Ecology 8310
Population (and Community) Ecology

How do we study competition?

- Pattern
- Experiments
  - De Wit Replacement Series (substitutive)
  - Additive designs
  - Full designs or Response Surfaces
  - Target-Neighbor experiments

Beyond chemo-stats:
How do we empirically study competition?

1. Pattern
2. Experimentation
3. Mechanism

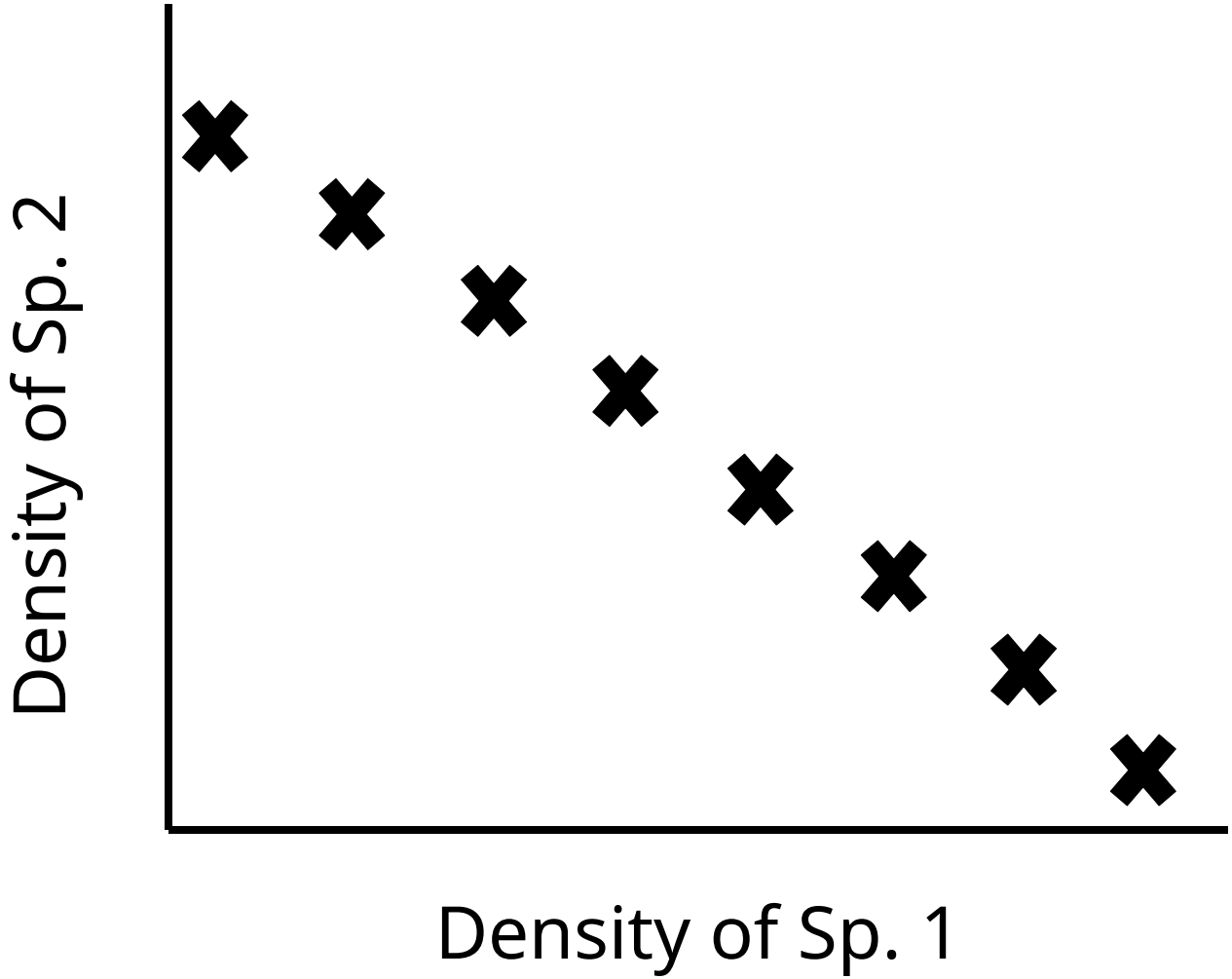
Pattern

1. Spatial
2. Temporal

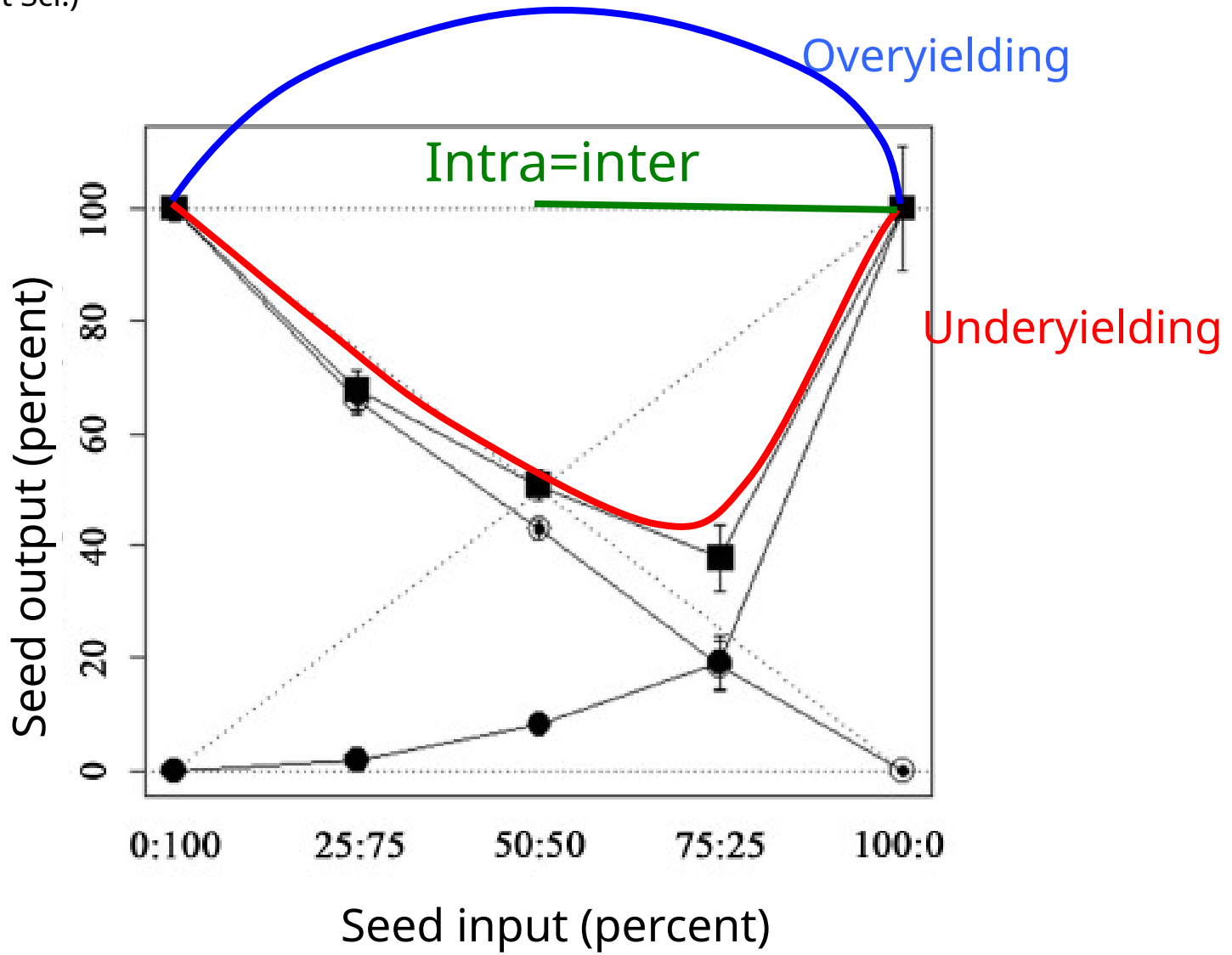
Experiments

De Wit Replacement Series
(substitutive design)

- Keep the total seed number the same
  - Vary the proportion of two species
- Quantify seed production of each species


Density of Sp. 2
Density of Sp. 1

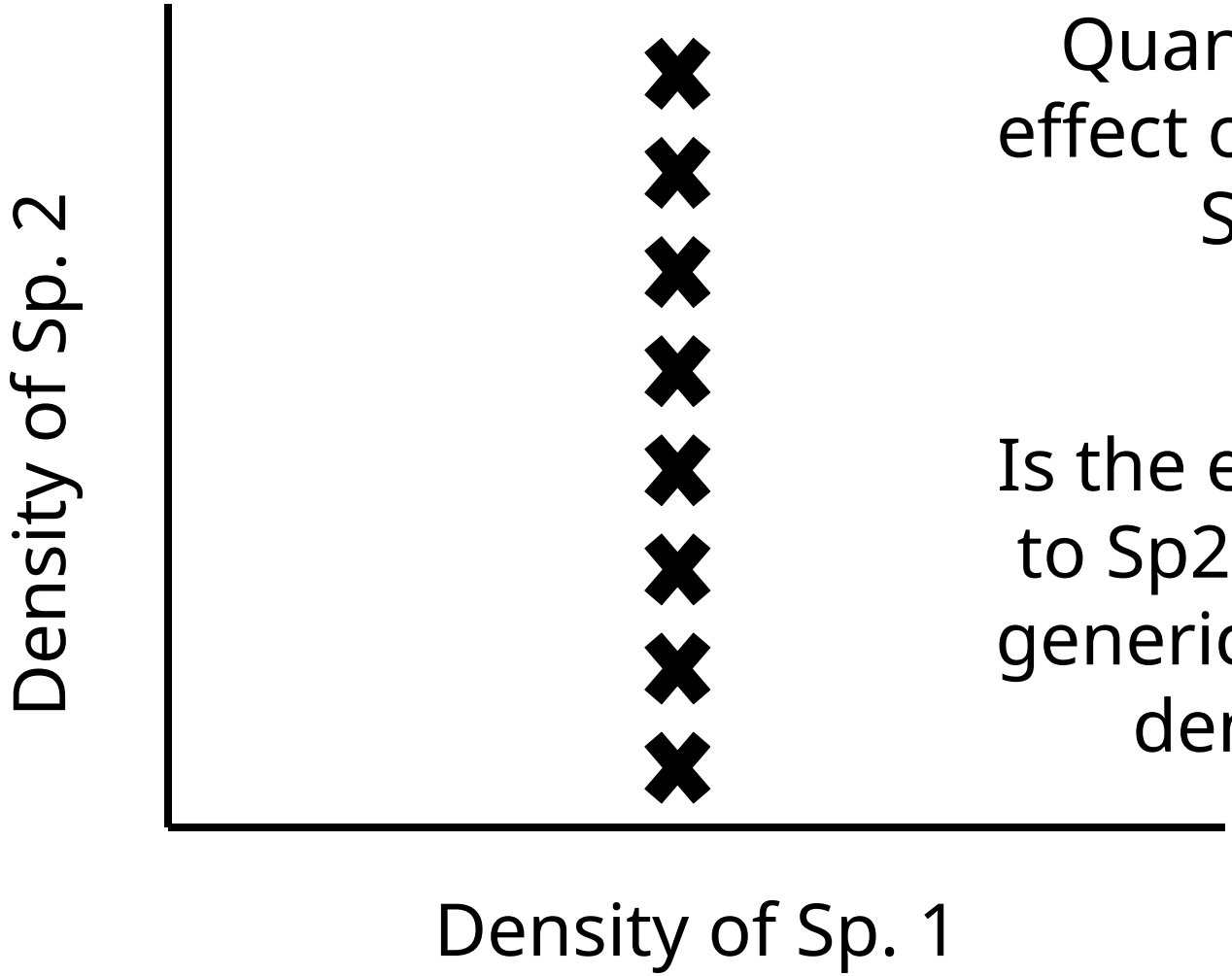
Data from Galon et al. 2015 (Am. J. Plant Sci.)



Why do you get over- vs. under-yielding?

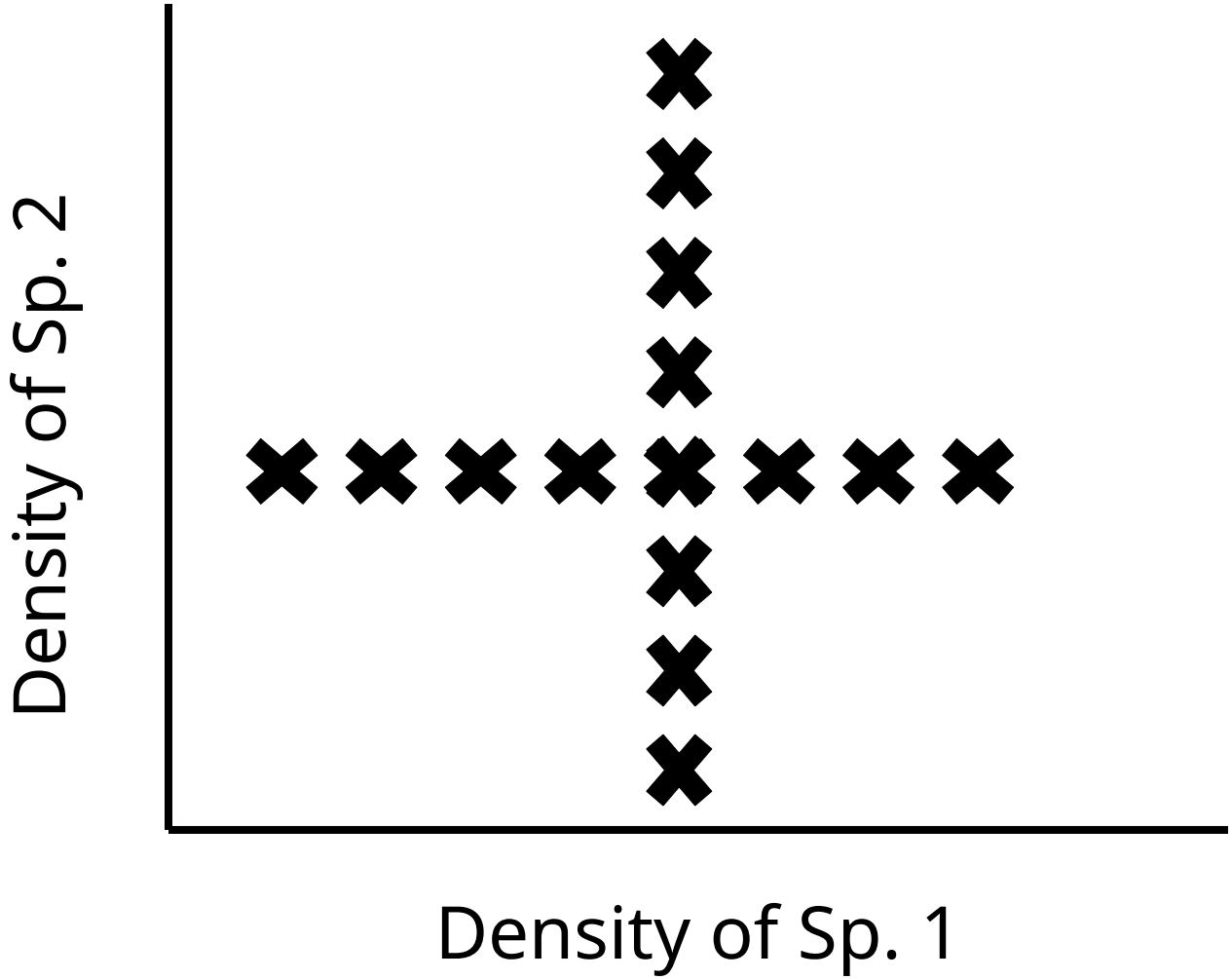
What if intra=inter?

Additive designs



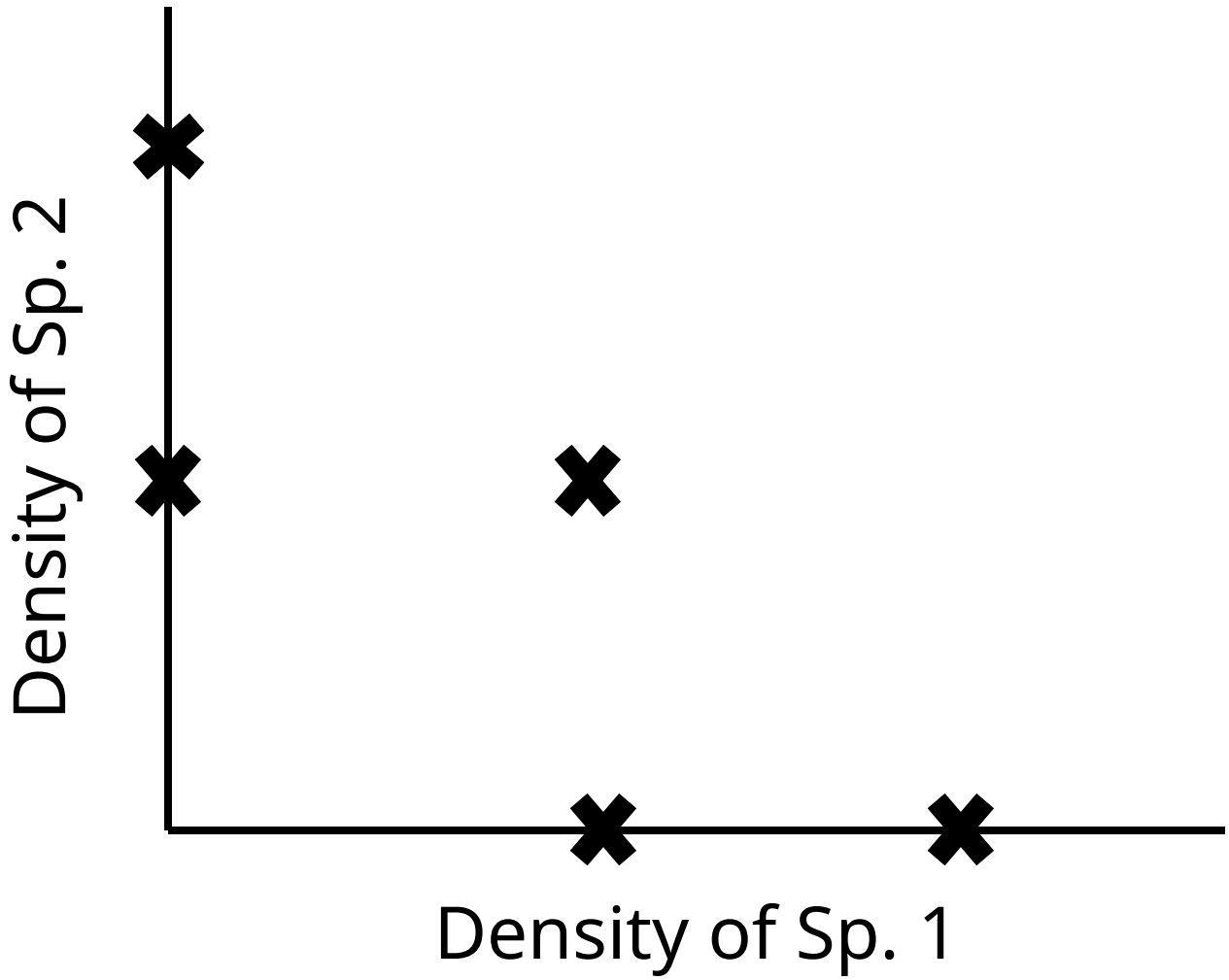
Quantify the effect of Sp.2 on Sp.1

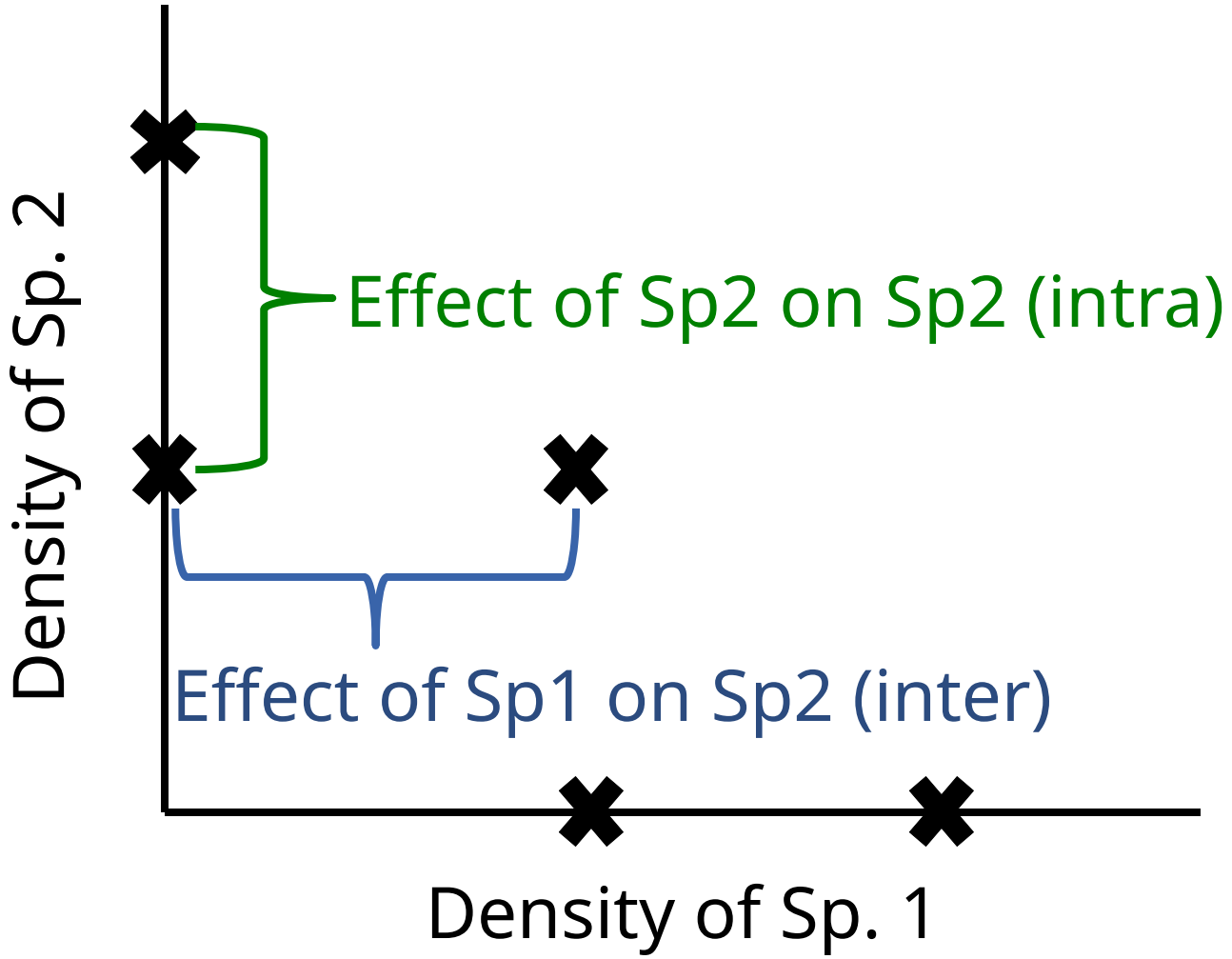
Is the effect due to Sp2 or just a generic effect of density?

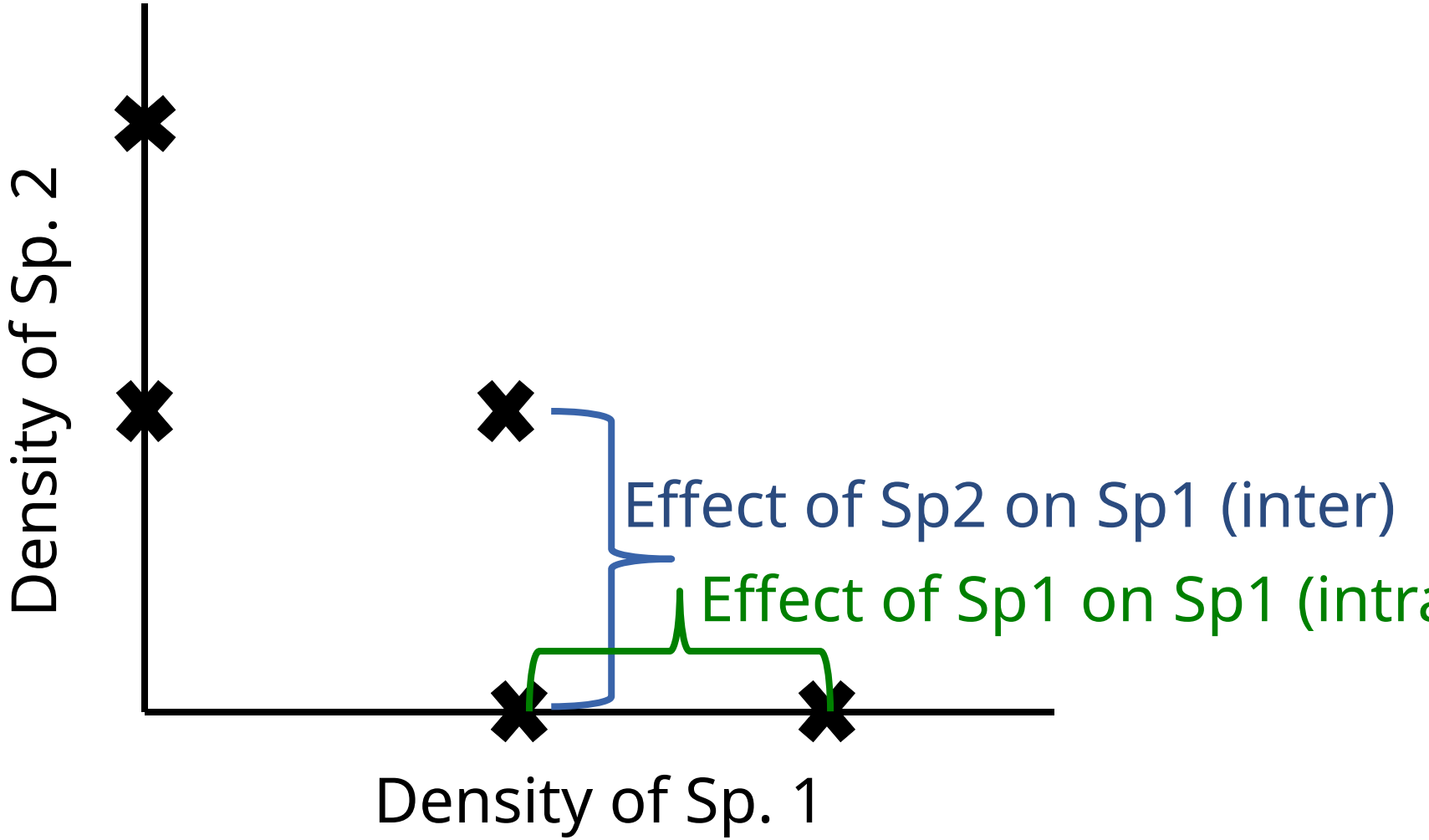

Density of Sp. 2
Density of Sp. 1

Minimal design

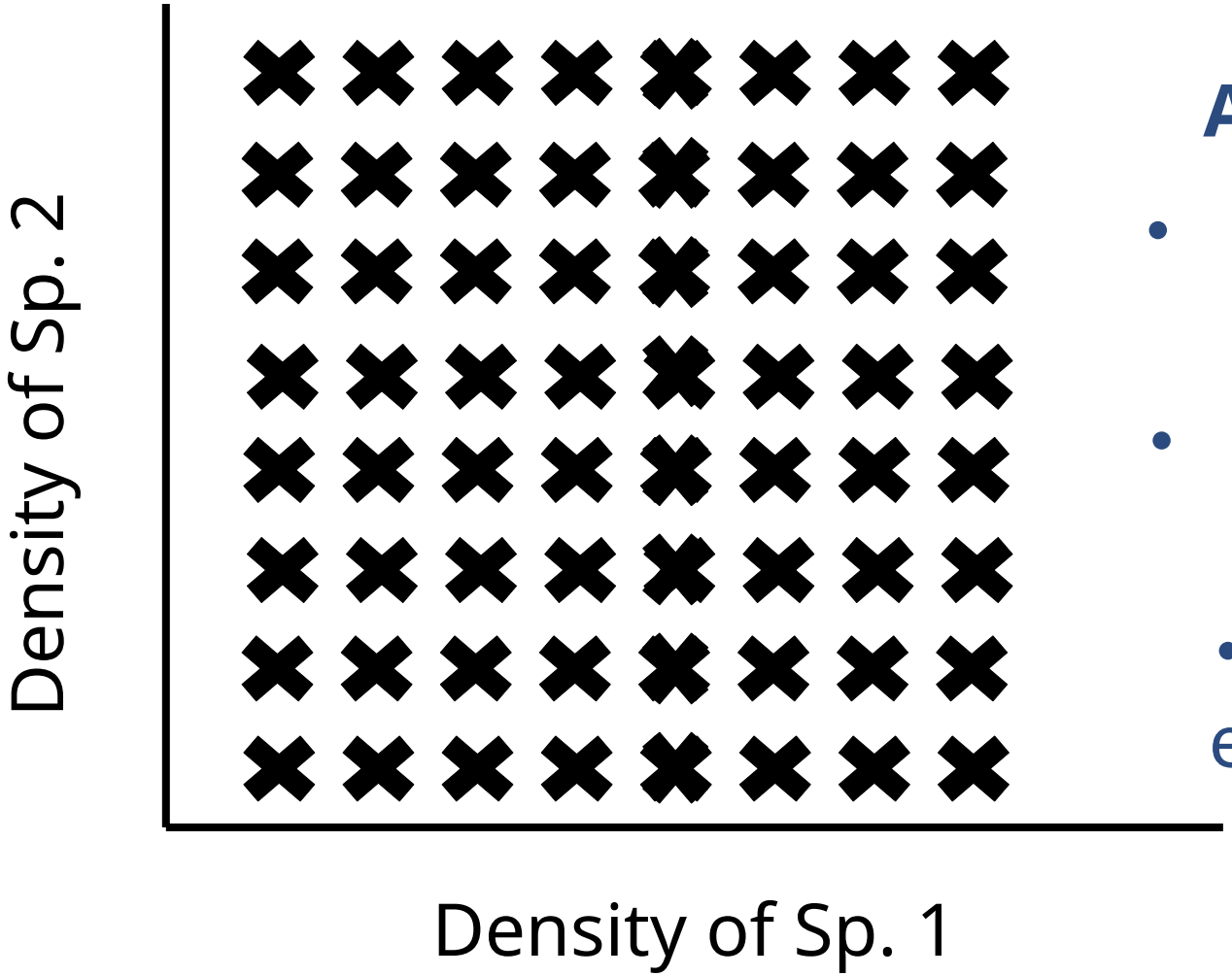
(to quantify effect of inter and intraspecific effects)


Density of Sp. 2
Density of Sp. 1


Density of Sp. 2
Effect of Sp2 on Sp2 (intra)
Effect of Sp1 on Sp2 (inter)
Density of Sp. 1


Density of Sp. 2
Effect of Sp2 on Sp1 (inter)
Effect of Sp1 on Sp1 (intra
Density of Sp. 1

Response Surface



Advantages:

- Quantify intra vs. inter
- Evaluate non-linearities
- Describes entire response surface

But a lot more work

Responses: individuals or populations?

Proc. Nat. Acad. Sci. USA
Vol. 70, No. 12, Part I, pp. 3590–3593, December 1973

Global Models of Growth and Competition

(population dynamics/niche theory/coexistence)

MICHAEL E. GILPIN AND FRANCISCO J. AYALA

Department of Entomology and Department of Genetics, University of California, Davis, Calif. 95616

Communicated by Theodosius Dobzhansky,

THEORETICAL POPULATION BIOLOGY 4, 331–356 (1973)

Competition Between Species: Theoretical Models and Experimental Tests*

FRANCISCO J. AYALA

Department of Genetics, University of California, Davis, California 95616

MICHAEL E. GILPIN

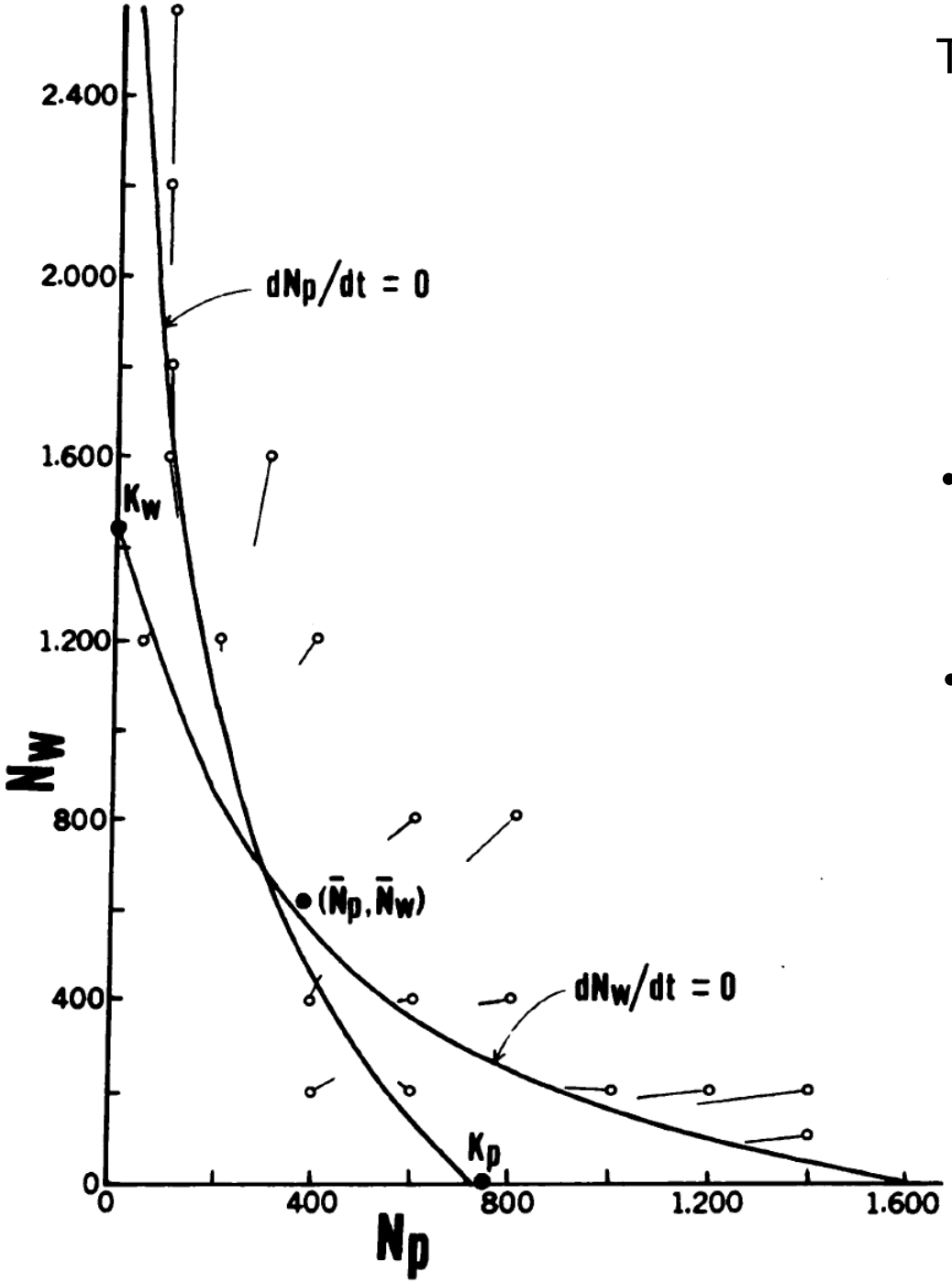
Department of Entomology, University of California, Davis, California 95616

AND

JOAN G. EHRENFELD

Department of Biology, City College of New York, New York, New York 10031

Received August 18, 1972



Two species of Drosophila, *D. willistoni* and *D. pseudoobscura*

- Set up at a range of densities
- Monitored pop. sizes at start and after reproduction
- Plotted on phase-plane
- Compared to independent estimates of 1- and 2-species equilibria.

Another approach (focus on individuals):

Target-Neighbor Designs

Target-Neighbor Designs

Amer. J. Bot. 70(7): 1098–1104. 1983.

SPECIAL PAPER

EQUIVALENCE OF COMPETITORS IN PLANT COMMUNITIES: A NULL HYPOTHESIS AND A FIELD EXPERIMENTAL APPROACH[1]

DEBORAH E. GOLDBERG AND PATRICIA A. WERNER

W. K. Kellogg Biological Station, and Department of Botany and Plant Pathology, Michigan State University, Hickory Corners, Michigan 49060

Journal of Ecology (1991), **79**, 1013–1030

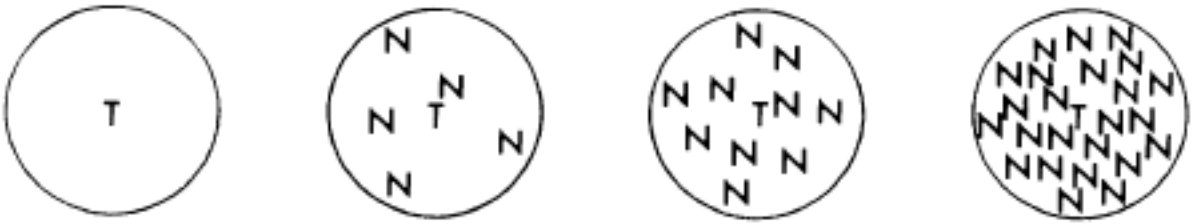
COMPETITIVE EFFECT AND RESPONSE: HIERARCHIES AND CORRELATED TRAITS IN THE EARLY STAGES OF COMPETITION

DEBORAH E. GOLDBERG AND KEITH LANDA*

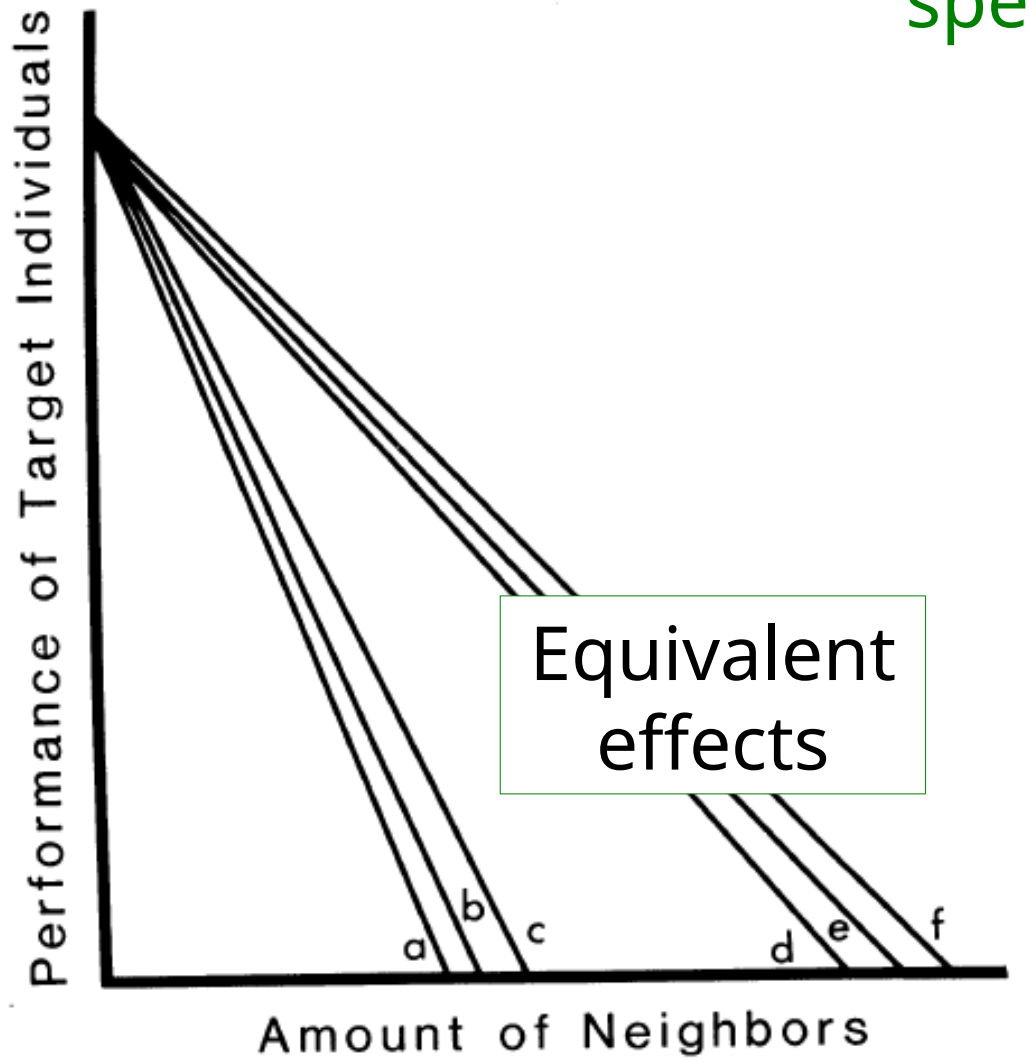
Department of Biology, University of Michigan, Ann Arbor, MI 48109, U.S.A.

A. INITIAL FIELD CONDITIONS

B. AFTER TREATMENT



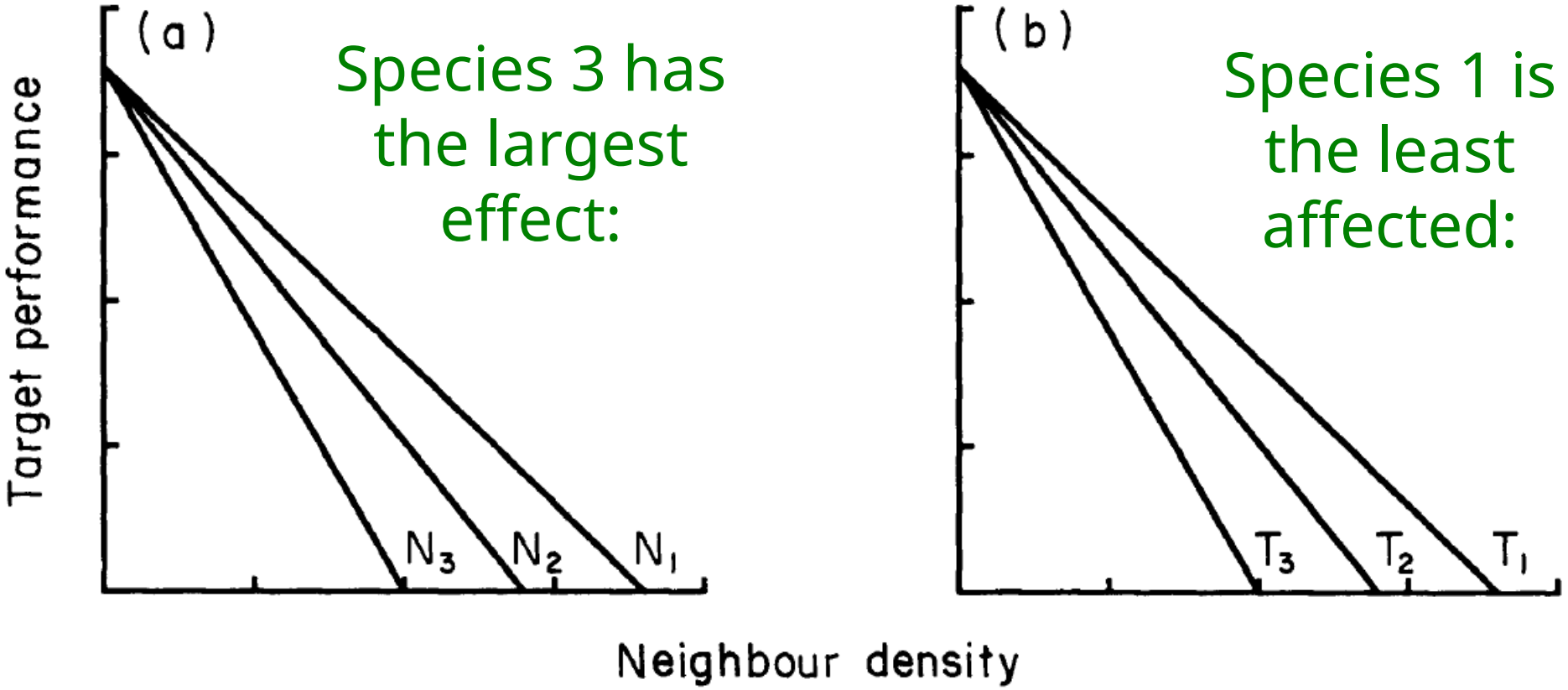
Compare effects of 6 different neighbor species on 1 target species…



Equivalent effects

Different effects:

Different responses:



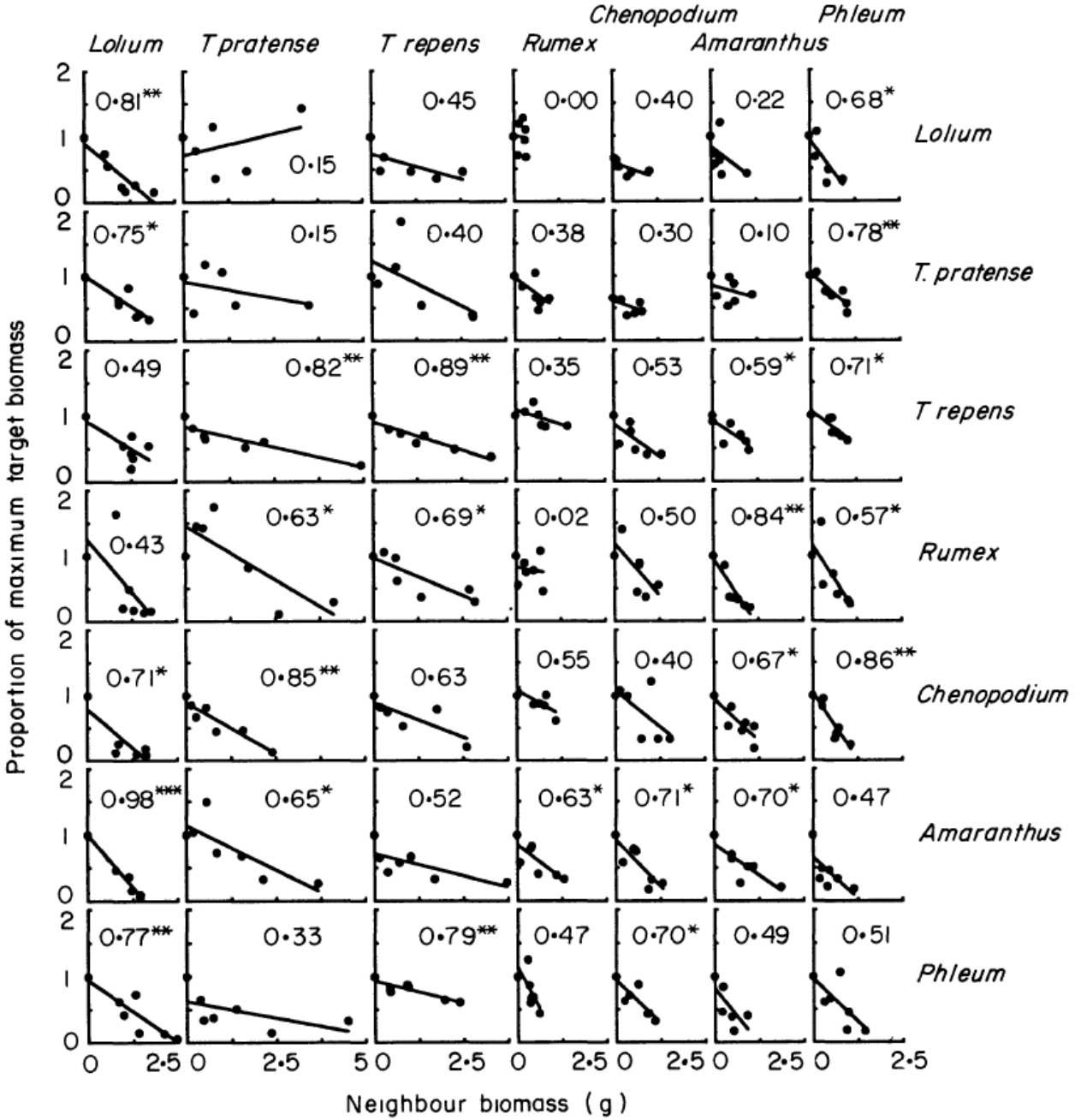
Species 3 has the largest effect:

Species 1 is the least affected:

“Equivalence” provides a null hypothesis:

if neighbor biomass (resources acquired) drives competitive effects, then neighbors should yield equal effects (when compared with respect to their biomass).

Neighbor species



Equivalence?

Rejected, although per-gram effects were much more similar than per-plant effects

Trifolium = weak effects (N-fixer?)

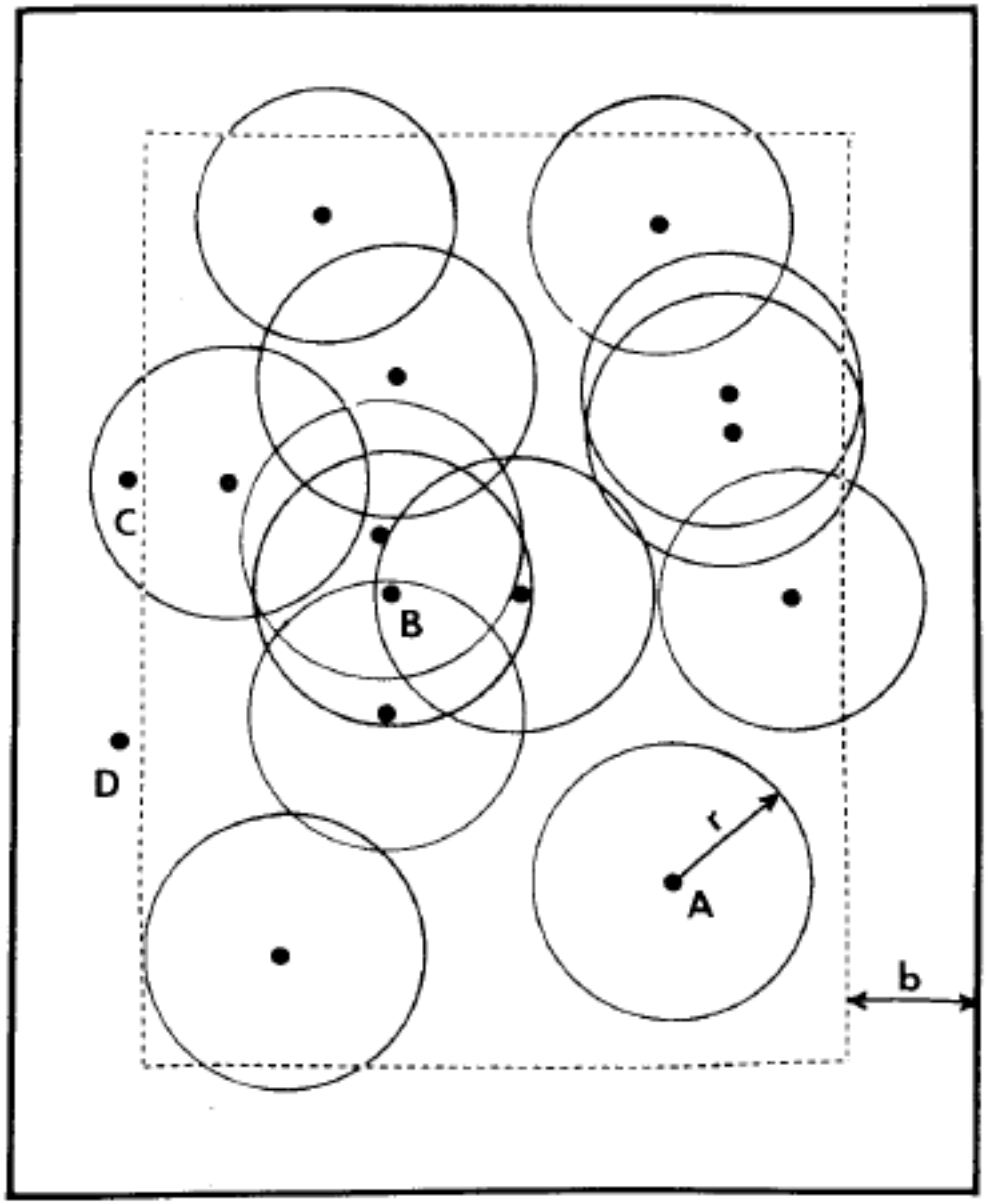
Phleum = strong effects

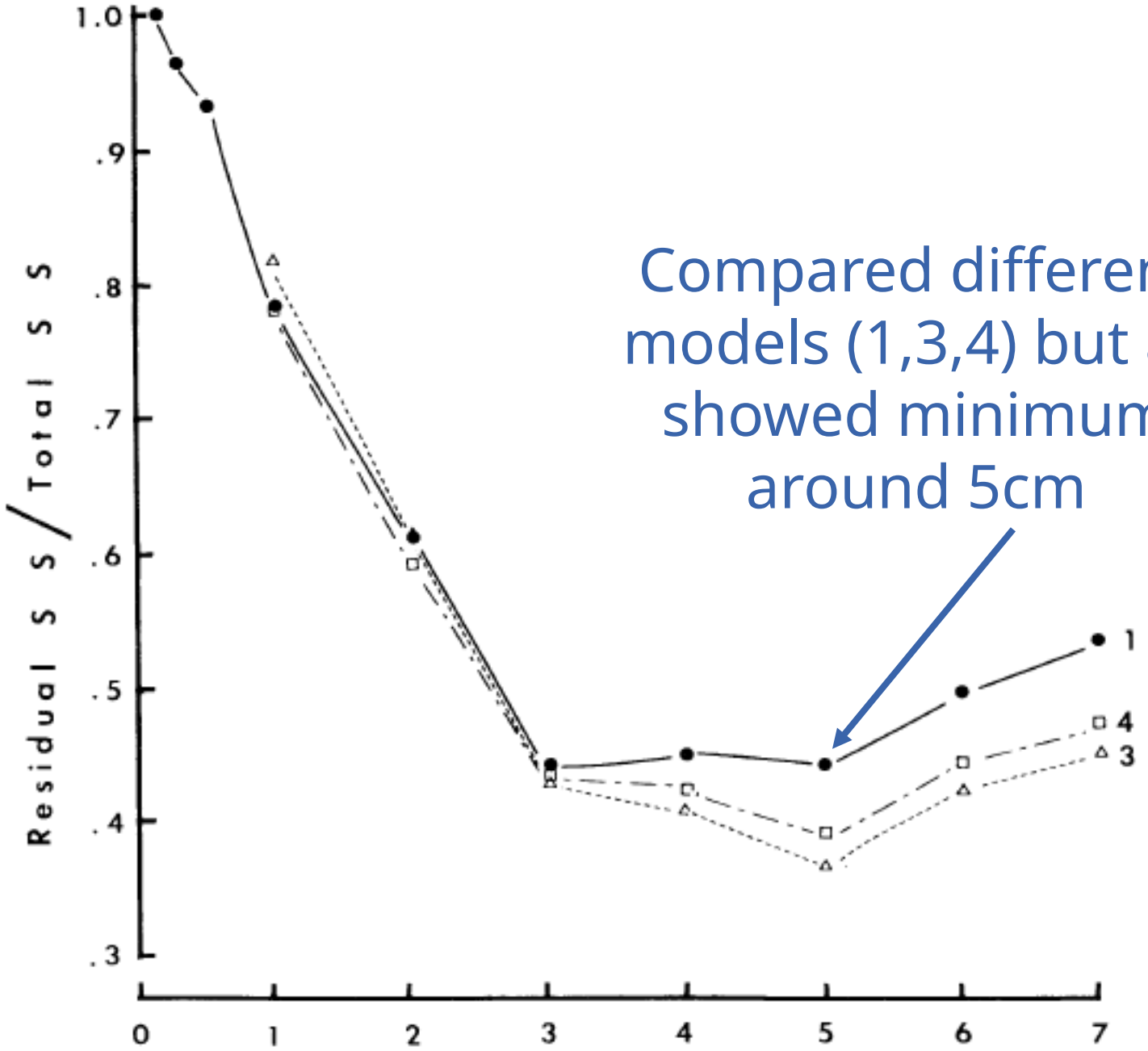
Oecologia (Berlin) (1985) 66:256–263

Oecologia

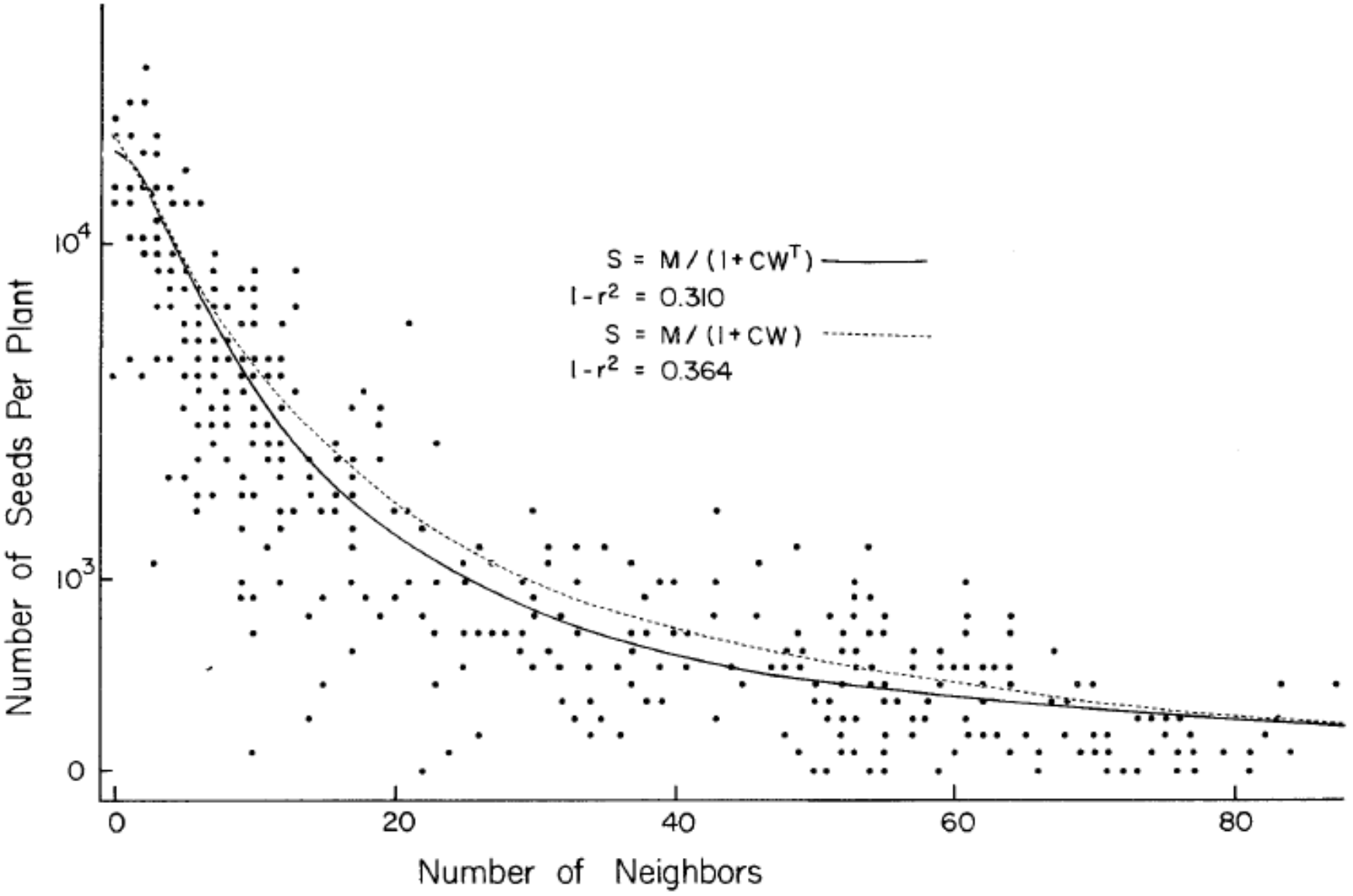
Neighborhood predictors of plant performance

John A. Silander Jr. and Stephen W. Pacala
Ecology Section, Biological Sciences Group, The University of Connecticut, Storrs, CT 06268, USA


C
B
D
r
A
b



Compared different models (1,3,4) but all showed minimum around 5cm


Number of Seeds Per Plant
10^4
10^3
0
0
20
40
60
80
Number of Neighbors
$S = M / (1 + CW^T)$
$1 - r^2 = 0.310$
$S = M / (1 + CW)$
$1 - r^2 = 0.364$

Another approach using resource-based mechanisms:

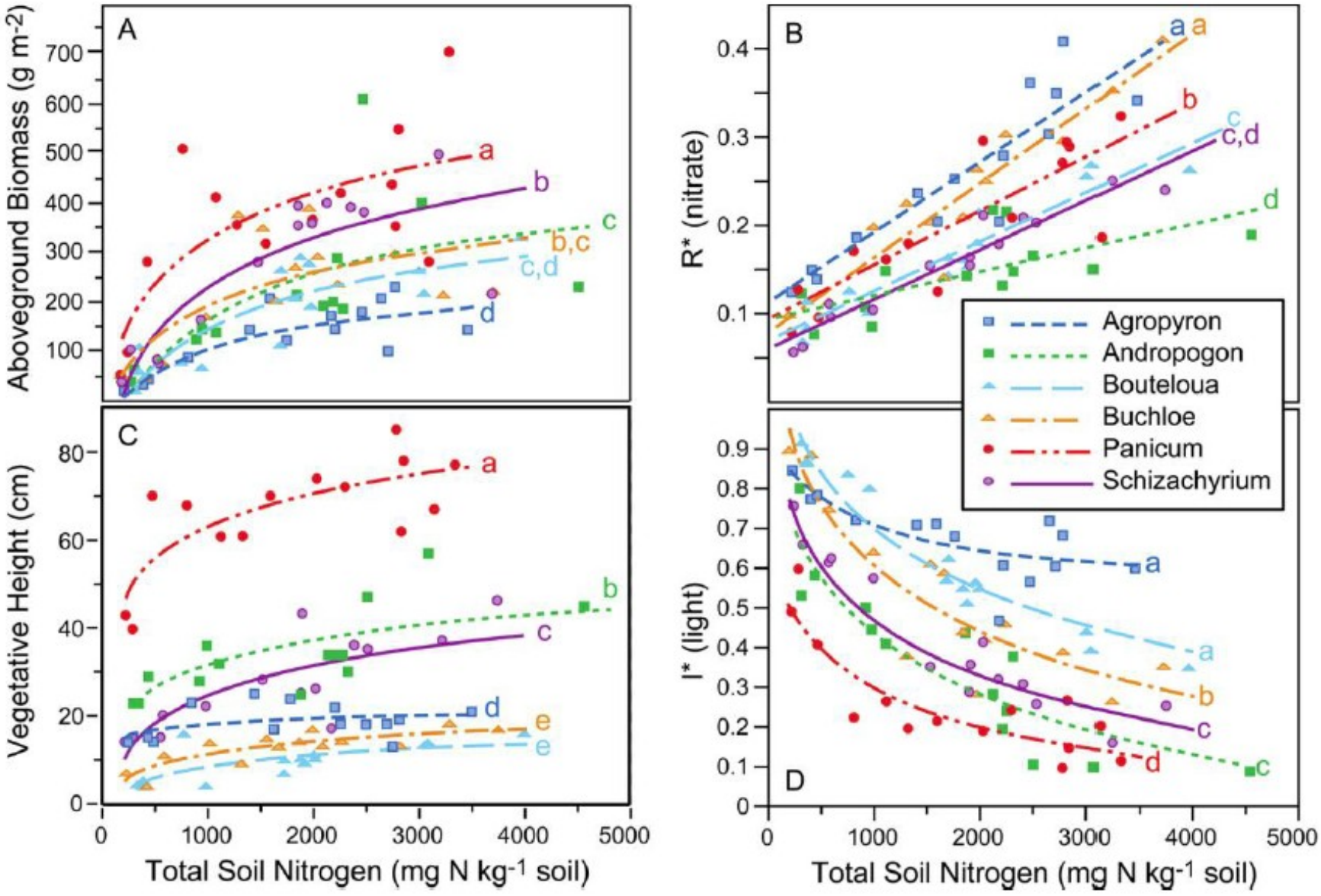
R* with terrestrial plants

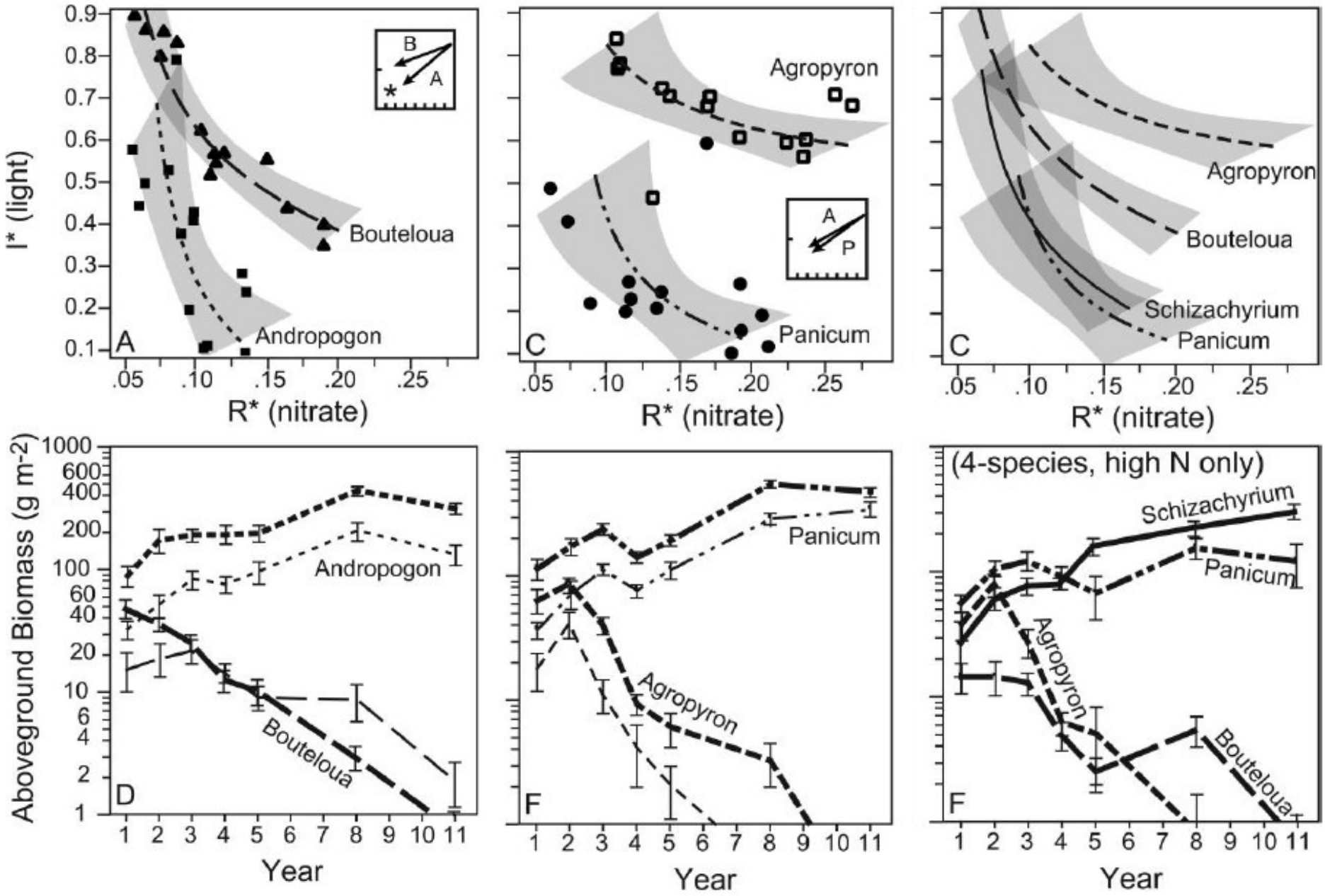
VOL. 170, NO. 3 THE AMERICAN NATURALIST SEPTEMBER 2007

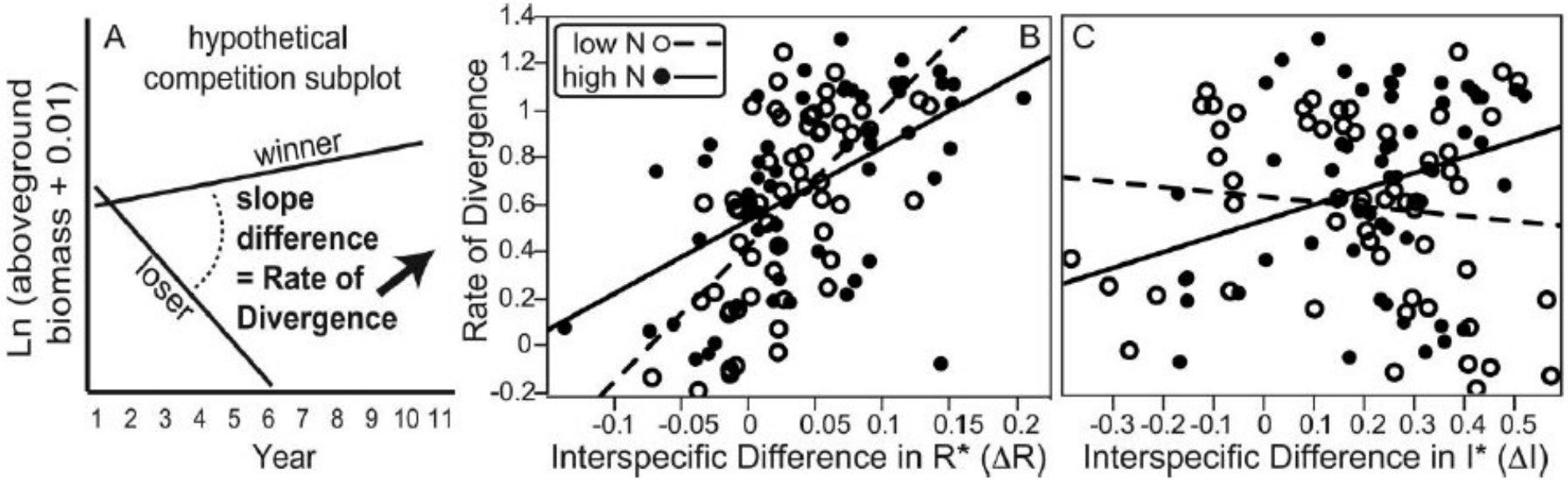
Resource Use Patterns Predict Long-Term Outcomes of Plant Competition for Nutrients and Light

Ray Dybzinski* and David Tilman†

- Grew monocultures of 6 species for 11 years. Determine R* (nitrogen) and I* (light).
- Crossed with total N (supply point))
- Also grew combinations of spp.


A
Aboveground Biomass (g m-2)
700
600
500
400
300
200
100
a
b
c
b,c
c,d
d
B
R* (nitrate)
0.4
0.3
0.2
0.1
a
a
b
c
c,d
d
Agropyron
Andropogon
Bouteloua
Buchloe
Panicum
Schizachyrium
C
Vegetative Height (cm)
80
60
40
20
0
a
b
c
d
e
e
D
I* (light)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
a
a
b
c
d
c
0
1000
2000
3000
4000
5000
Total Soil Nitrogen (mg N kg-1 soil)
Total Soil Nitrogen (mg N kg-1 soil)


I* (light)
R* (nitrate)
A
B
*
Bouteloua
Andropogon
C
Agropyron
Panicum
Schizachyrium
Aboveground Biomass (g m-2)
Year
D
F
(4-species, high N only)


A
hypothetical
competition subplot
winner
loser
slope
difference
= Rate of
Divergence
Ln (aboveground
biomass + 0.01)
1 2 3 4 5 6 7 8 9 10 11
Year
B
low N
high N
Rate of Divergence
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.1 -0.05 0 0.05 0.1 0.15 0.2
Interspecific Difference in R* (ΔR)
C
-0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5
Interspecific Difference in I* (ΔI)

“only a few of our paired species coexisted under our experimentally imposed conditions (homogeneous soils, high seeding densities, minimal disturbance, regular water, and low herbivory levels), suggesting that other coexistence mechanisms help generate the diversity observed in natural communities”

Bottom-lines:

- Experimental approaches (good for revealing causation, but time scale is limited)
- Observational approaches (poor for causation, but time scale often more appropriate)
- Resource-based “mechanism” helpful
- Caveat 1: Other factors have been omitted
- Caveat 2: responses often measured on individuals vs. populations