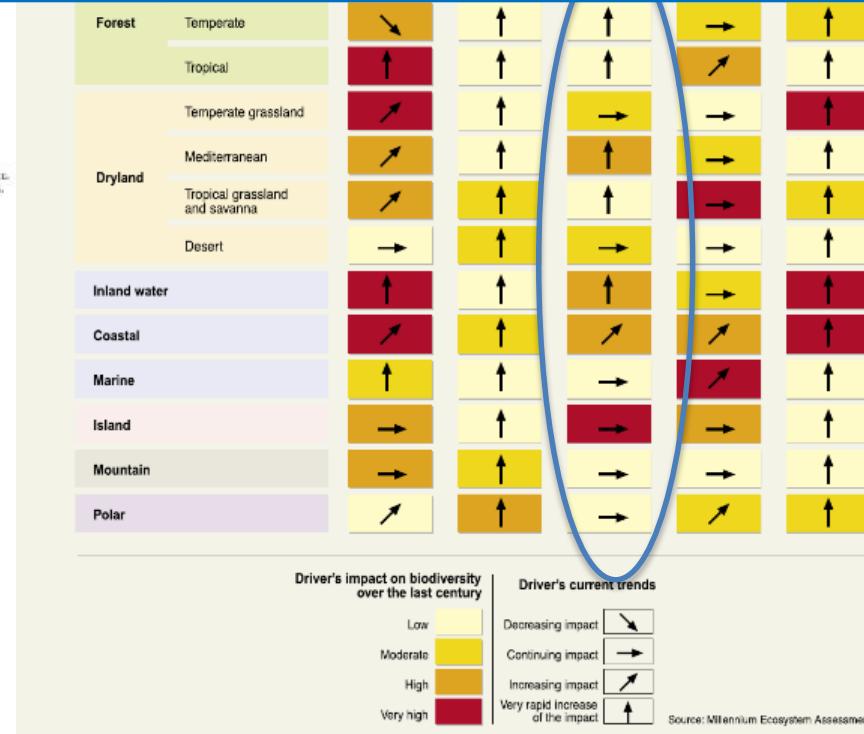
Synthesis Team Members

TUNSI AGABEY, NEVILLE J. ASH, H. DAVID COOPER, SANDRA DÍAZ, DANIEL F. FAITH, GEORGINA MACLEOD, JEFFREY A. MCNEILLY, HAROLD A. MOONEY, ALFRED A. OTENG-YEBOMAH, HENRIQUE MIGUEL PEREIRA, STEPHEN POLASKY, CHRISTIAN PÖPPL, WALTER V. REID, CRISTIÁN SAMPER, PETER JOSHUA SCHILL, ROBERT SCHOLAIAS, FREDERIK SCHUTTEVeld, ALBERT VAN JAARSVELD

This Figure is based on expert opinion

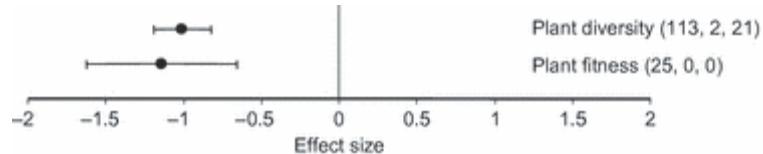
Figure 3.10. MAIN DIRECT DRIVERS

The cell color indicates the impact to date of each driver on biodiversity in each biome over the past 50–100 years. The arrows indicate the trend in the impact of the driver on biodiversity. Horizontal arrows indicate a continuation of the current level of impact; diagonal and vertical arrows indicate progressively increasing trends in impact. This Figure is based on expert opinion consistent with and based on the analysis of drivers of change in various chapters of the assessment report of the Condition and Trends Working Group. This Figure

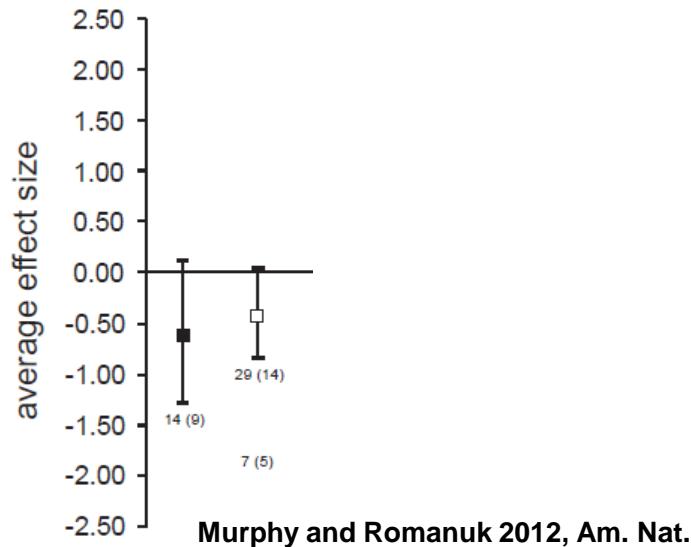


Millennium Ecosystem Assessment 2005

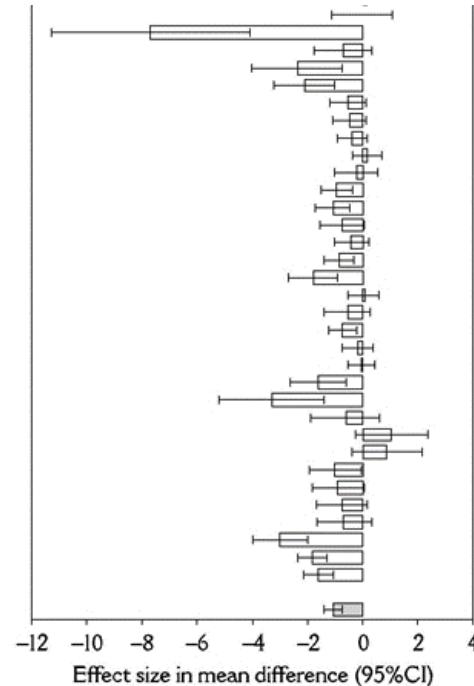
Meta-Analyses of Invasive Species Impacts → Invasives are “Bad”



Vila et al. 2011 Ecol. Letters



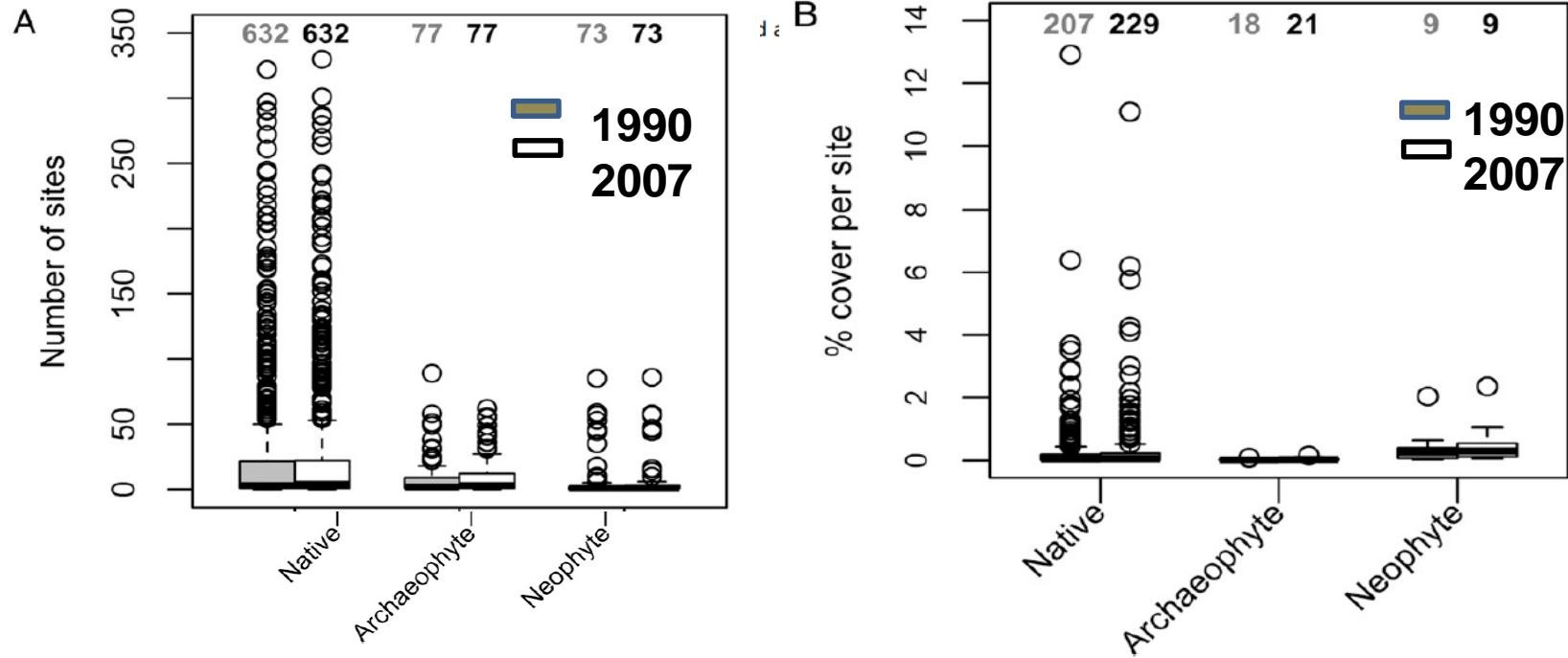
Murphy and Romanuk 2012, Am. Nat.



Gaertner et al. 2009,
Prog. Phys. Geog.

Non-native plants add to the British flora without negative consequences for native diversity

Chris D. Thomas¹ and G. Palmer

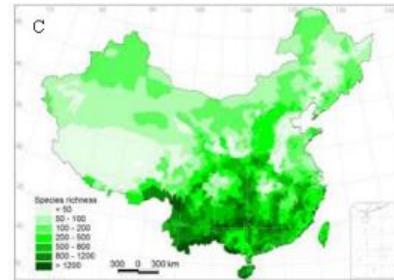


invaders”

A Resolution?



.....Spatial Scale

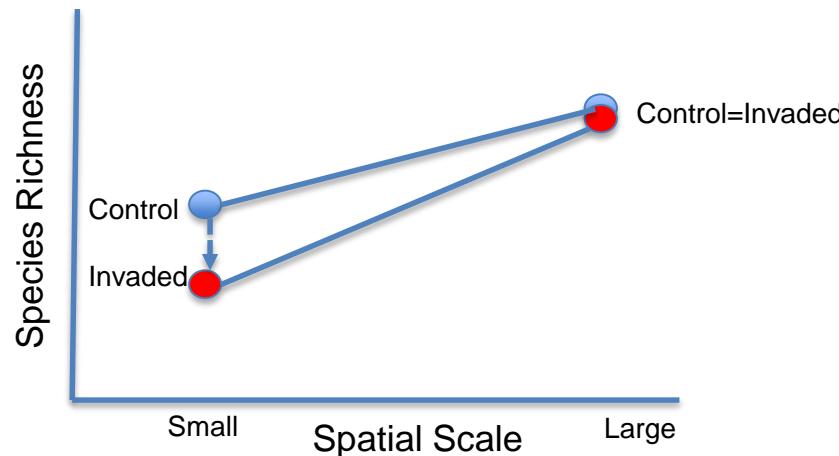


Experiments and meta-analyses

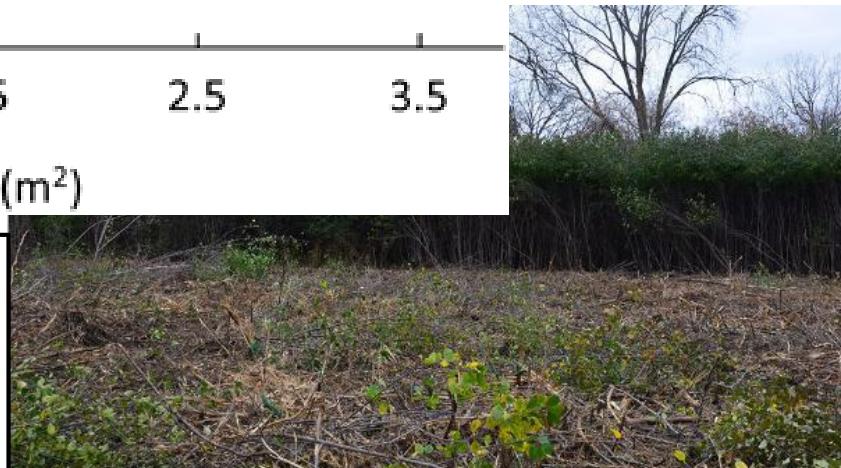
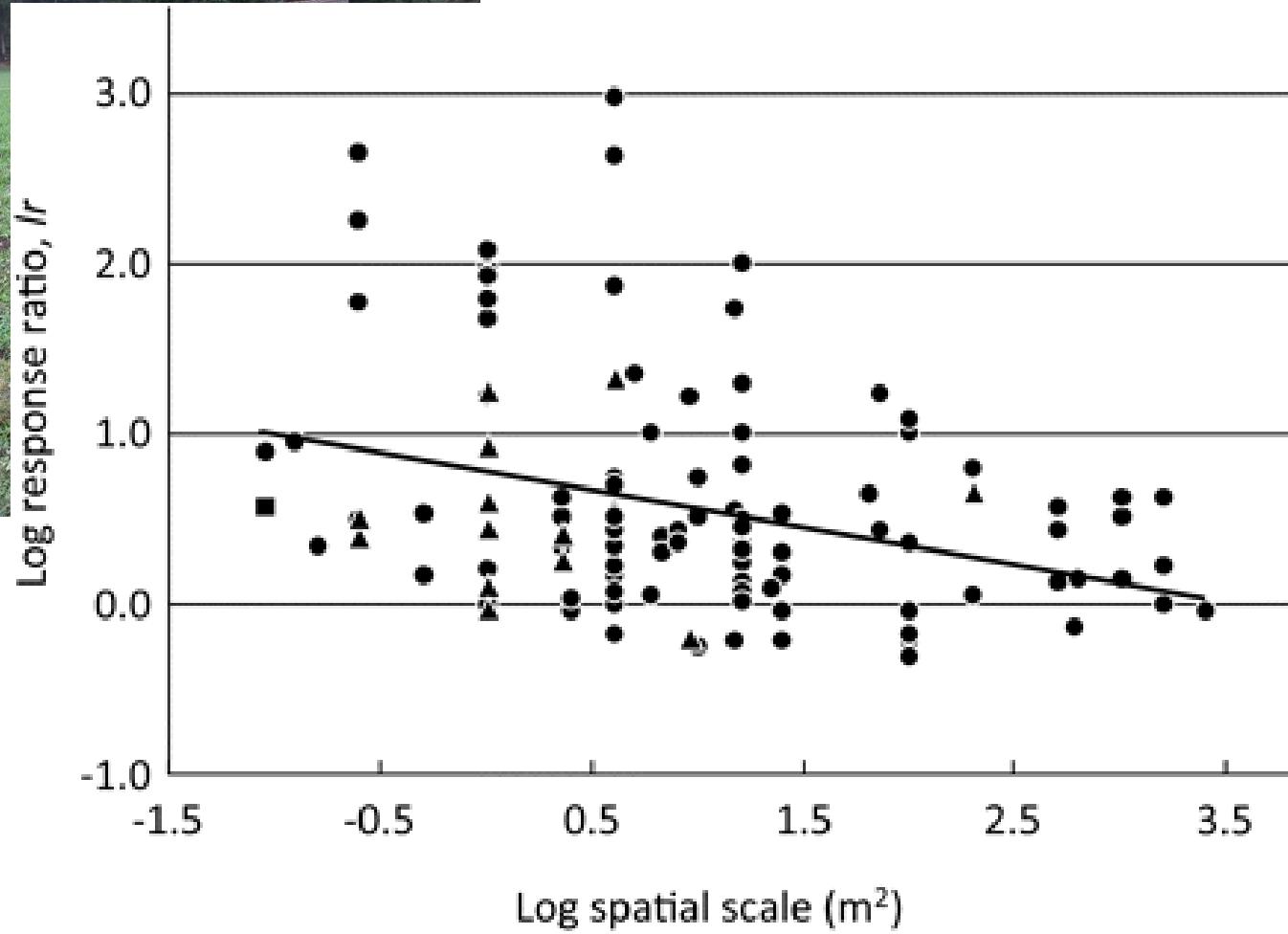
- Richness decreases
- Typically $<<100 \text{ m}^2$
- Richness → changes in relative abundance

Observations

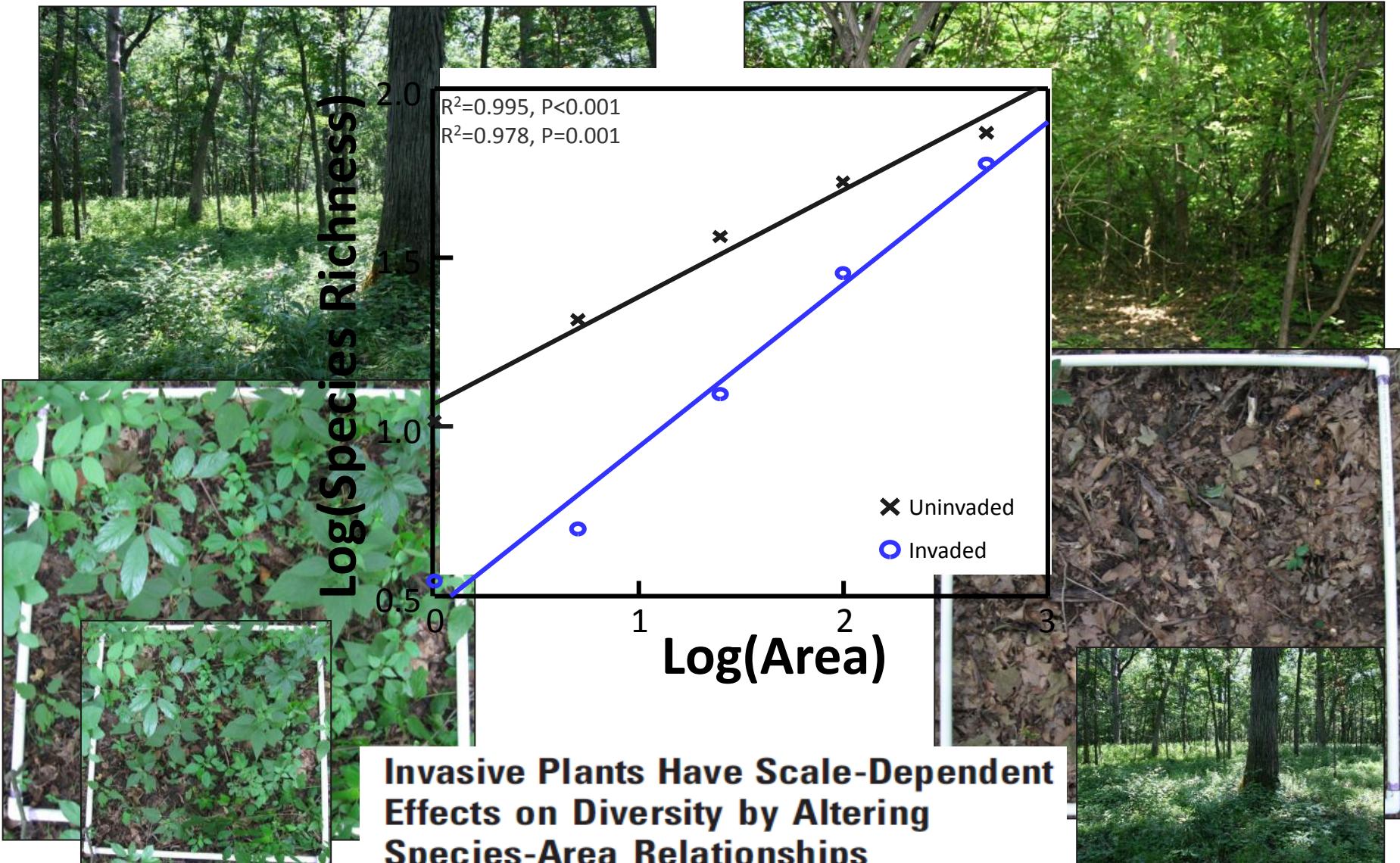
- Little effect on richness
- Typically $>>10,000 \text{ m}^2$
- Richness → Local extirpation/extinction



Effect Size of Invaders Declines with Spatial Scale

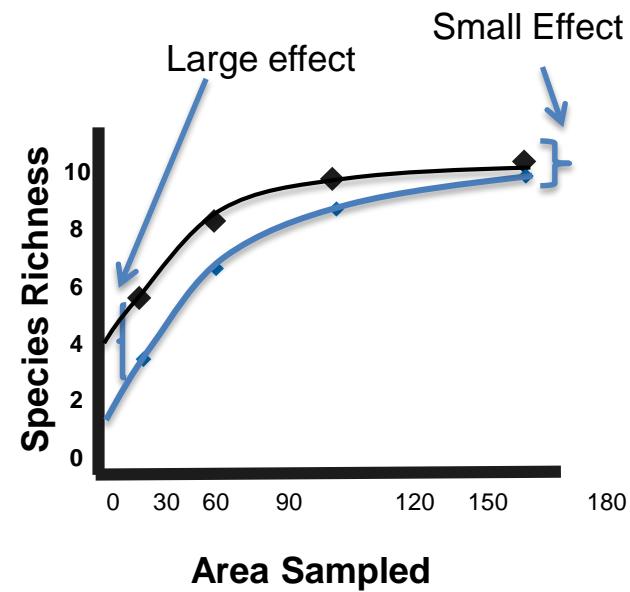
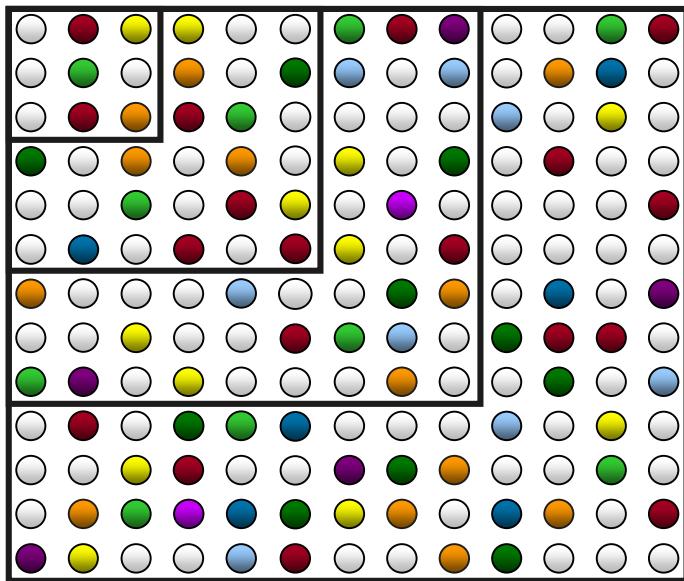


Scale-dependence of invasive species impacts

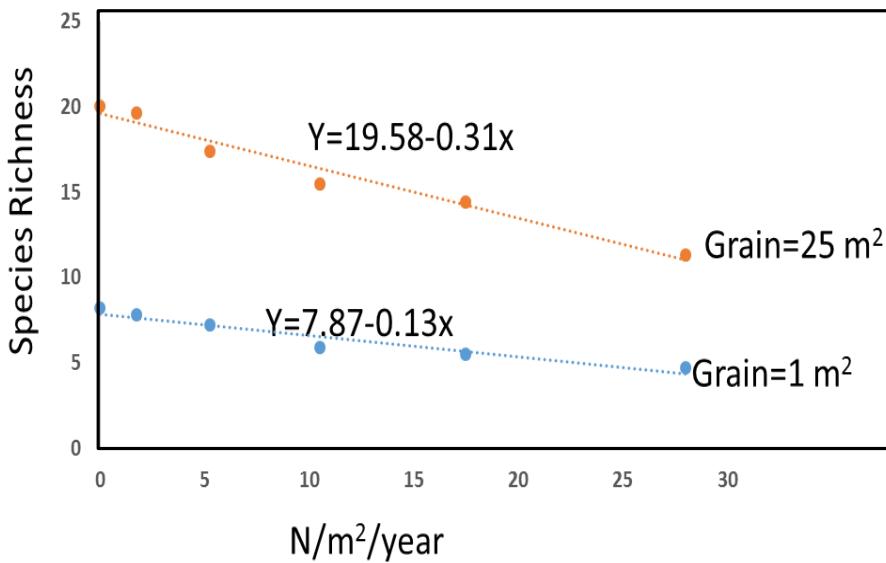


A Neutral Sampling Effect

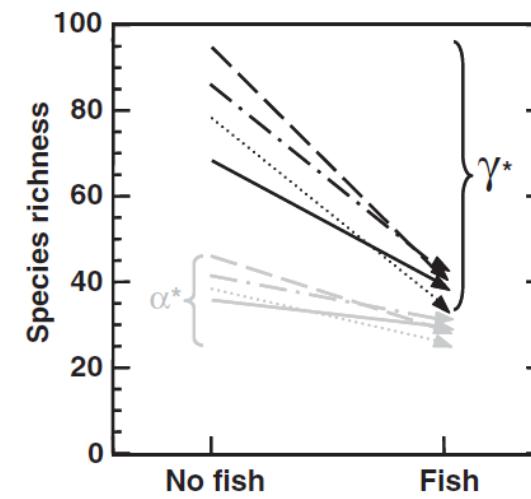
Degraded Community



Chase and Knight 2013 Ecology Letters

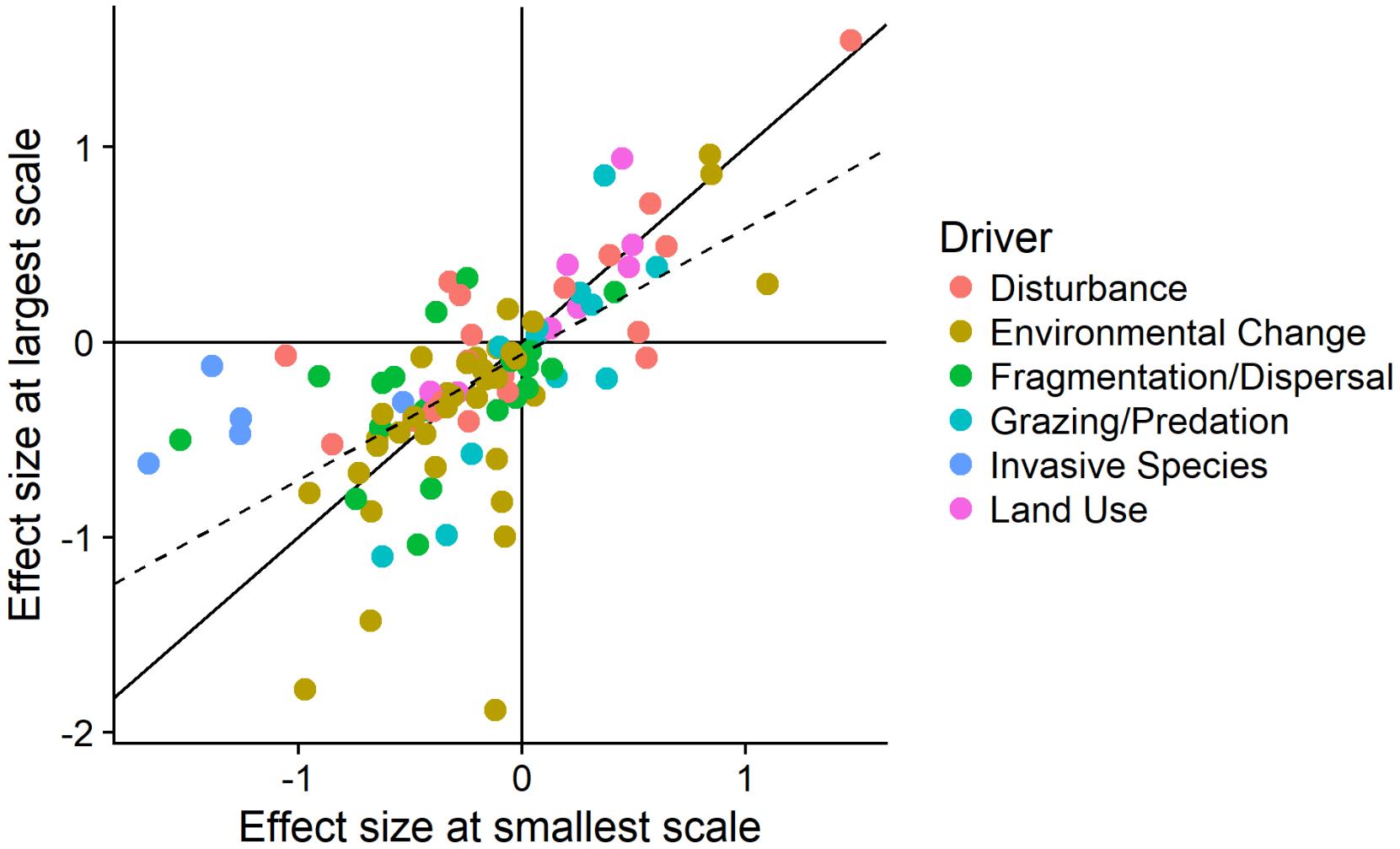


Lan et al. J. Ecol. 2015

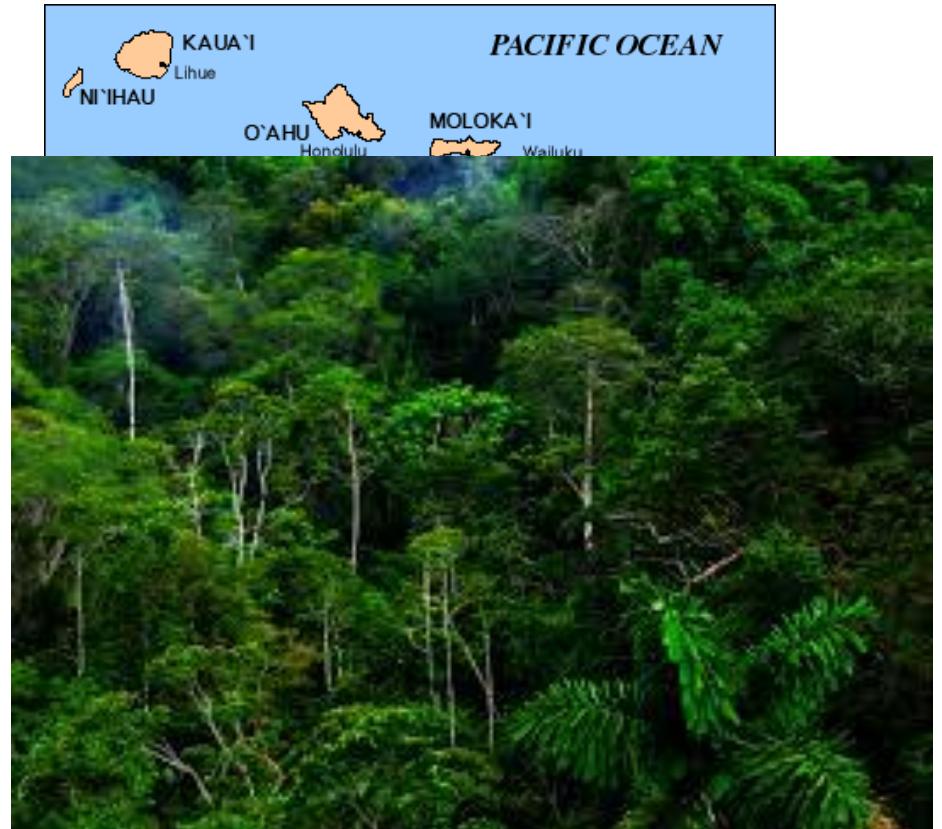


Chase et al. 2009 Ecol. Lett.

Meta-analysis of 2-scale measurements



Can't we just correct for area?



Aren't consistent sampling schemes enough?

CTFS-SGIEO Forest Plots

Unfortunately, no....



ECOLOGY LETTERS

Ecology Letters, (2013) **16**: 17–26

doi: 10.1111/ele.12112

REVIEW AND
SYNTHESIS

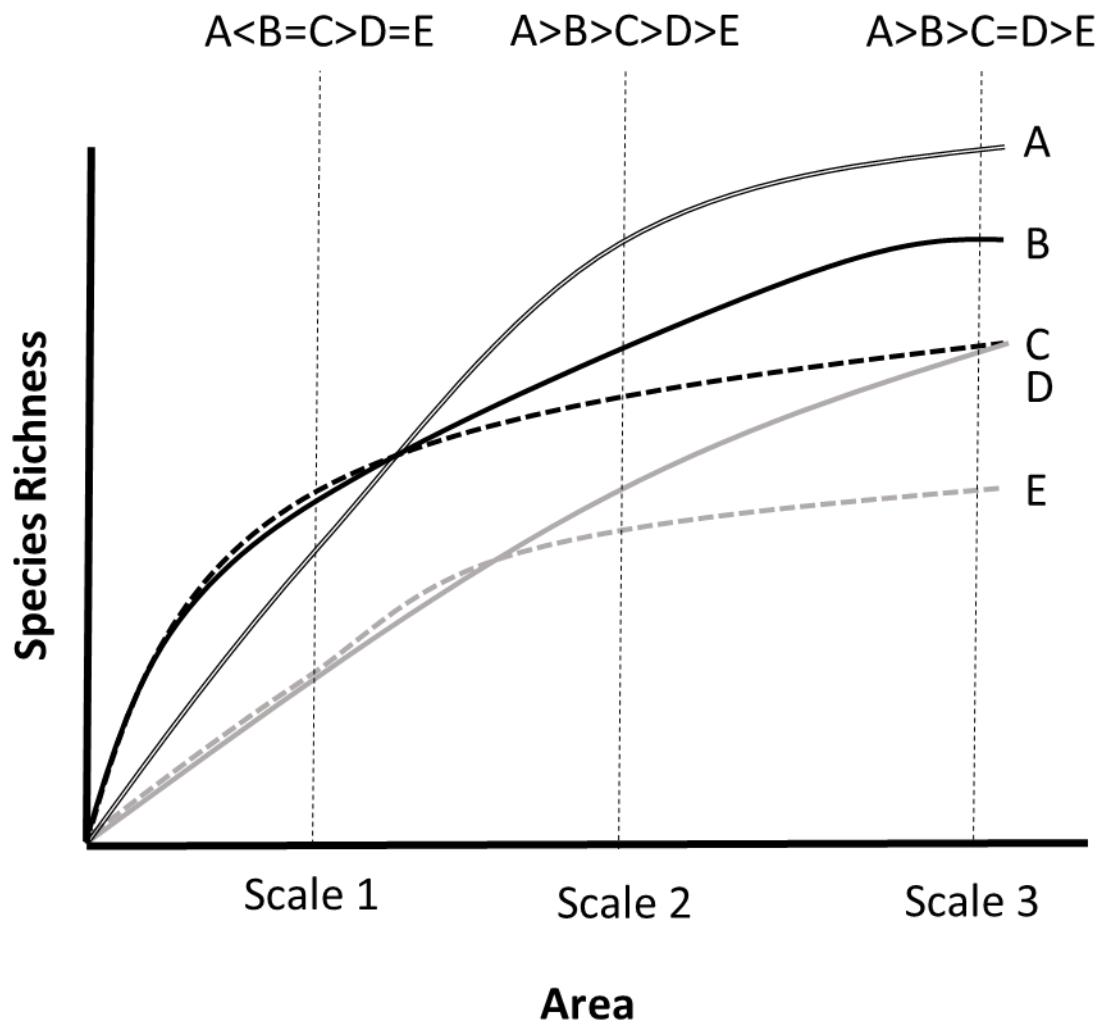
Scale-dependent effect sizes of ecological drivers on biodiversity: why standardised sampling is not enough

Abstract

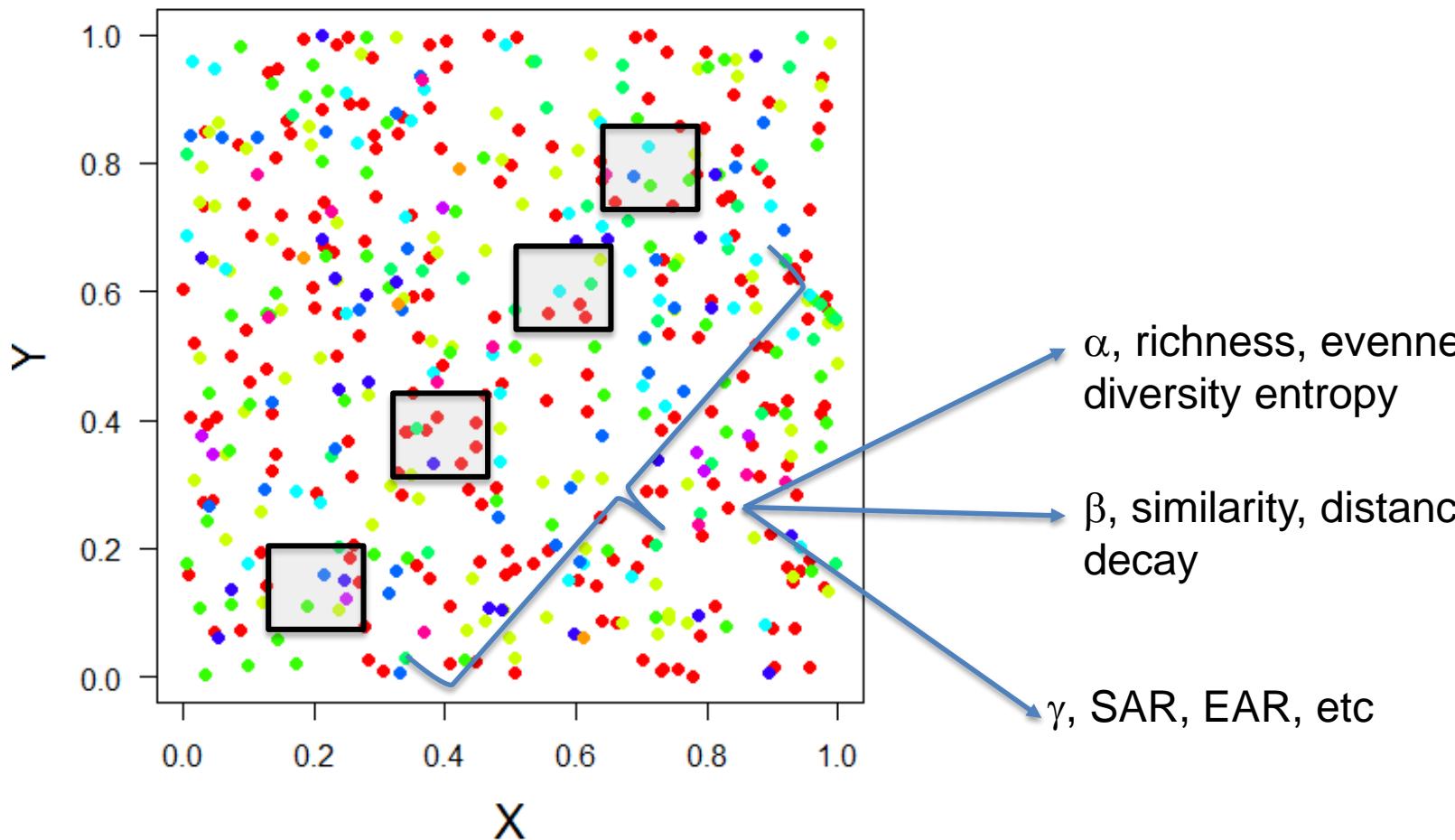
There is little consensus about how natural (e.g. productivity, disturbance) and anthropogenic (e.g. invasive species, habitat destruction) ecological drivers influence biodiversity. Here, we show that when sampling is

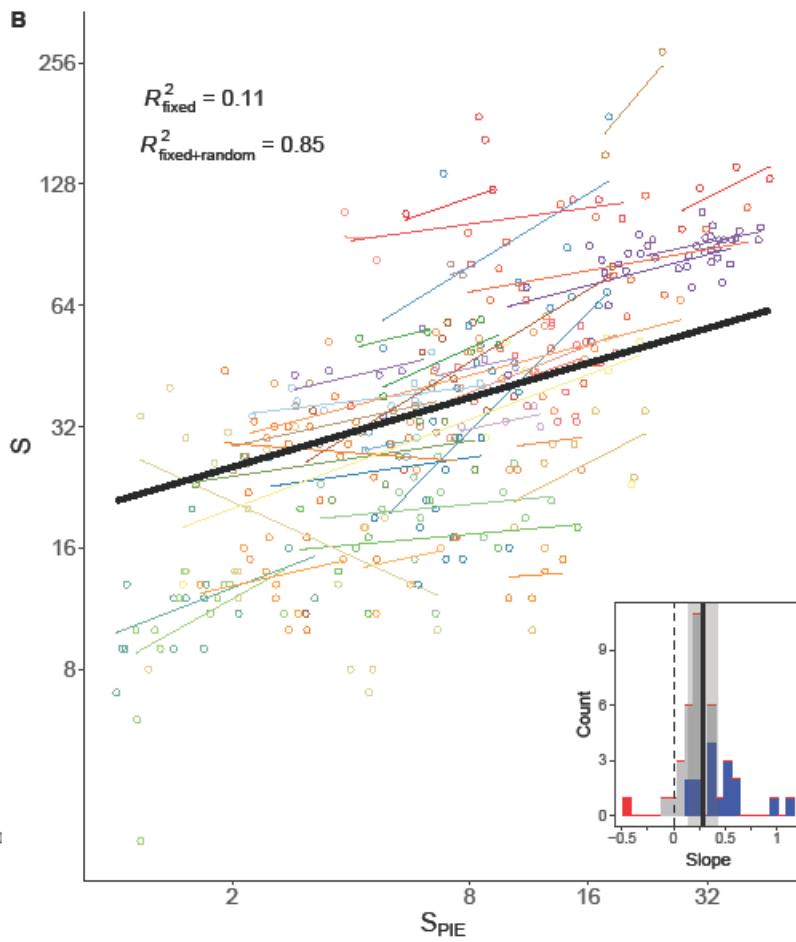
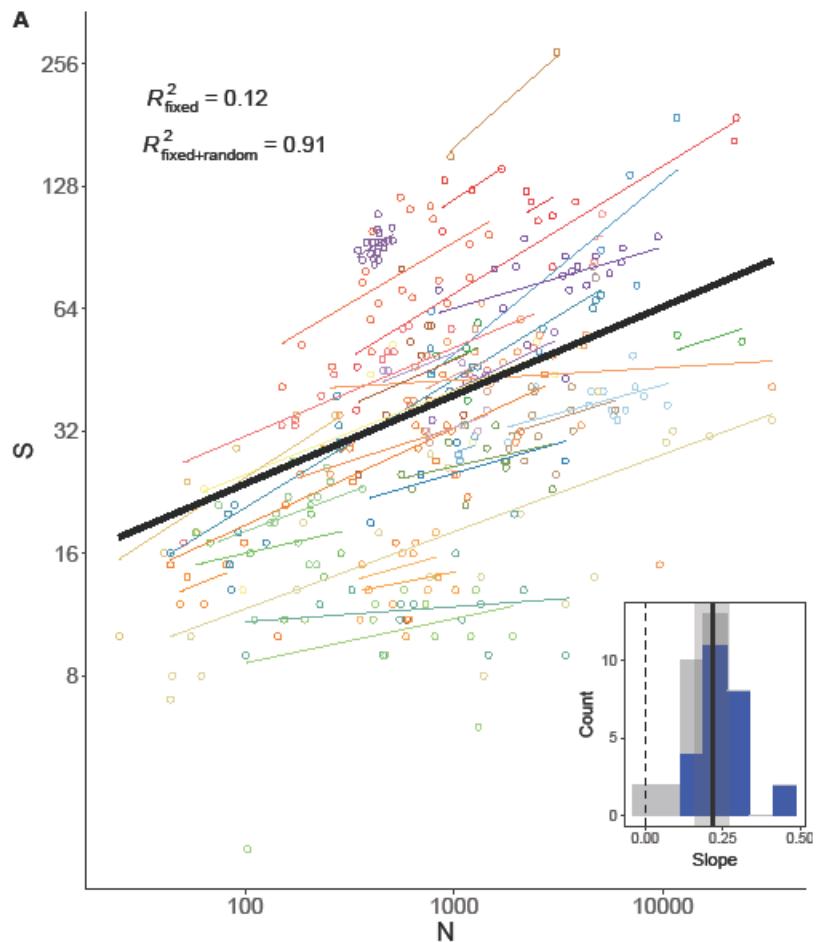
Jonathan M. Chase^{1*} and Tiffany M. Knight²





Any measure of diversity only captures part of the picture





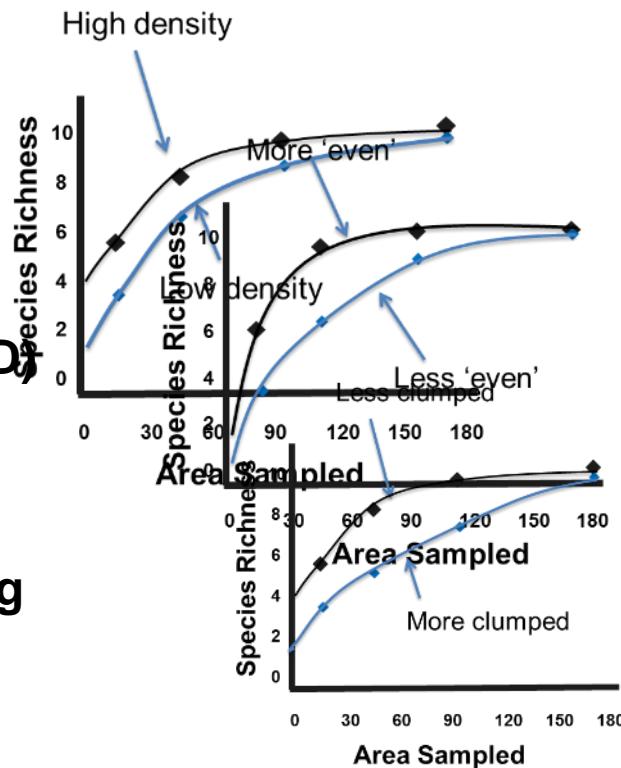
Key Take Home Message:

- Species accumulation with scale will be non-parallel when the abundance and spatial distribution of species is altered

1) The density of individuals

2) The Species Abundance Distribution (SAD), S and evenness

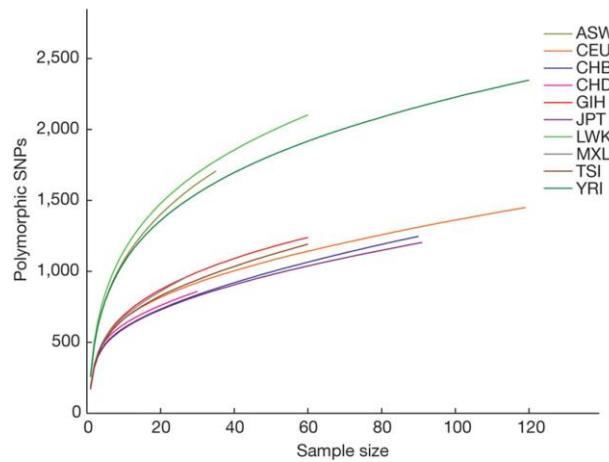
3) The spatial aggregation (clumping) among individuals



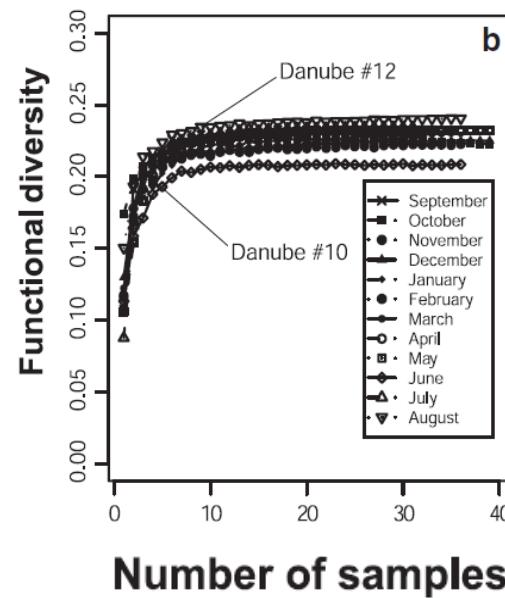
- Scale-dependent effect sizes are ubiquitous
- Standard analyses and meta-analyses provide ambiguous answers

All diversity measures have this form....

Genetic Diversity



Functional diversity



Phylogenetic diversity

