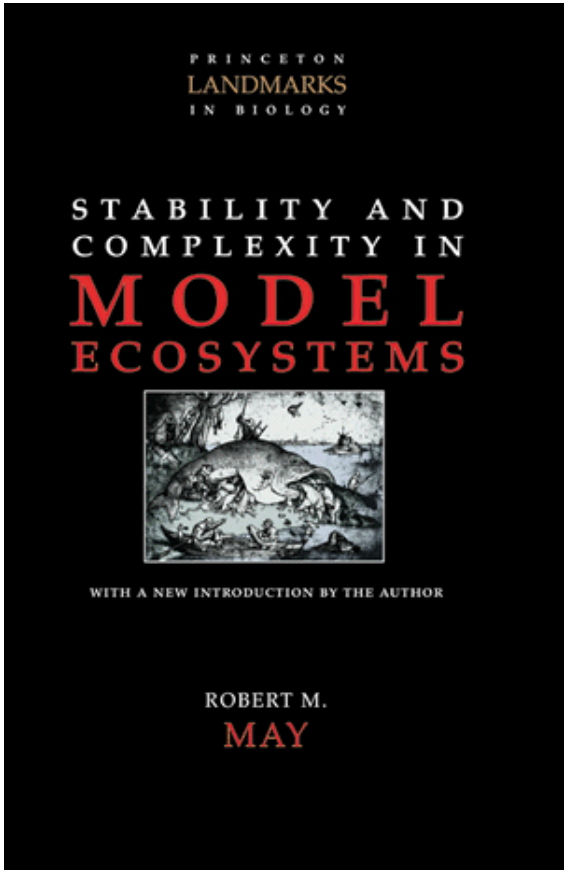
Ecology 8310
Population (and Community) Ecology

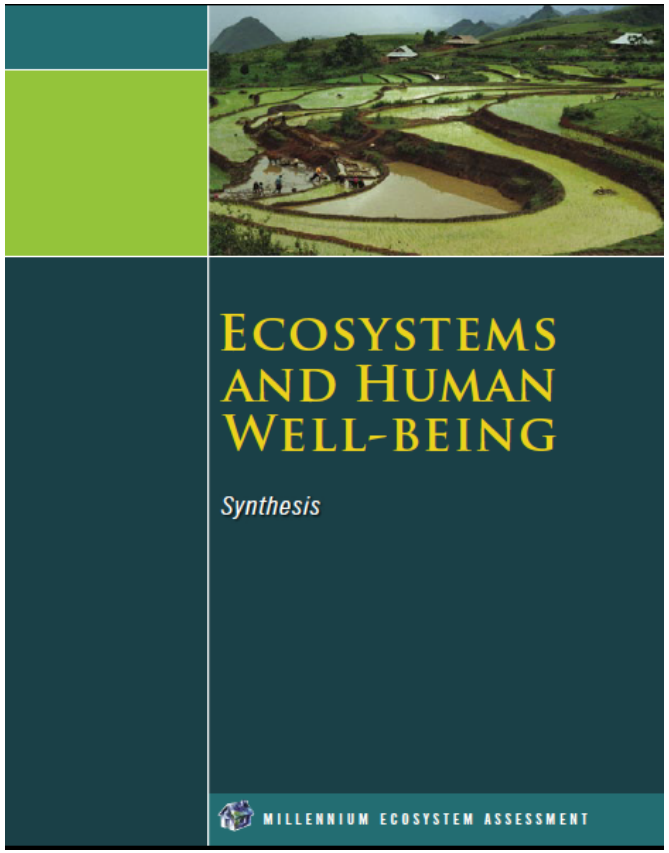
The effects of diversity

- Background
- Tilman and Downing 1994
- Species vs. functional diversity
- Foodwebs (instead of primary producers only)
- Form of BES relationship
- Niche complementarity vs. sampling effects
- Portfolio effect

How will a system's "function" be affected if you change the diversity of a guild of coexisting species…

"function"?





RESILIENCE AND STABILITY OF ECOLOGICAL SYSTEMS ❖ 4050

C. S. Holling
Institute of Resource Ecology, University of British Columbia, Vancouver, Canada

More diverse systems might:

- Be more resistant or resilient
- Provide greater ecosystem function (fluxes)
- Provide greater ecosystem services (benefits to society: water quality, food production, shoreline protection…)

WRT ecosystem functions, there are two divergent views:

- Species are redundant
- Species are complementary

Let's examine some empirical studies…

Biodiversity and stability in grasslands

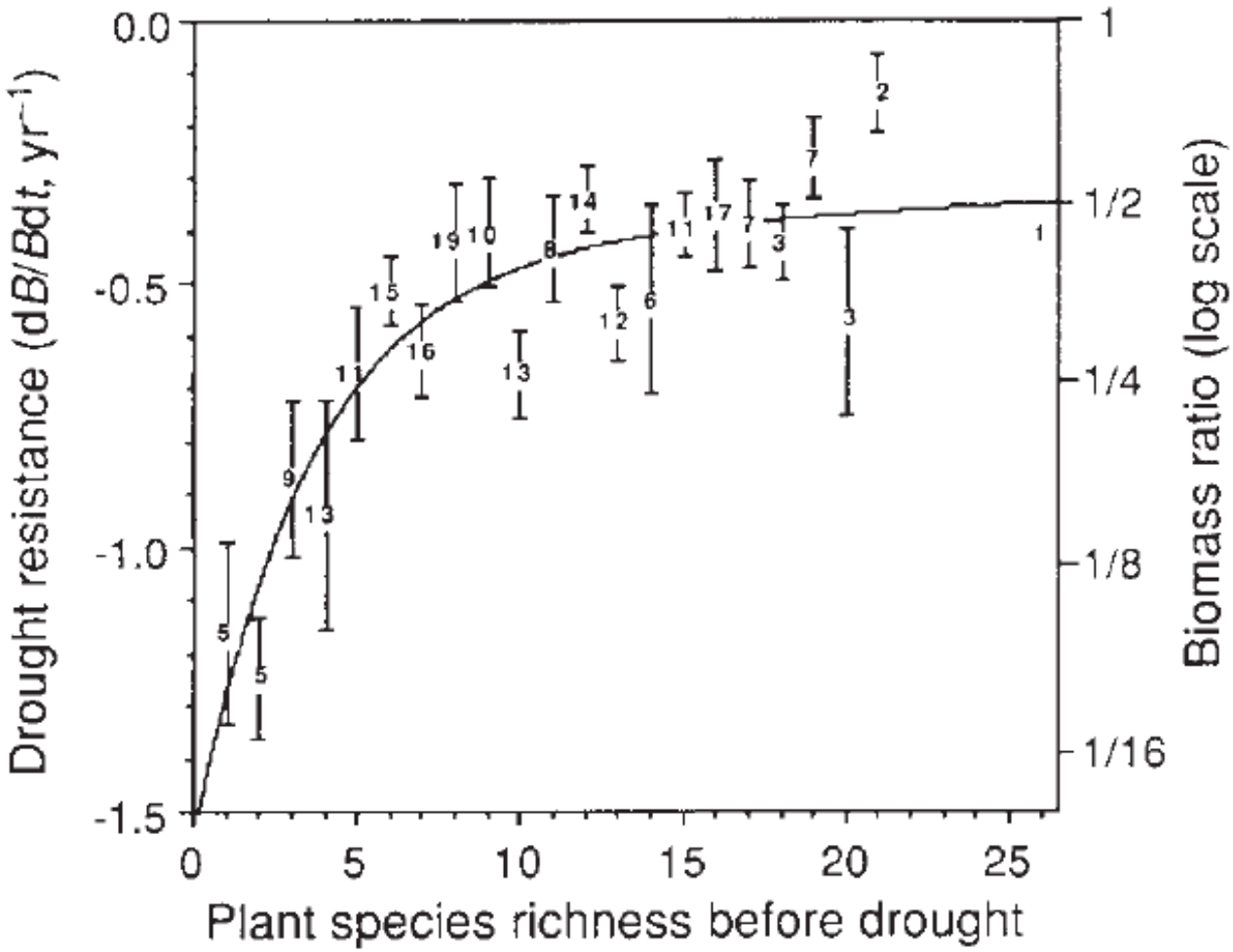
David Tilman & John A. Downing

Department of Ecology, Evolution and Behaviour,
University of Minnesota, 1987 Upper Buford Circle, St Paul,
Minnesota 55108, USA
Département de Sciences biologiques, Université de Montréal,
CP, 6128, Succursale 'A', Montréal,
Québec H3C 3J7, Canada

Approach

1. Severe drought 1987 and 1988
2. Long-term data on experimental plots that varied in plant species richness
3. Compared effect of drought (as function of species richness): 'resistence'
4. Response: $\text{Biomass}_{1988}/\text{Biomass}_{1986}$

Results:

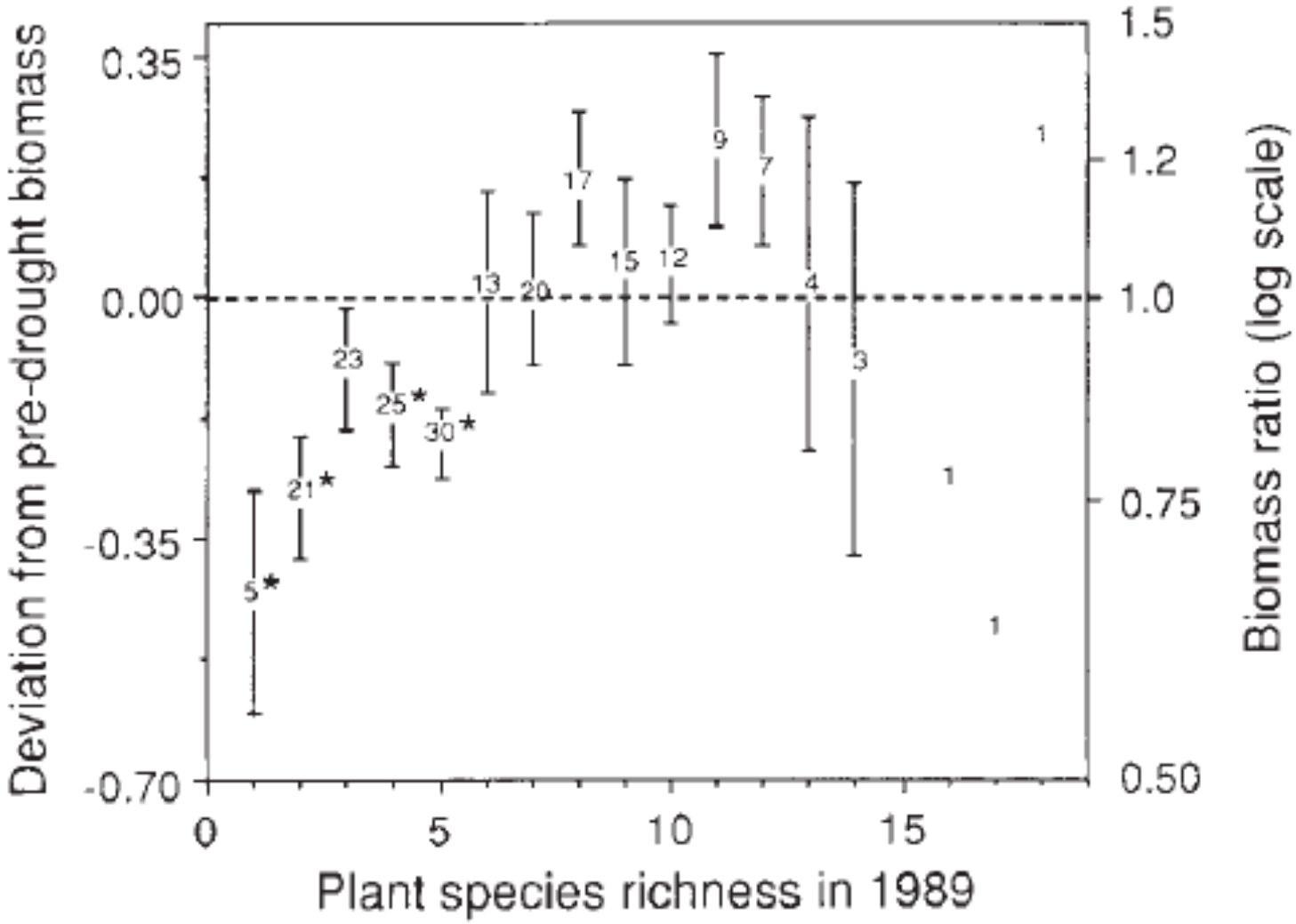

Drought resistance (dB/Bdt, yr⁻¹)
0.0
-0.5
-1.0
-1.5
0
5
10
15
20
25
Plant species richness before drought
1
1/2
1/4
1/8
1/16
Biomass ratio (log scale)

Recovery?

Response:

$$\text{Biomass}_{1992}/\text{Biomass}_{1986}$$

Recovery?


Deviation from pre-drought biomass
0.35
0.00
-0.35
-0.70
0
5
10
15
Plant species richness in 1989
1.5
1.2
1.0
0.75
0.50
Biomass ratio (log scale)
5*
21*
23
25*
30*
13
20
17
15
12
9
7
4
3
1
1
1

Issues?

1. What generated the gradient in diversity ?
    - Nitrogen manipulation
    - more N → increased plant biomass & decreased species richness
    - i.e., species richness or nitrogen?
2. Species vs. functional diversity
3. Species (sampling effect) vs. niche complementarity?
4. "Averaging" (the portfolio effect)

Identity vs. Diversity:

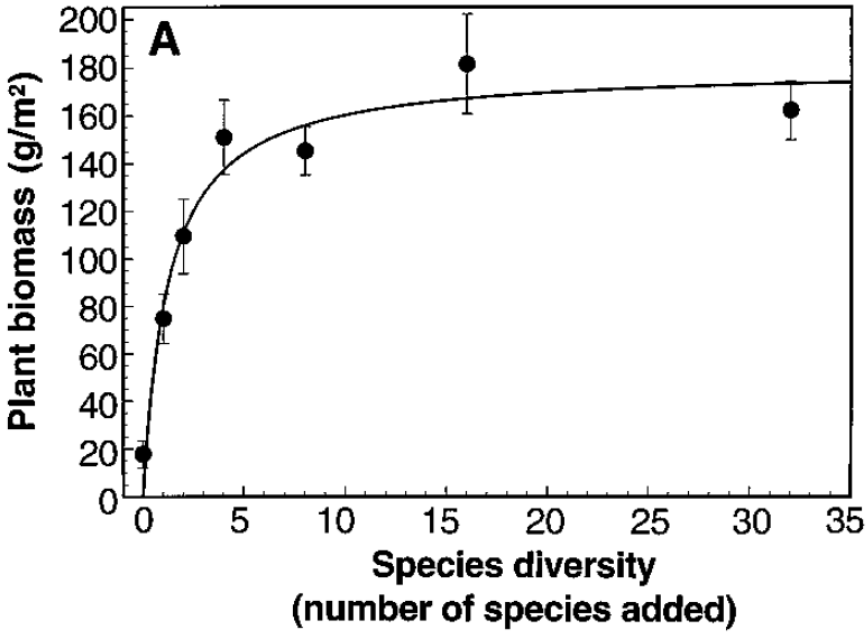
The Influence of Functional Diversity and Composition on Ecosystem Processes

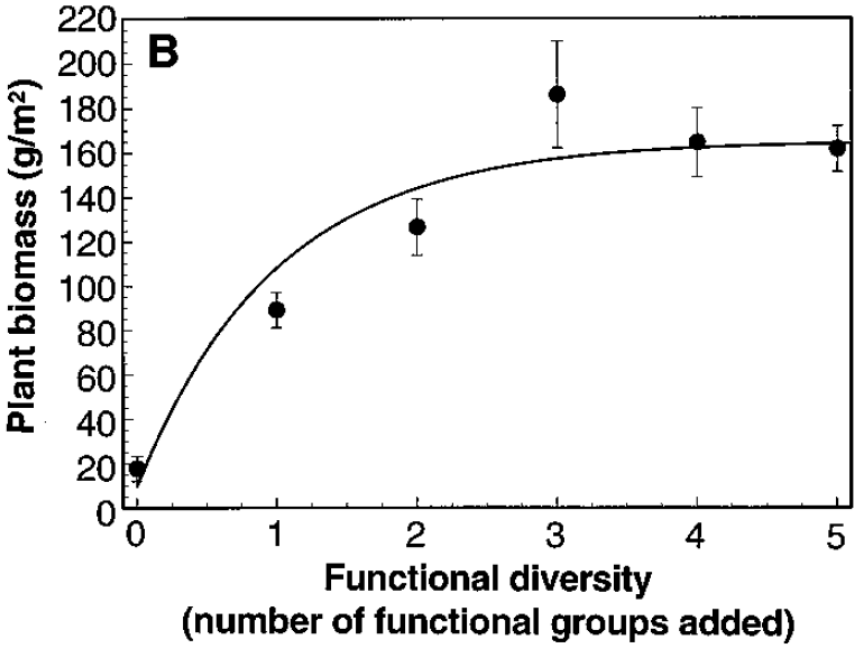
David Tilman,* Johannes Knops, David Wedin, Peter Reich, Mark Ritchie, Evan Siemann

SCIENCE • VOL. 277 • 29 AUGUST 1997 • www.sciencemag.org

Results

Response	Species diversity	Funct'nal diversity
Plant biomass	+	+
Plant % N	0	-
Plant total N	0	+
Soil ammonia	0	-
Soil nitrate	0	-
Light penetration	0	-





Ecology Letters, (2003) **6**: 567–579

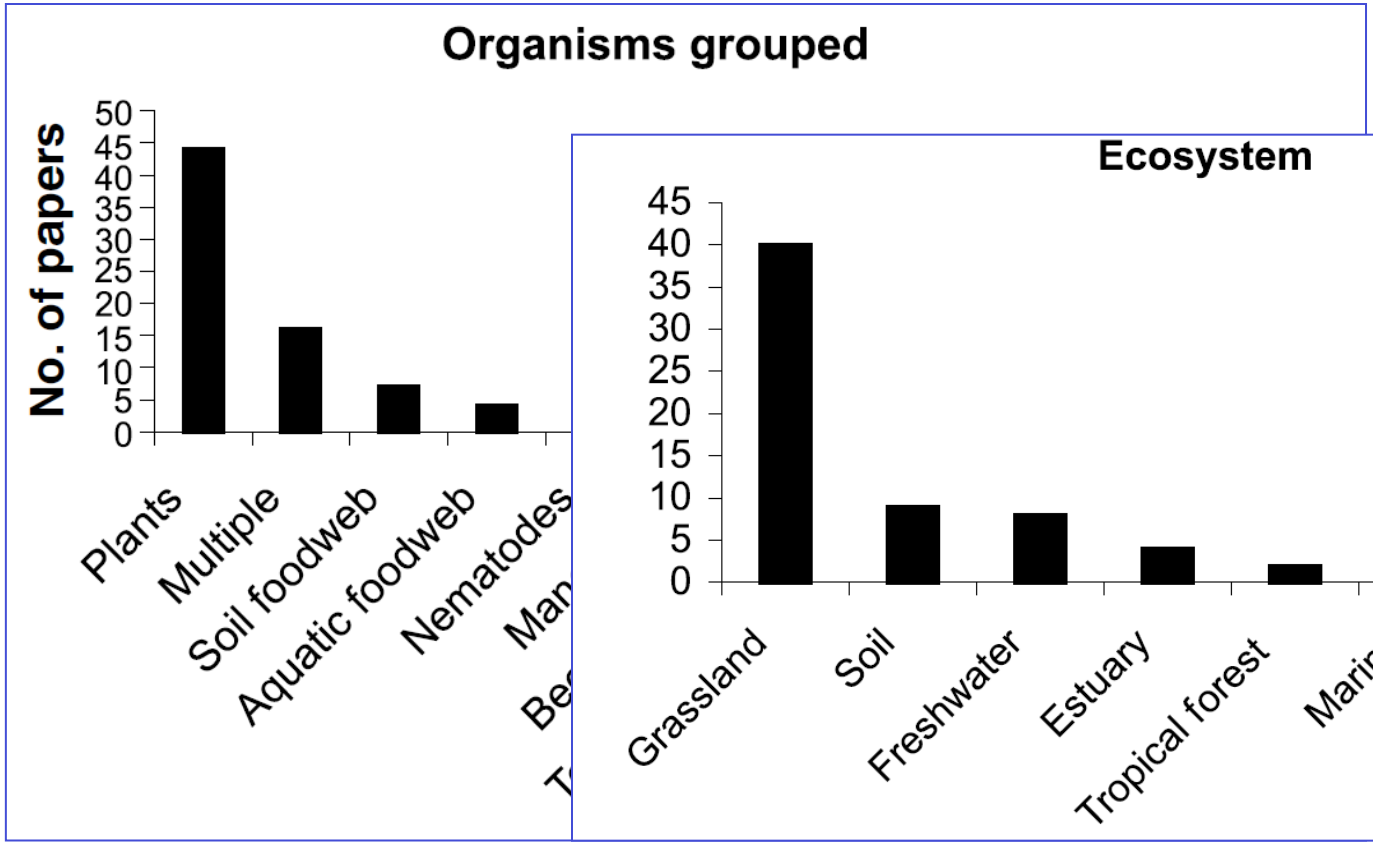
REVIEW

Disentangling biodiversity effects on ecosystem functioning: deriving solutions to a seemingly insurmountable problem

Shahid Naeem* and
Justin P. Wright

Abstract

Experimental investigations of the relationship between biodiversity and ecosystem functioning (BEF) directly manipulate diversity then monitor ecosystem response to the



Biodiversity regulates ecosystem predictability

Jill McGrady-Steed, Patricia M. Harris & Peter J. Morin

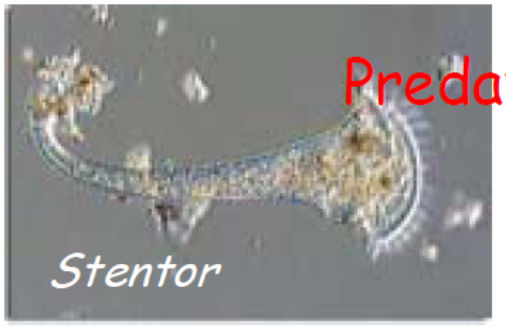
Department of Ecology, Evolution & Natural Resources, PO Box 231, Cook College, Rutgers University, New Brunswick, New Jersey 08903-0231, USA

NATURE | VOL 390 | 13 NOVEMBER 1997

- 8 eukaryote species richness levels (0 – 31)
- 4 trophic levels
- Measured:
  - Realized richness
  - Densities
  - Respiration (CO_2)
  - Decomposition
  - Invasions success

Some of the organisms included in the microcosms

Predators



2° Consumers

Herbivores

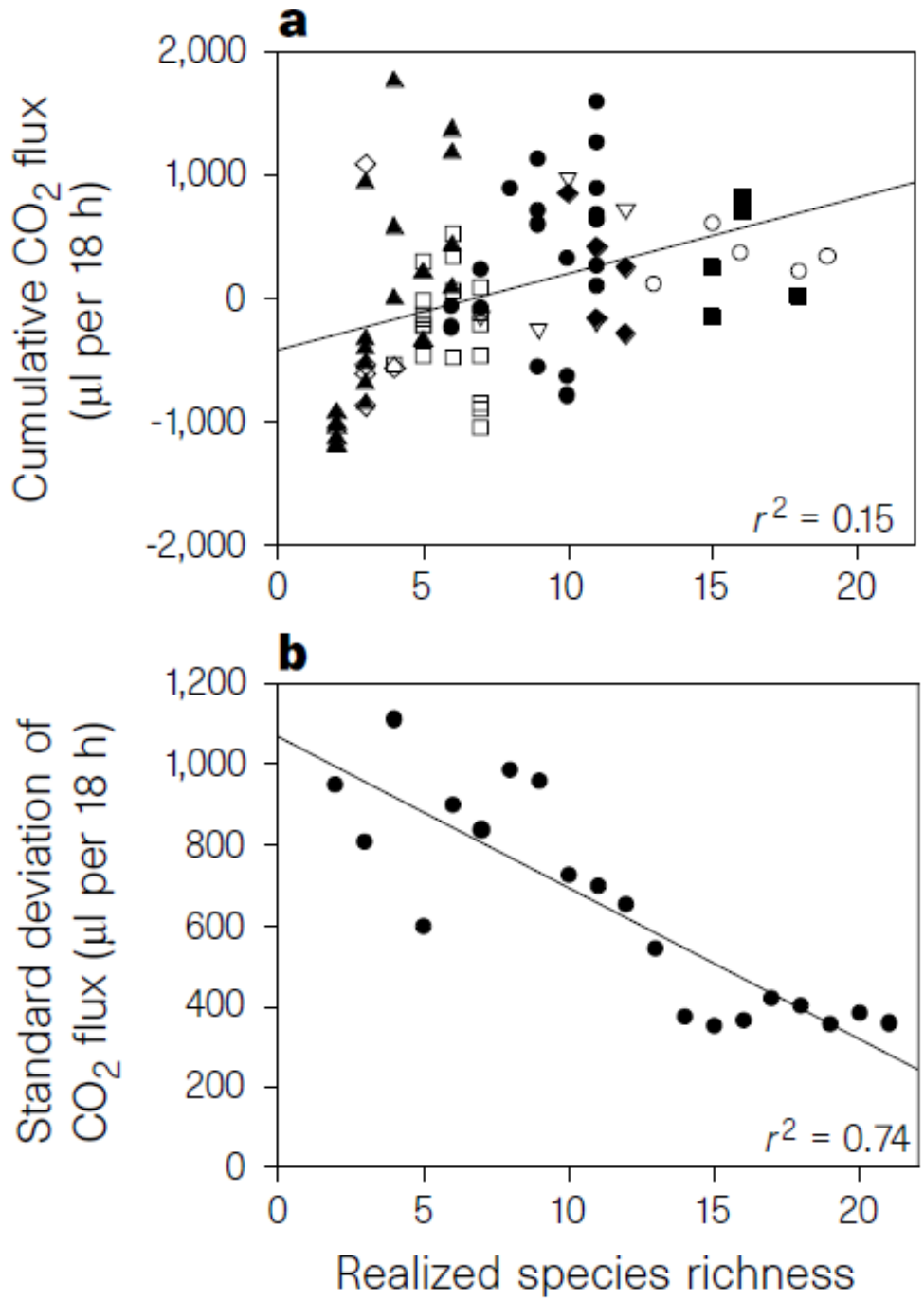
Bacterivores

1° Consumers

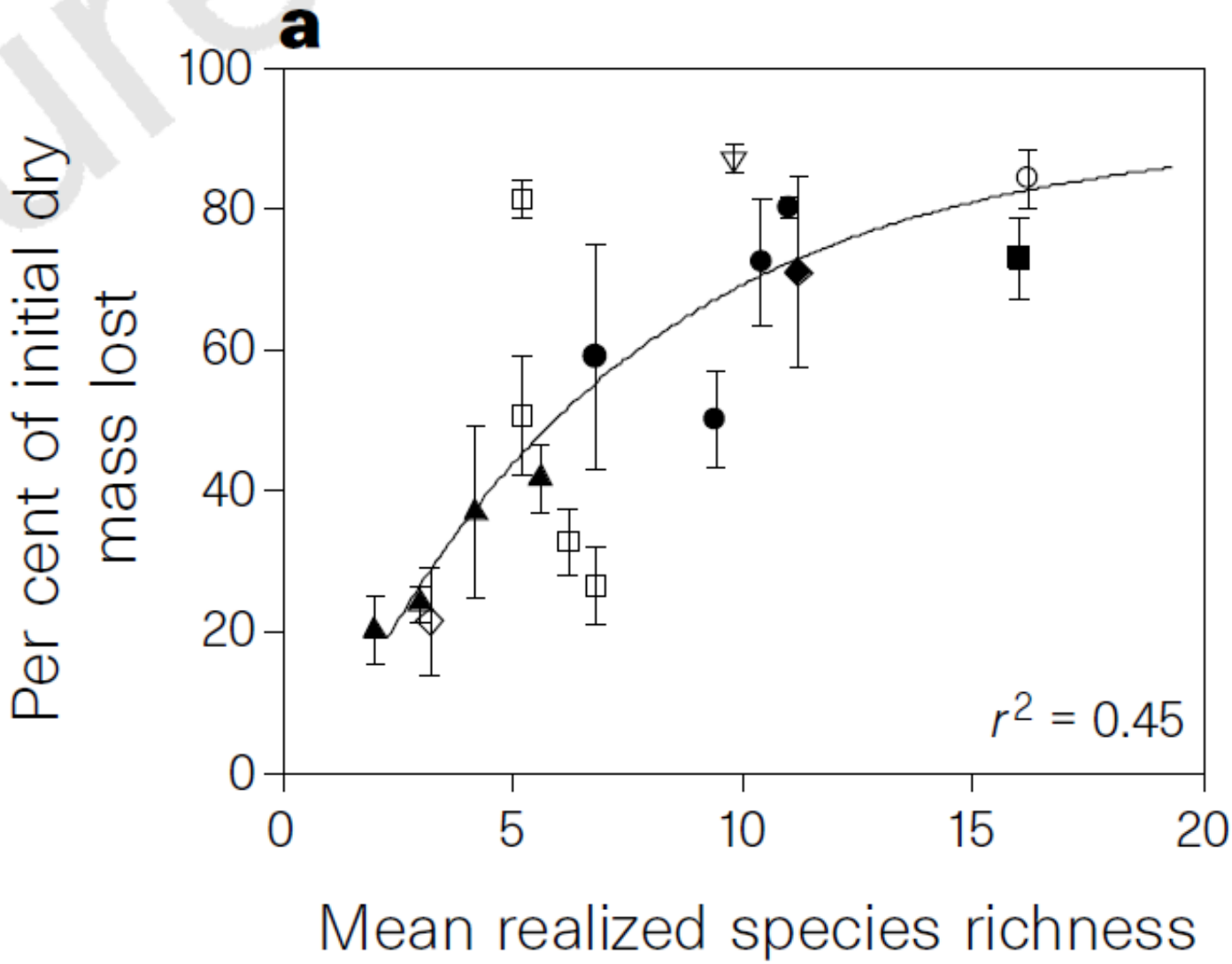
Algae

1° Producers

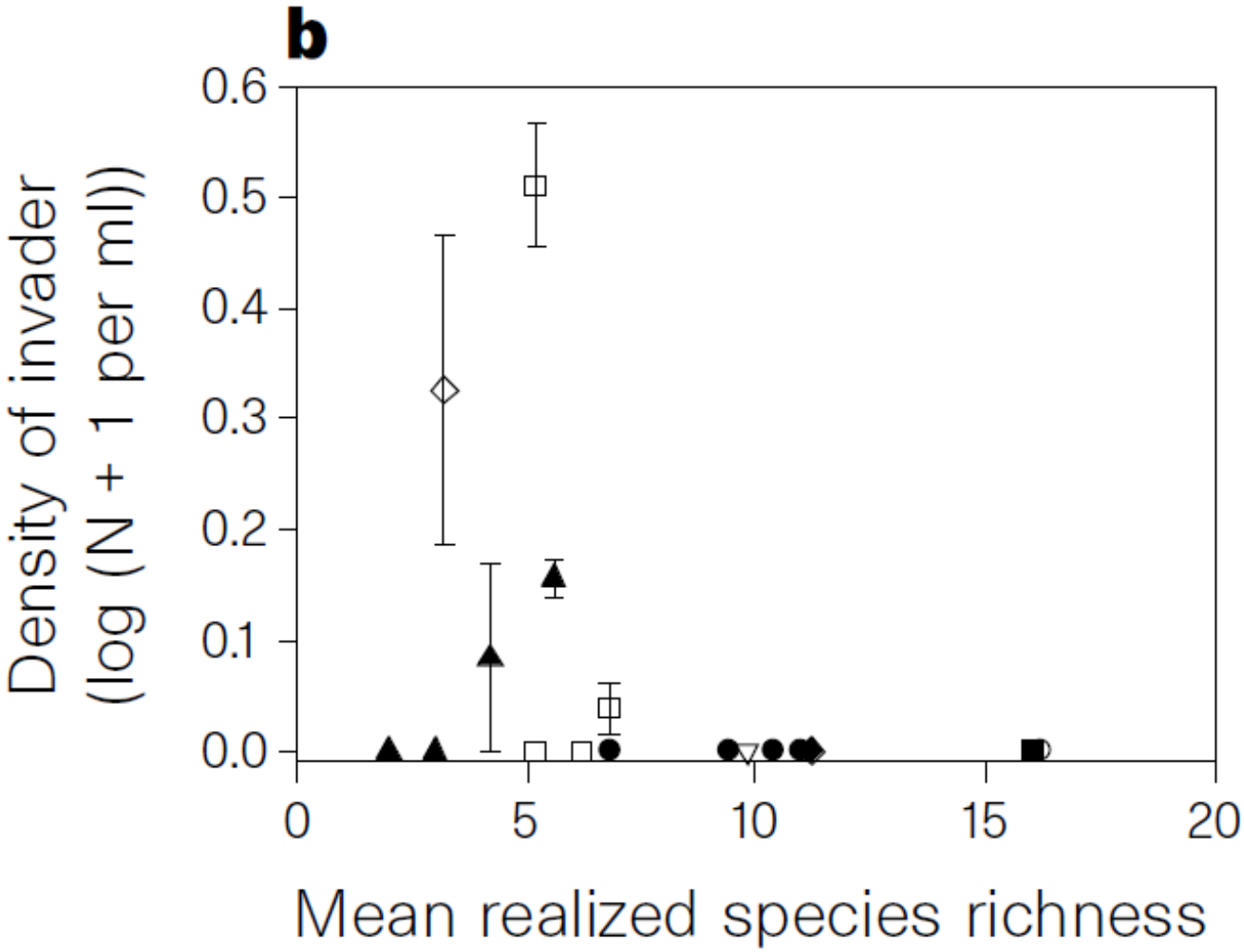
Ecosystem respiration:



Decomposition



Invasibility:



7 JUNE 2012 | VOL 486 | NATURE | 59

doi:10.1038/nature11148

Biodiversity loss and its impact on humanity

Bradley J. Cardinale[1], J. Emmett Duffy[2], Andrew Gonzalez[3], David U. Hooper[4], Charles Perrings[5], Patrick Venail[1], Anita Narwani[1], Georgina M. Mace[6], David Tilman[7], David A. Wardle[8], Ann P. Kinzig[5], Gretchen C. Daily[9], Michel Loreau[10], James B. Grace[11], Anne Larigauderie[12], Diane S. Srivastava[13] & Shahid Naeem[14]

By the mid-1990s, BEF studies had manipulated the species richness of plants in laboratory and field experiments and suggested that ecosystem functions, like biomass production and nutrient cycling, respond strongly to changes in biological diversity[7–10]. Interpretation of these studies was initially controversial, and by the late 1990s BEF researchers were involved in a debate over the validity of experimental designs, the mechanisms responsible for diversity effects, and the relevance of results to non-experimental systems[11]. This controversy helped to create a decade of research that, by 2009, generated several hundred papers reporting results of >600 experiments that manipulated more than 500 types of organisms in freshwater, marine and terrestrial ecosystems[11,12].

Consensus statement one

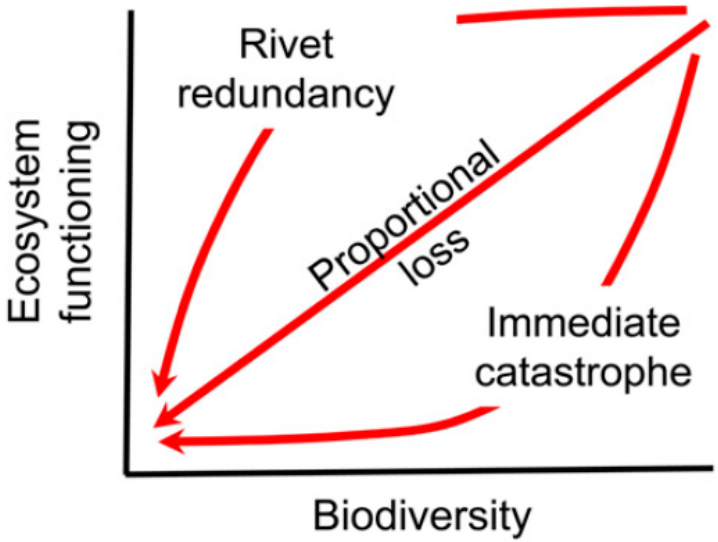
There is now unequivocal evidence that biodiversity loss reduces the efficiency by which ecological communities capture biologically essential resources, produce biomass, decompose and recycle biologically essential nutrients.

American Journal of Botany

American Journal of Botany 98(3): 572–592. 2011.

The functional role of producer diversity in ecosystems[1]

Bradley J. Cardinale[2,12], Kristin L. Matulich[3], David U. Hooper[4], Jarrett E. Byrnes[5], Emmett Duffy[6], Lars Gamfeldt[7,8], Patricia Balvanera[9], Mary I. O'Connor[10], and Andrew Gonzalez[11]



Niche complementarity

vs.

Sampling ("selection") effects

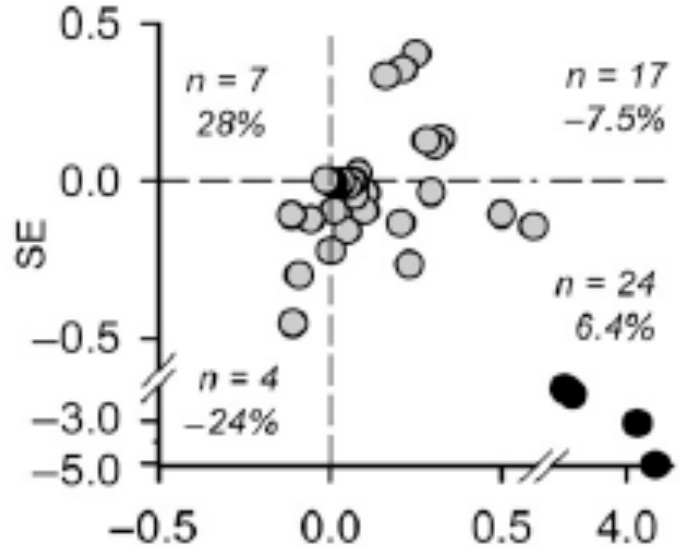
Both tend to be present

Do polycultures perform better than monocultures of the "best" species (transgressive overyielding)?

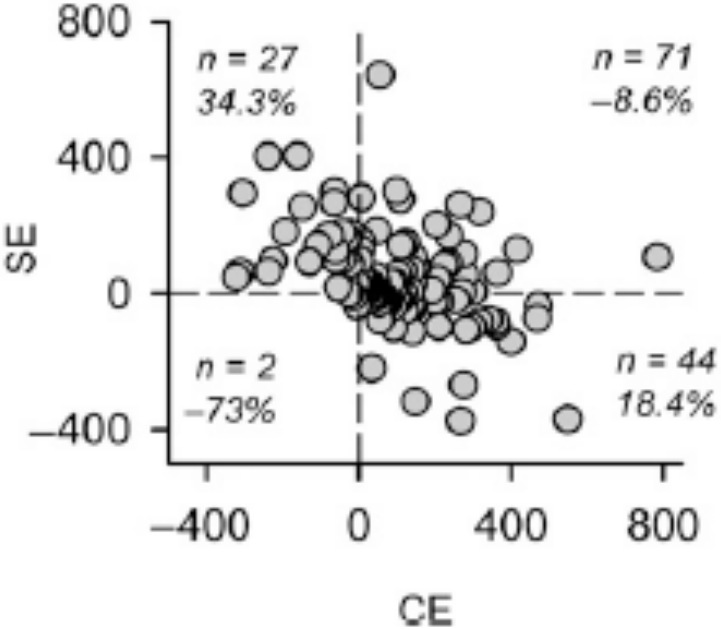
Yes ➔ niche complementarity

No ➔ sampling effect

37% of studies show transgressive overyielding (63% do not)


0.5
0.0
−0.5
−3.0
−5.0
SE
n = 7
28%
n = 17
−7.5%
n = 24
6.4%
n = 4
−24%
−0.5
0.0
0.5
4.0

H


800
400
0
−400
SE
n = 27
34.3%
n = 71
−8.6%
n = 2
−73%
n = 44
18.4%
−400
0
400
800
CE

More diverse communities have lower temporal variance

The portfolio effect

VOL. 151, NO. 3 THE AMERICAN NATURALIST MARCH 1998

The Statistical Inevitability of Stability-Diversity Relationships in Community Ecology

D. F. Doak,* D. Bigger, E. K. Harding, M. A. Marvier, R. E. O'Malley, and D. Thomson†

VOL. 151, NO. 3 THE AMERICAN NATURALIST MARCH 1998

Notes and Comments

Diversity-Stability Relationships: Statistical Inevitability or Ecological Consequence?

David Tilman,* Clarence L. Lehman, and Charles E. Bristow

PERSPECTIVES

THE ROBERT H. MACARTHUR AWARD LECTURE

Ecology, 80(5), 1999, pp. 1455–1474

THE ECOLOGICAL CONSEQUENCES OF CHANGES IN BIODIVERSITY: A SEARCH FOR GENERAL PRINCIPLES[1]

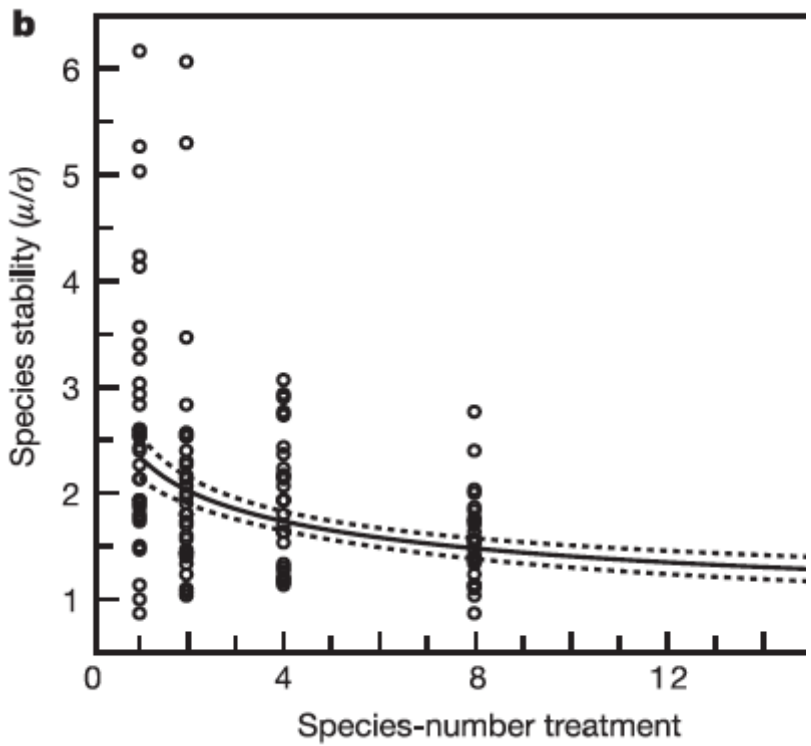
DAVID TILMAN

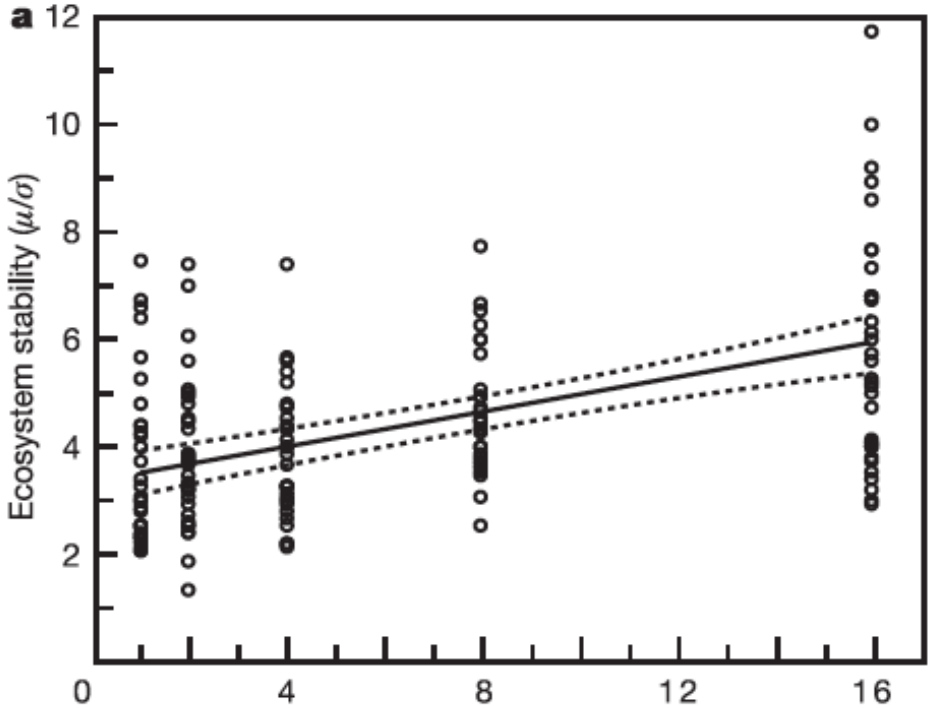
Vol 441|1 June 2006|doi:10.1038/nature04742

LETTERS

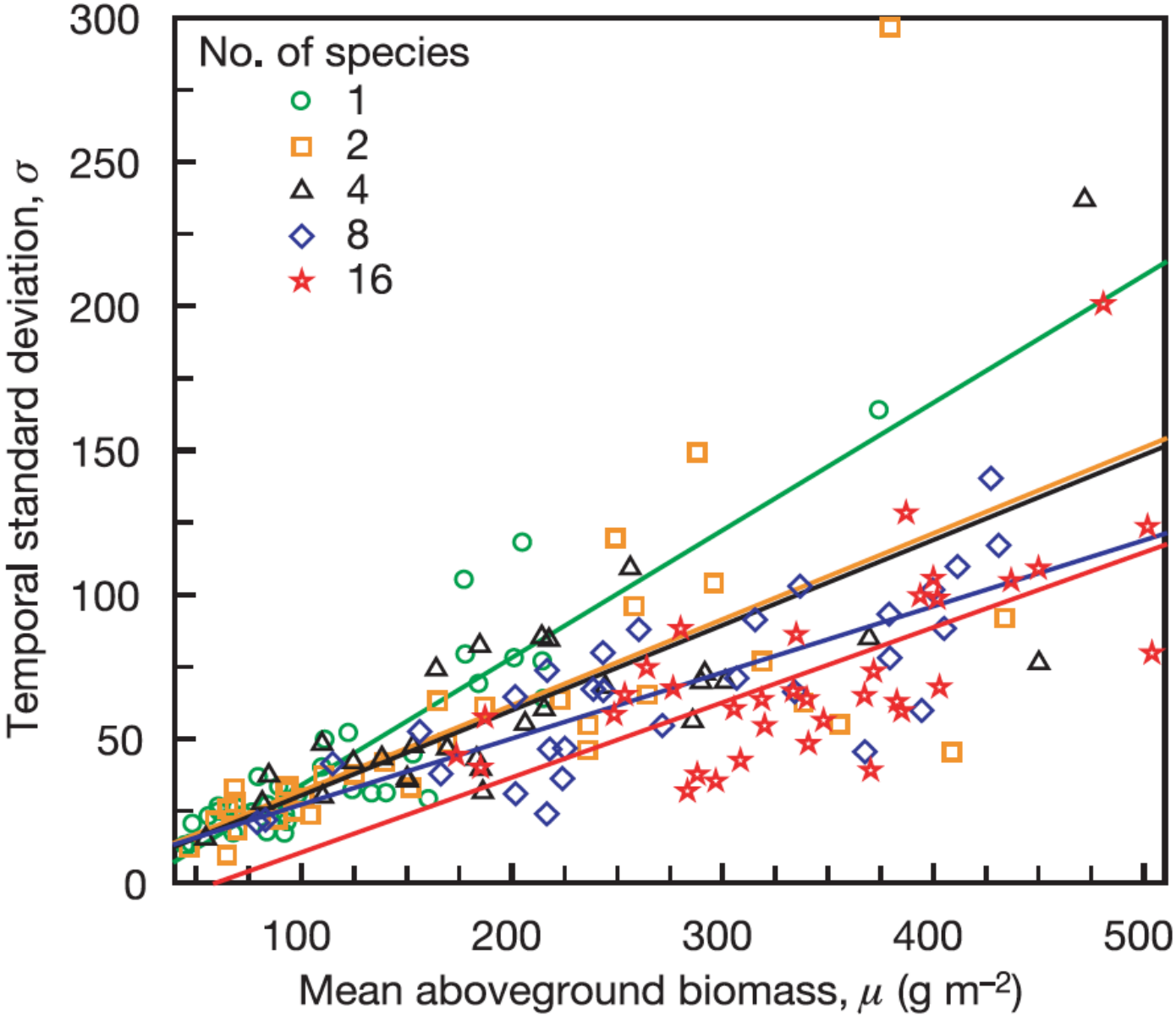
Biodiversity and ecosystem stability in a decade-long grassland experiment

David Tilman[1], Peter B. Reich[2] & Johannes M. H. Knops[3]





But might mean-variance relationships confound these patterns?


No. of species
1
2
4
8
16
Temporal standard deviation, σ
Mean aboveground biomass, μ (g m⁻²)
0
50
100
150
200
250
300
100
200
300
400
500

Tilman distinguishes three components:

- Portfolio effect (baseline: species fluctuate independently; constant mean community biomass)
- Covariance effect (e.g., asynchrony)
- Overyielding (biomass increases with S)

Diversity is important (but a variety of mechanisms operate)