Plant traits in relation to environment:

Adaptation and community assembly

1) Plant traits along environment gradients

   - Trait-environment relationships of communities vs. species
   - Evolutionary divergences and adaptation

2) Limiting similarity and community assembly

3) Synthesis!

PLANT-GEOGRAPHY

UPON

A PHYSIOLOGICAL BASIS

By Dr. A. F. W. SCHIMPER

EXTRAORDINARY PROFESSOR IN THE UNIVERSITY OF BONN

THE AUTHORIZED ENGLISH TRANSLATION

By WILLIAM R. FISHER, B.A.

ASSISTANT PROFESSOR OF FORESTRY IN THE ROYAL INDIAN ENGINEERING COLLEGE COOPERS HILL

REVISED AND EDITED BY

PERCY GROOM, M.A., D.Sc., F.L.S.

AND

ISAAC BAYLEY BALFOUR, M.A., M.D., F.R.S.

KING'S BOTANIST IN SCOTLAND, PROFESSOR OF BOTANY IN THE UNIVERSITY AND KEEPER OF THE ROYAL BOTANIC GARDEN, EDINBURGH

WITH A PHOTOGRAVURE PORTRAIT, FIVE COLLOTYPES, FOUR MAPS, AND FOUR HUNDRED AND NINETY-SEVEN OTHER ILLUSTRATIONS

OXFORD

AT THE CLARENDON PRESS

1903

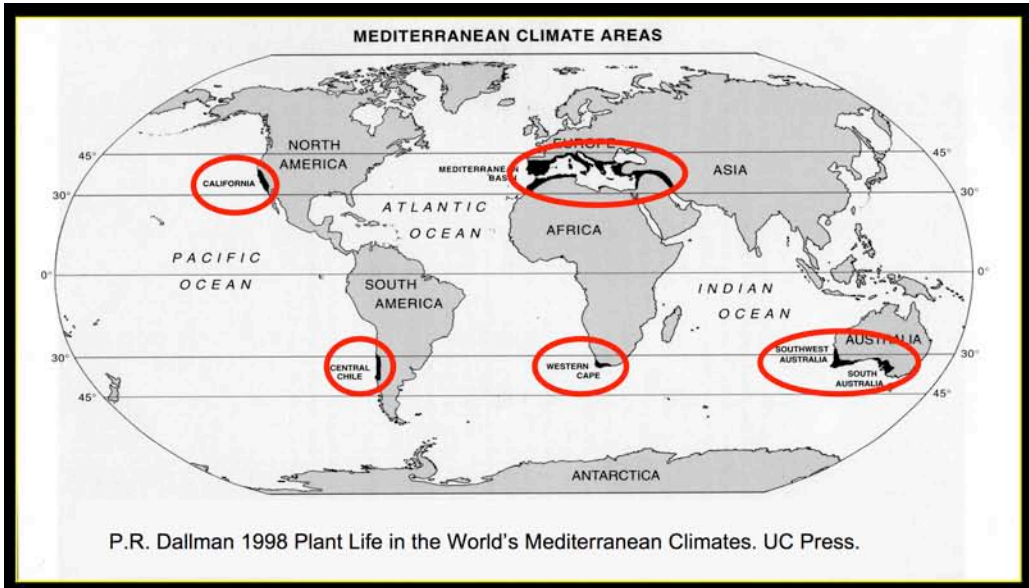
books.google.com

1. SCLEROPHYLLOUS WOODLAND IN GENERAL.

WHILST the districts referred to in the previous chapter resemble the tropics climatically in the coincidence of the rainy season with high temperatures, and accordingly possess a vegetation similar to that of the tropics, this likeness entirely ceases in countries where the precipitations coincide with low temperatures and at the same time the hot season is quite rainless or nearly so. Here the totally different aspect of the vegetation corresponds to the sharp difference in climatic conditions, and finds no analogy within the tropics. *The mild temperate districts with winter-rain and prolonged summer-drought are the home of evergreen xerophilous woody plants*, which, owing to the stiffness of their thick, leathery leaves, may be termed *sclerophyllous* woody plants.

The climatic districts belonging to this group are the littoral countries of the Mediterranean Sea, the south-west extremity of Africa, South-West Australia and the greater part of South Australia, Central Chili, and the greater part of the coastland of California. In all these widely separated countries the vegetation bears essentially the same stamp, in spite of deep-seated difference in the composition of the flora. It is dominated by sclero-

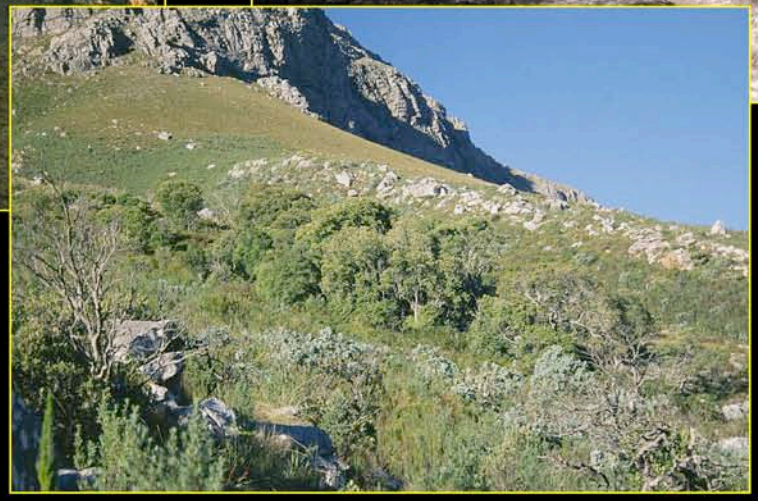
Schimper 1903, p. 507



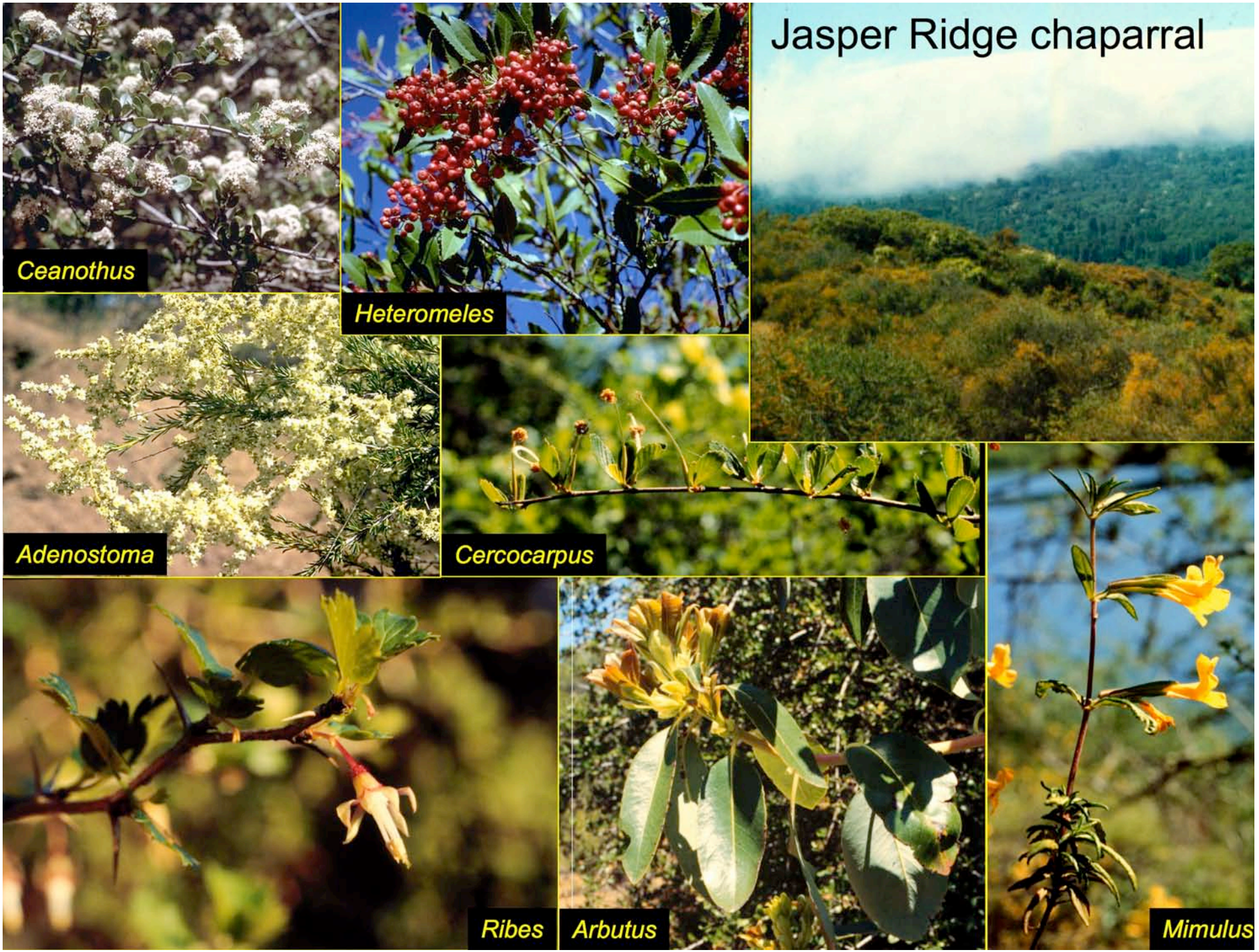
P.R. Dallman 1998 Plant Life in the World's Mediterranean Climates. UC Press.

"All [these] districts are the home of evergreen xerophilous woody plants which … may be termed **sclerophyllous**."

Schimper, 1903

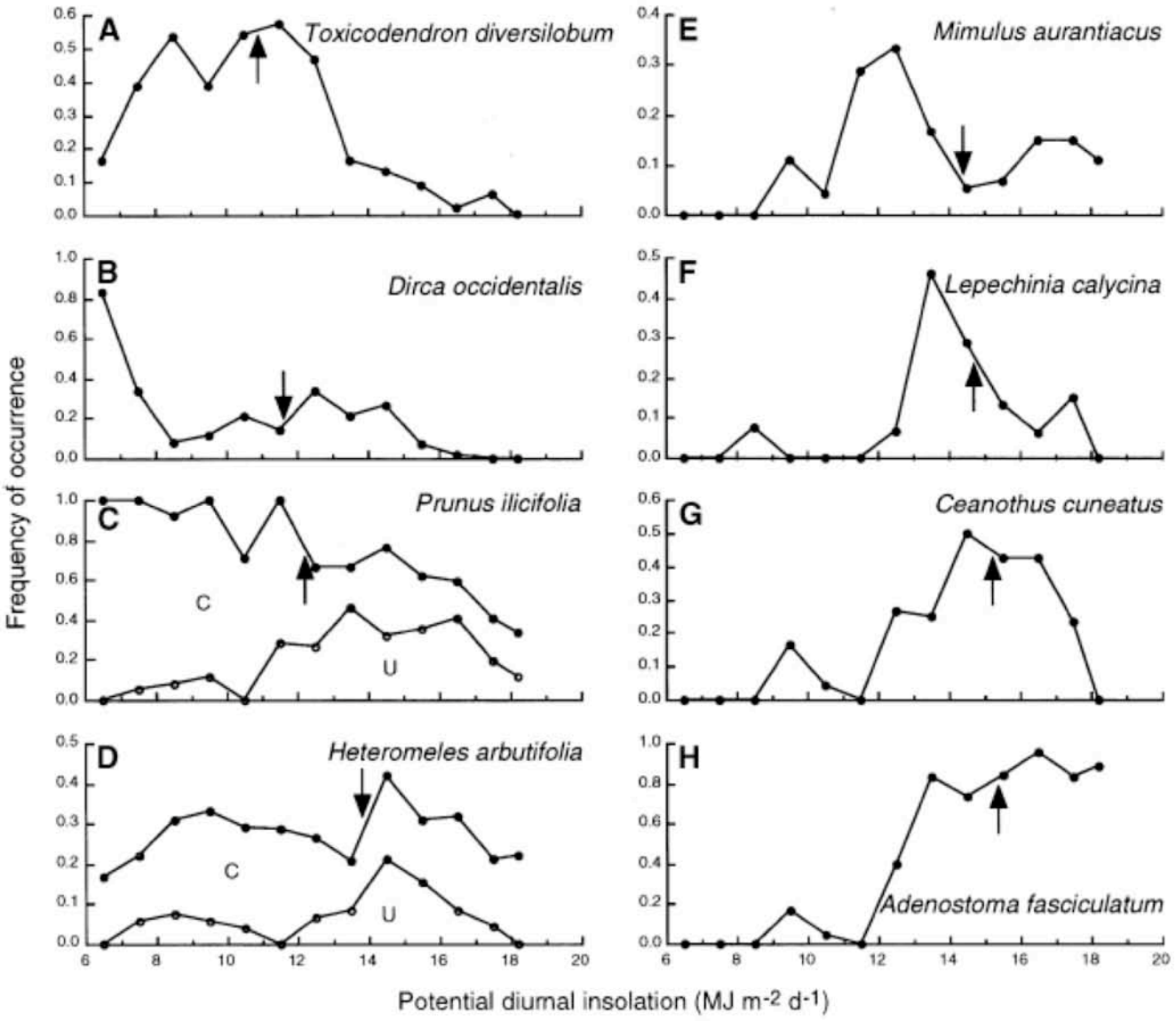


photos: R. Bhaskar, D. Schwilk


Jasper Ridge chaparral
Ceanothus
Heteromeles
Adenostoma
Cercocarpus
Ribes
Arbutus
Mimulus

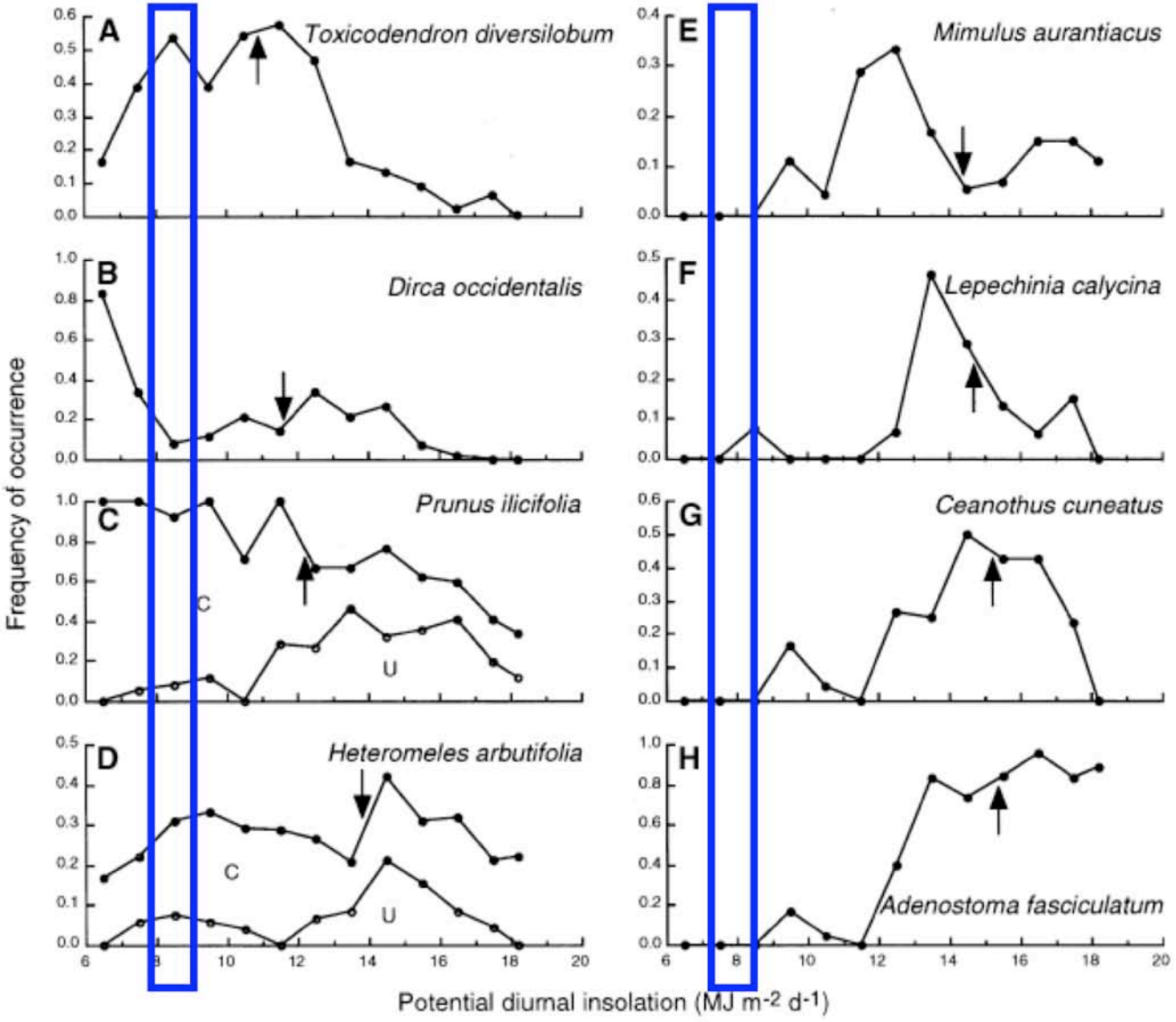
Distribution of shrubs along north-south insolation gradients

Jasper Ridge Biological Preserve, California



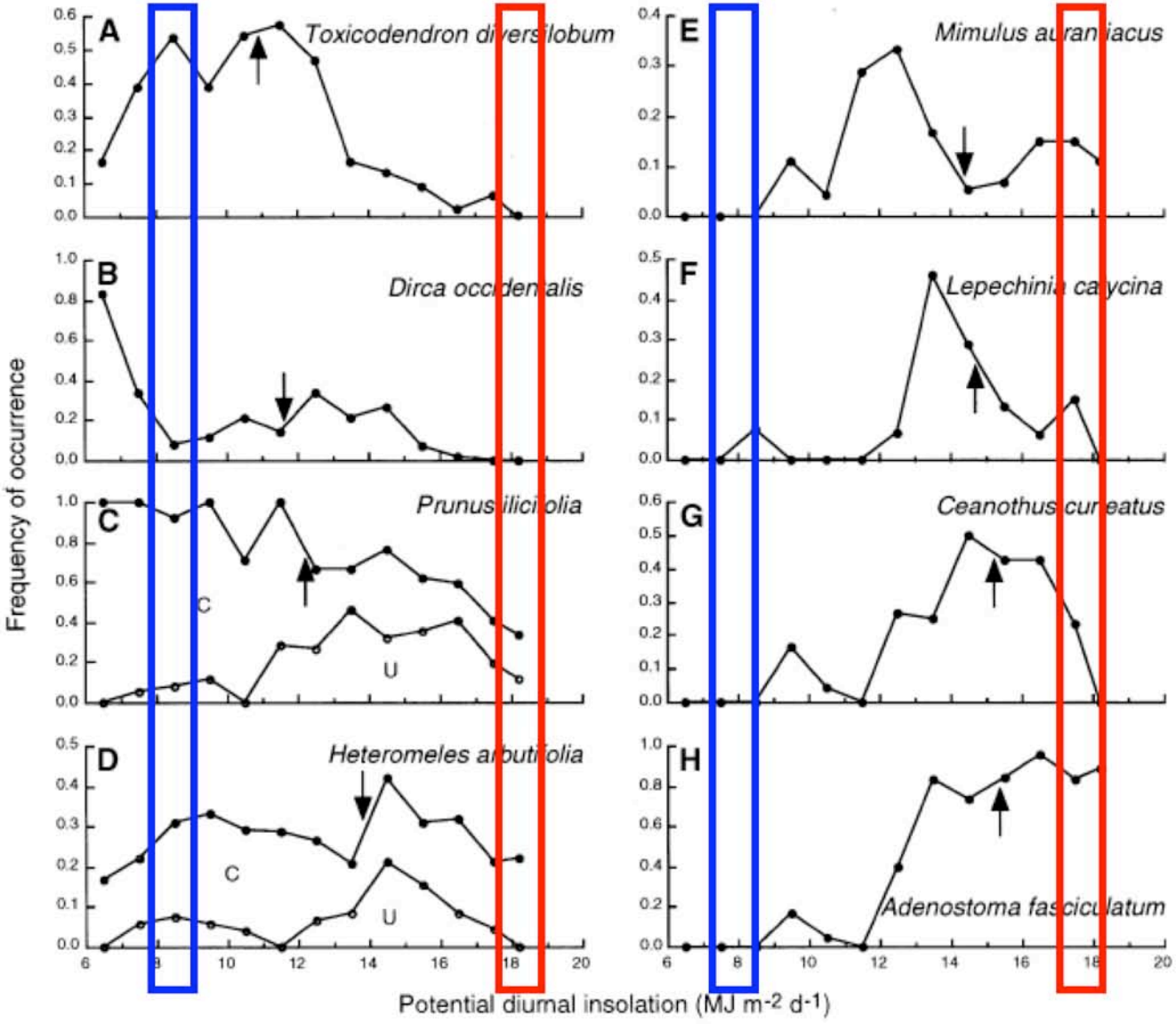
Distribution of shrubs along north-south insolation gradients

Jasper Ridge Biological Preserve, California

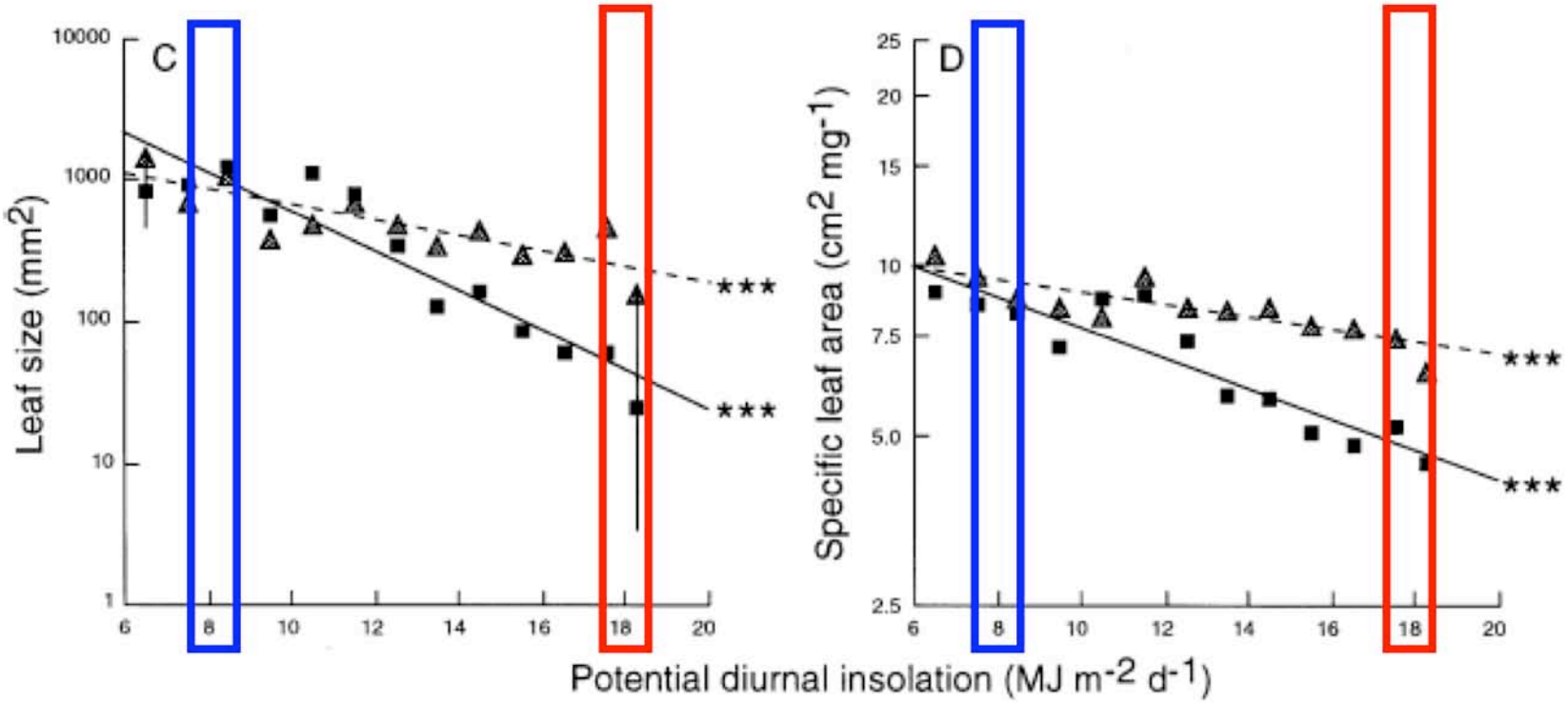


Distribution of shrubs along north-south insolation gradients

Jasper Ridge Biological Preserve, California



Leaf size and SLA of chaparral communities, along N-S topographic gradient



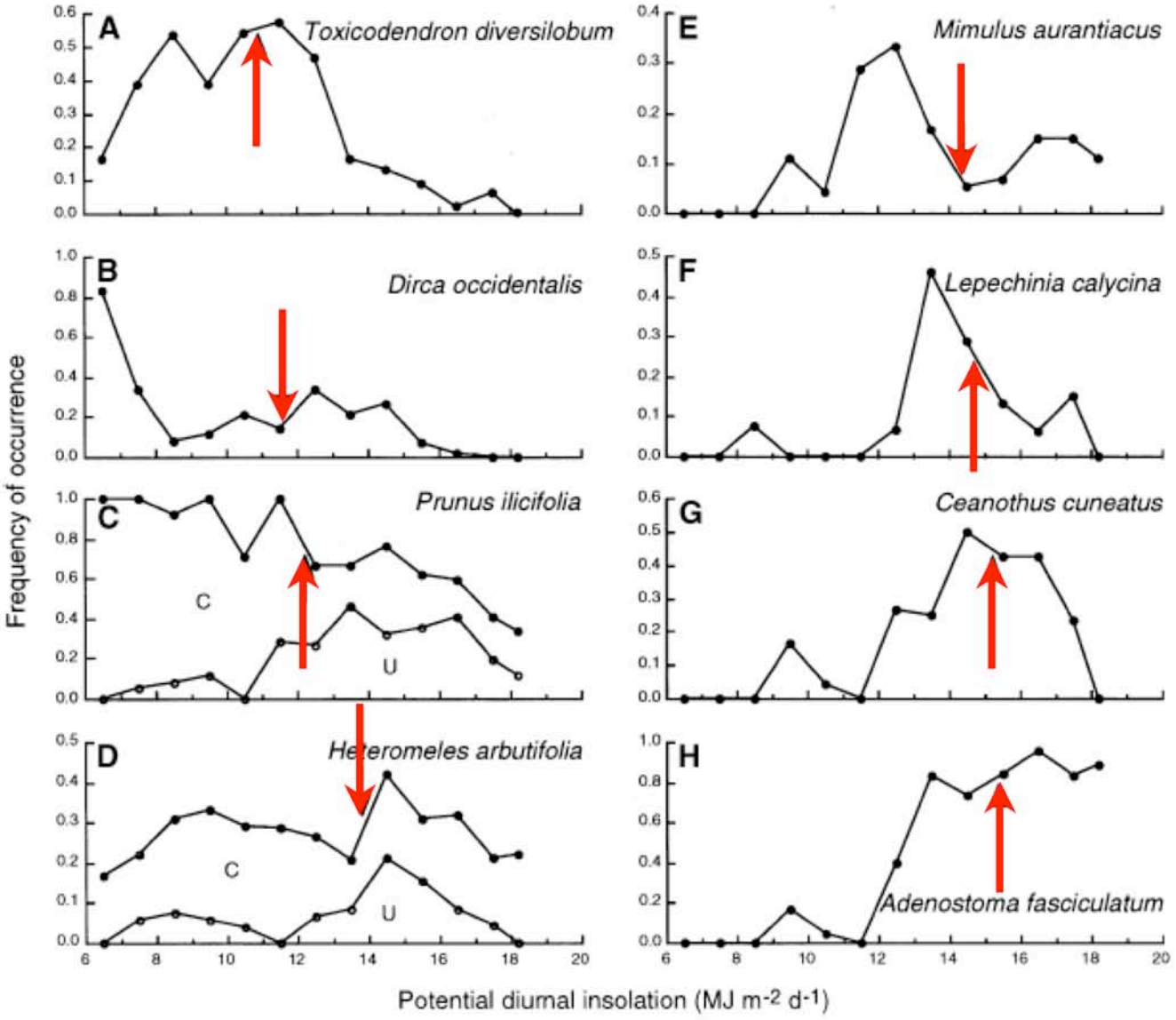
triangles: presence-absence mean

squares: abundance-weighted mean

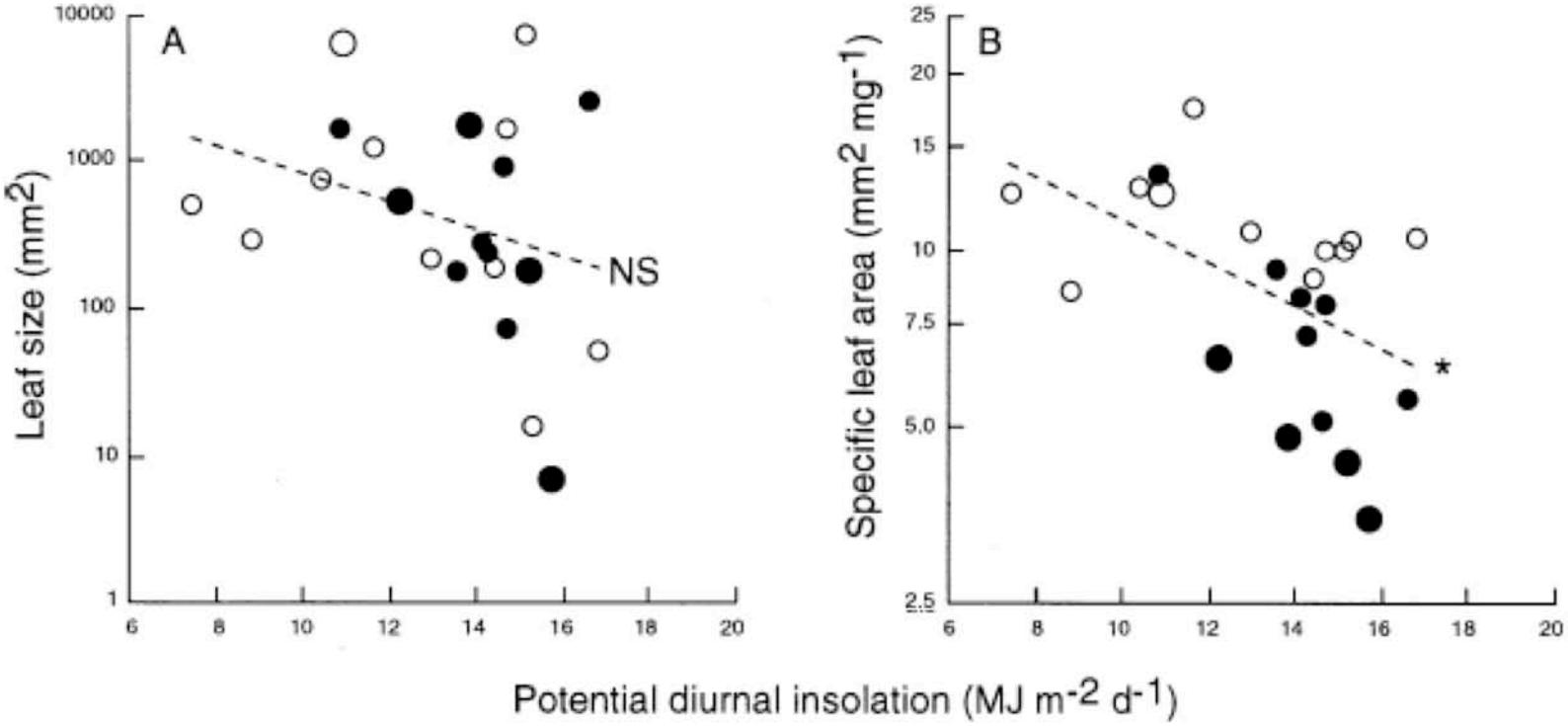
Ackerly et al. 2002 Oecologia

Distribution of shrubs along north-south insolation gradients

Jasper Ridge Biological Preserve, California

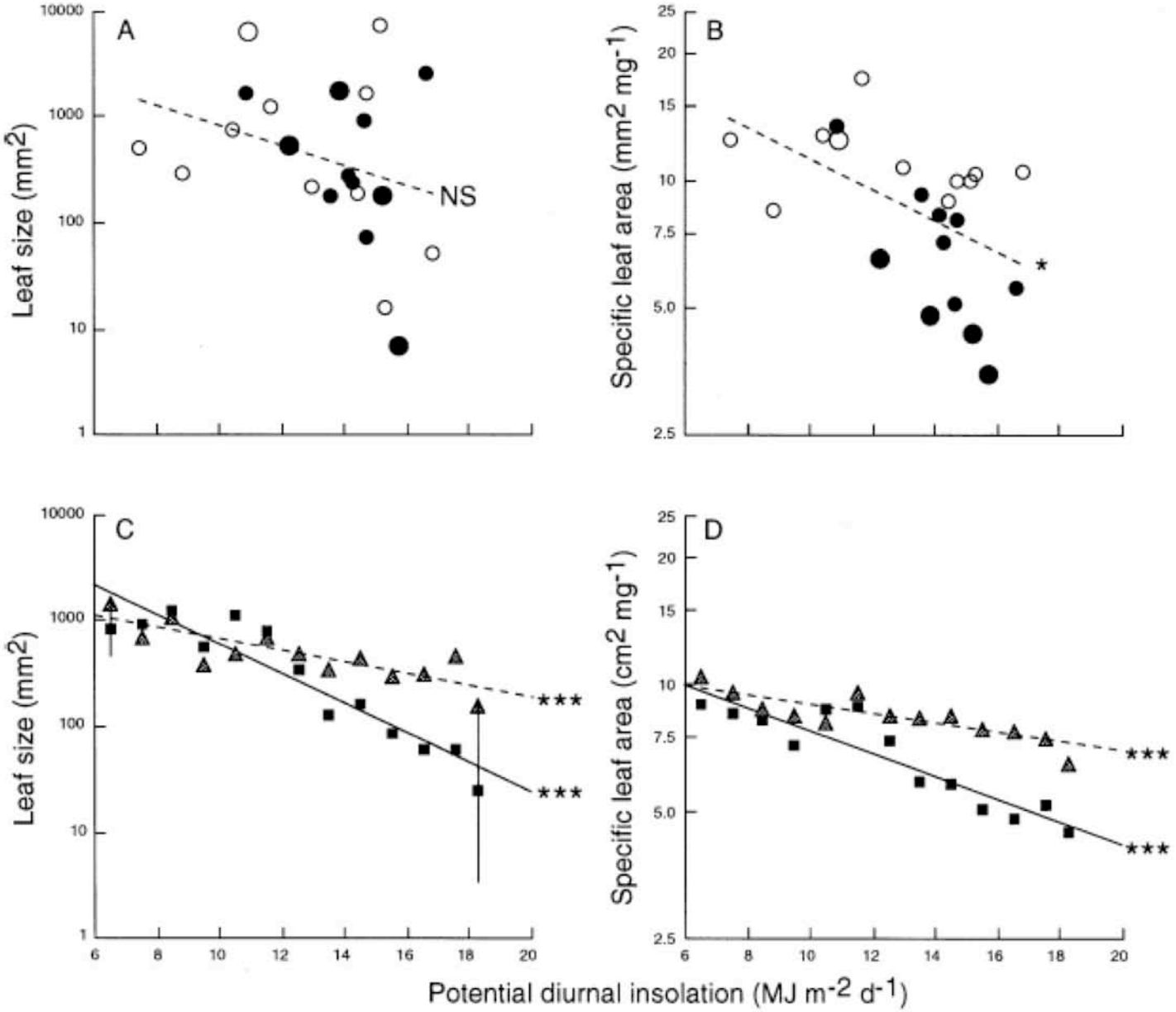


Leaf size and SLA of individual species vs. niche position along N-S topographic gradient

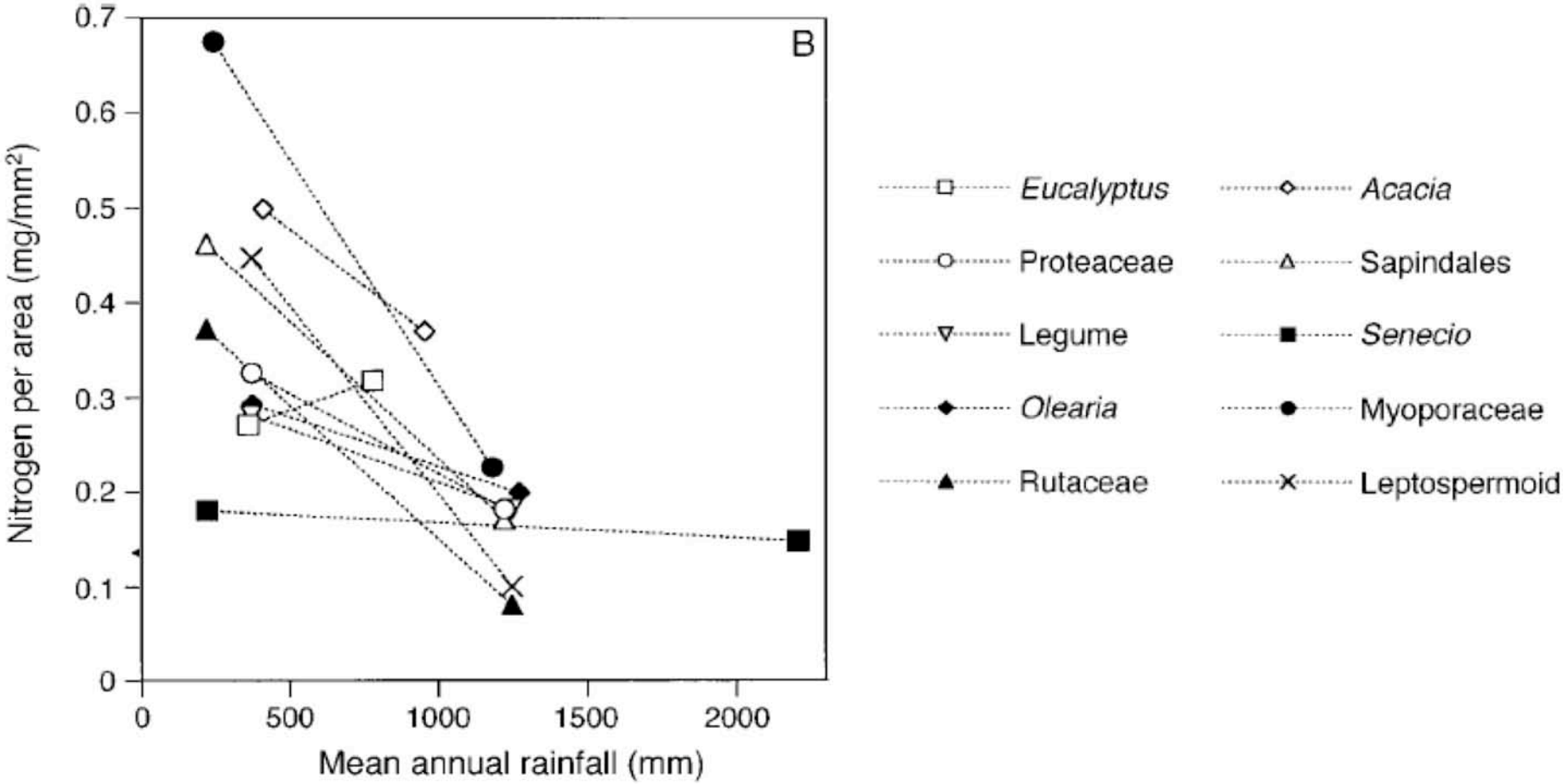


Ackerly et al. 2002 Oecologia

Traits vs. environments at species vs. community levels

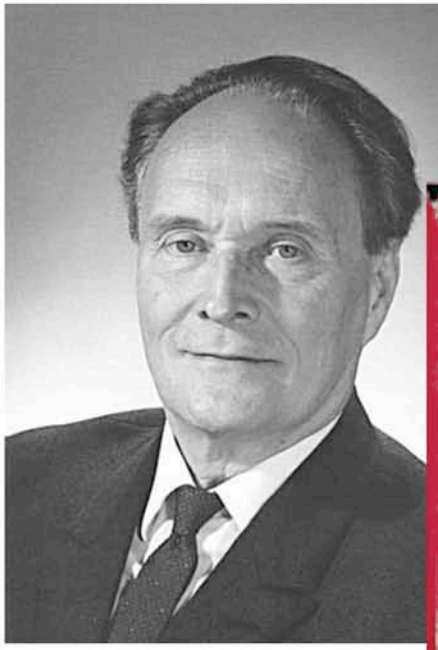


Leaf nitrogen per area in 10 evolutionary divergences across precipitation gradients (E. Australia)

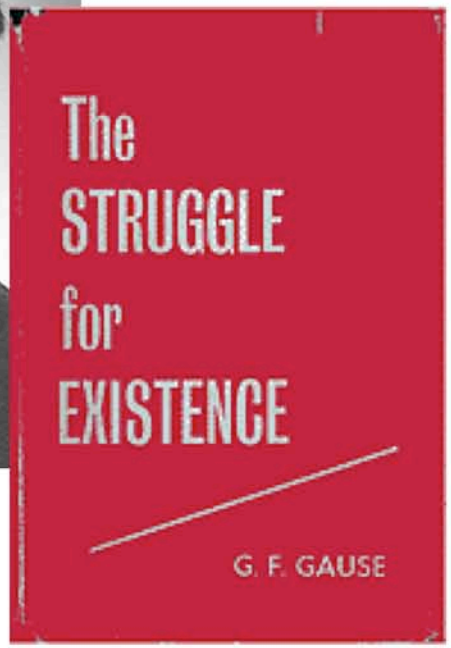


Cunningham et al. 1999 Ecol. Monogr.

“Why has one species been victorious over another in the great battle of life?”

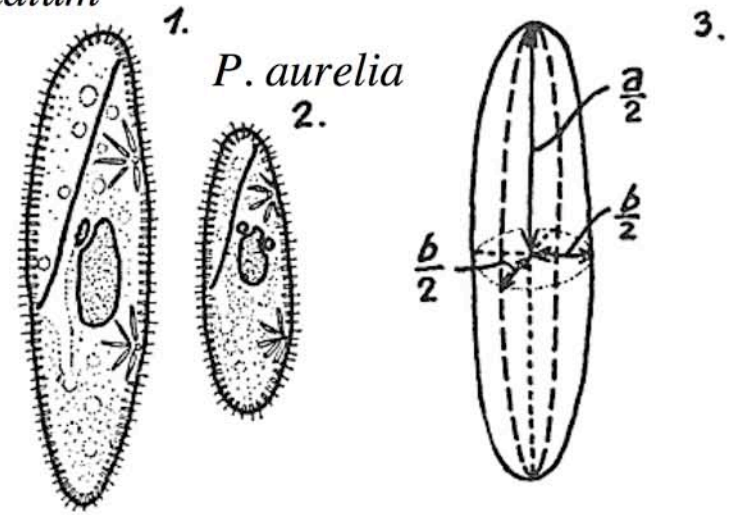


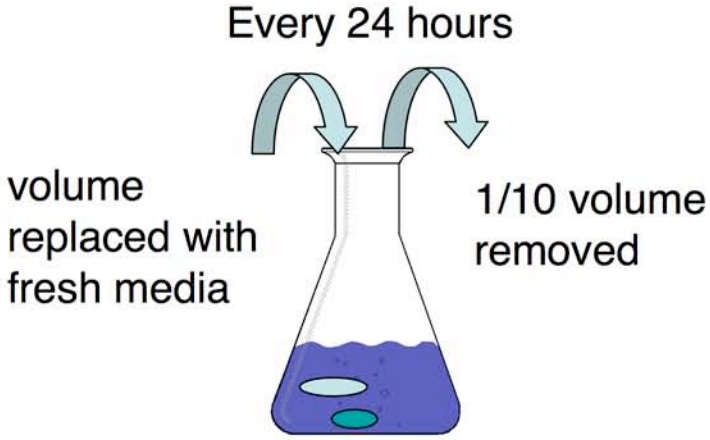
G. F. Gause



First edition 1934

Paramecium caudatum



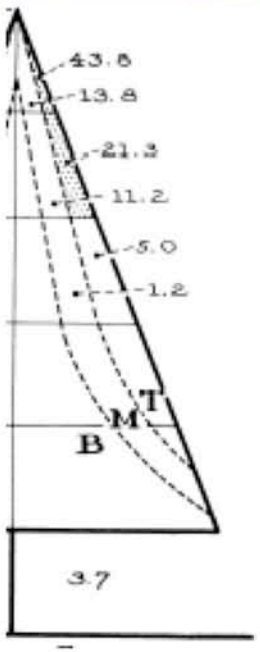


http://www.ggause.com/Contgau.htm

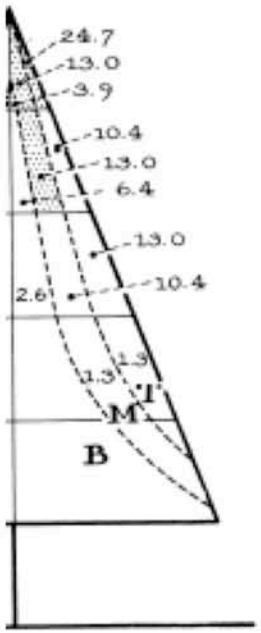
Ecology of wood warblers

R.H. MacArthur 1958 Ecology 39: 599

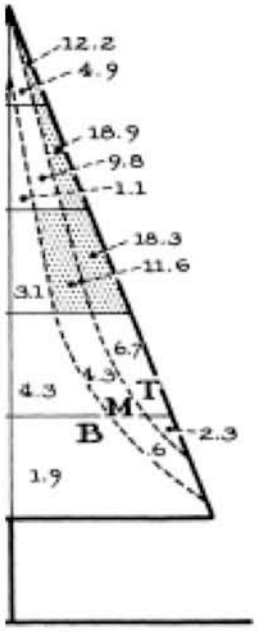
male Blackburnian Warbler by Larry McQueen 1999



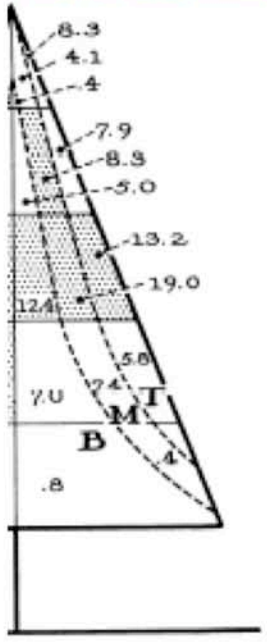
Cape May



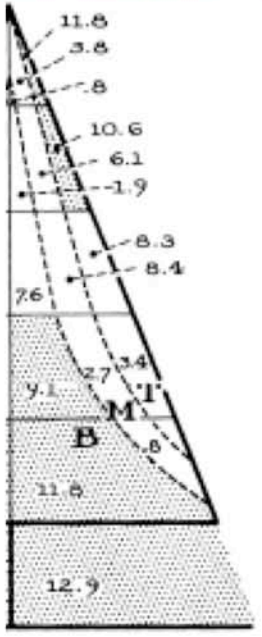
Blackburnian



Black-throated green



Bay-breasted



Myrtle

Images from: http://birdsource.cornell.edu/warblers/idguide.html

Limiting similarity among coexisting species

(MacArthur & Levins 1967)

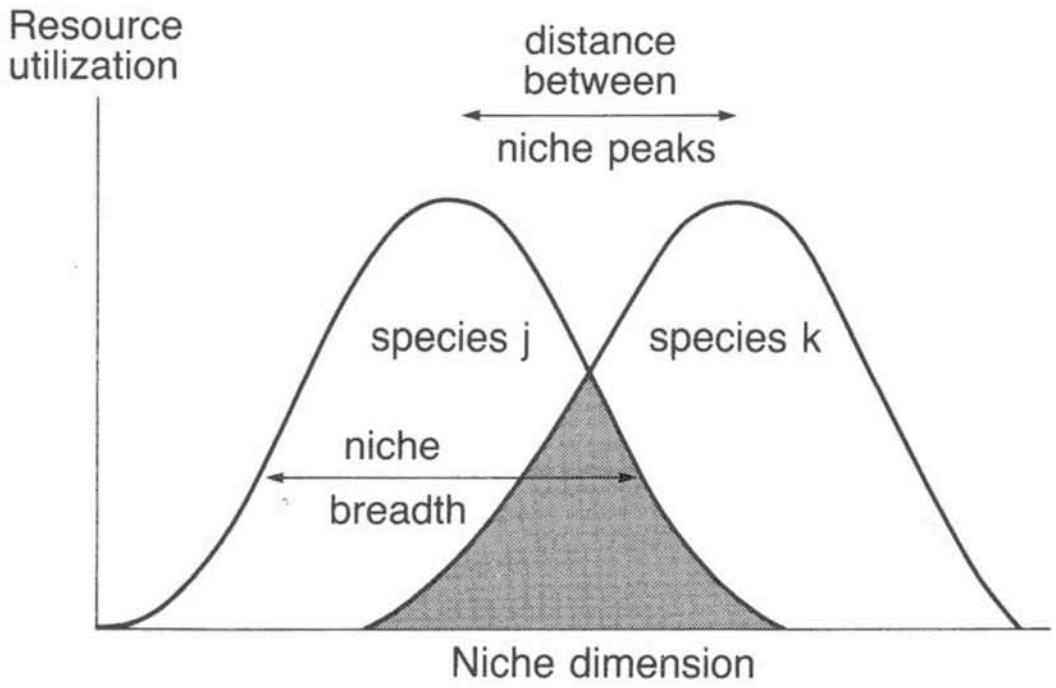
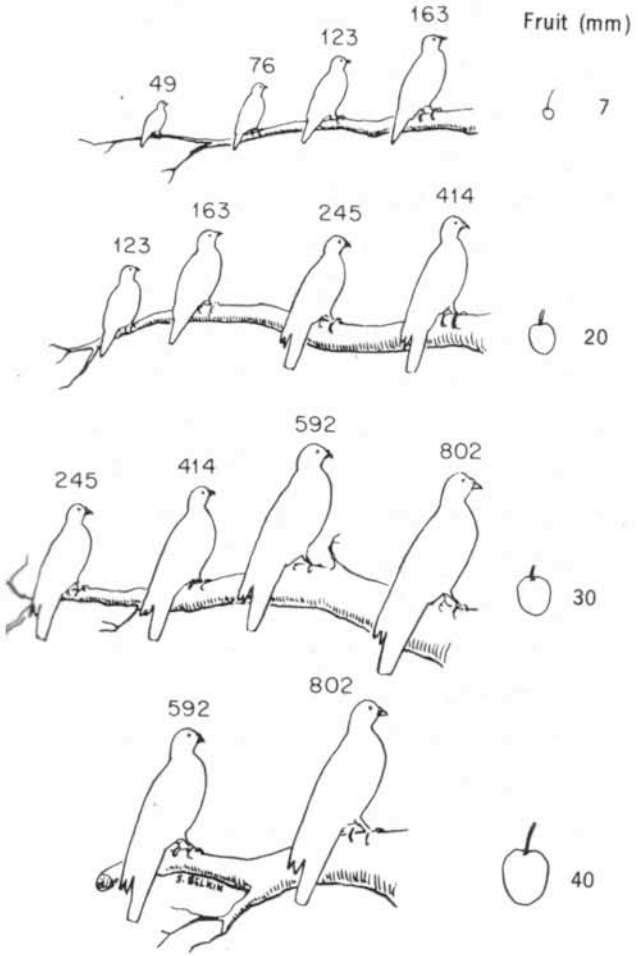
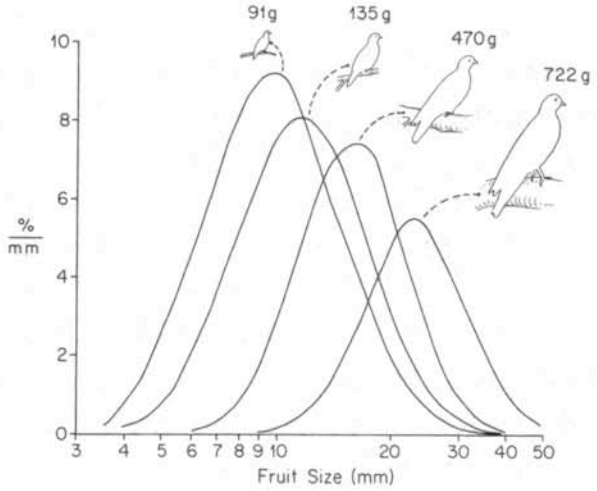


Figure 35–2
Activity curves of two species along a single resource dimension showing niche breadth, the distance between the centers of the niches, and niche overlap.

Body size ratios: the '1.3 rule'

(Hutchinson, 1959)





hypothesized patterns:

1) minimum size ratios
2) constant size ratios across an entire assemblage
3) large ratios on islands due to intense competition

Diamond 1975

Limits to similarity among coexisting competitors

Nature, 270: 660-661, 1977

from Henry S. Horn and Robert M. May

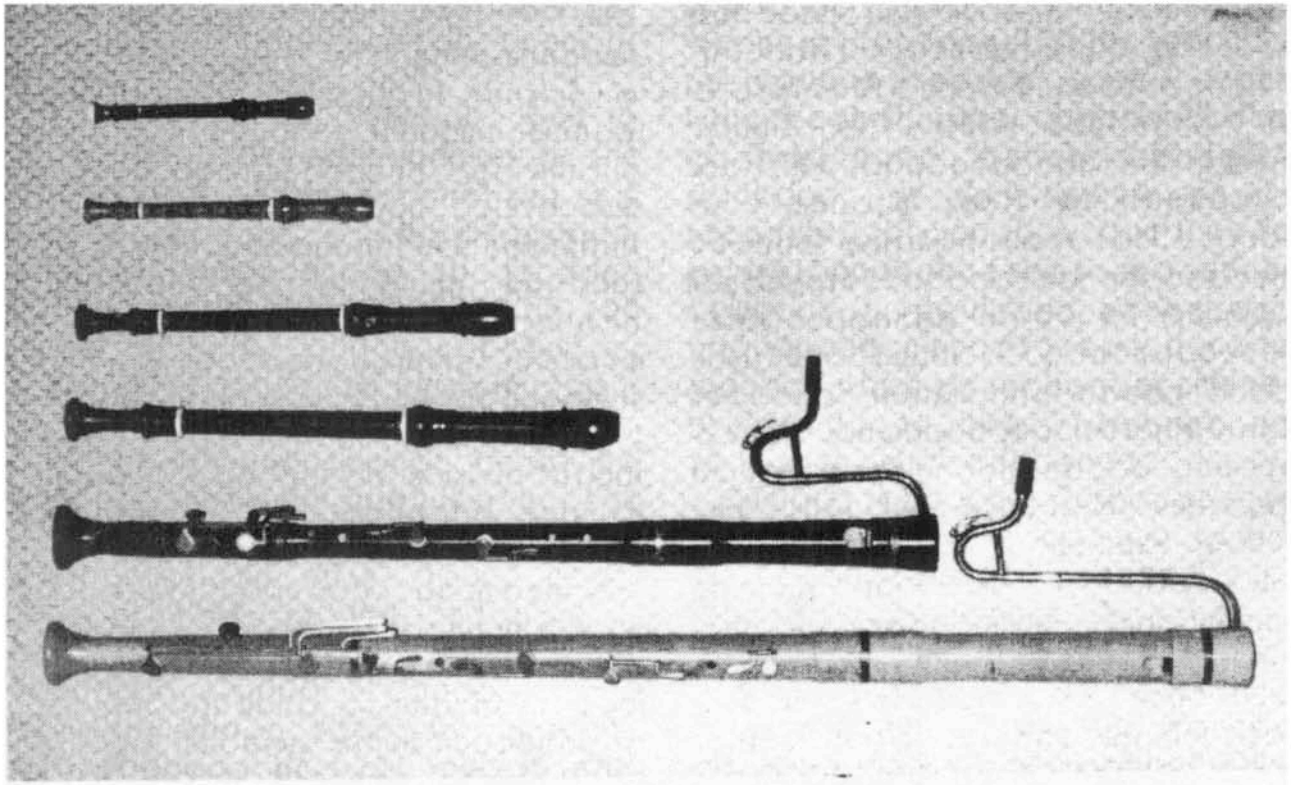


Fig. 1 The conventional ensemble of recorders, whose lengths roughly obey the '1 : 3 ratio rule'.

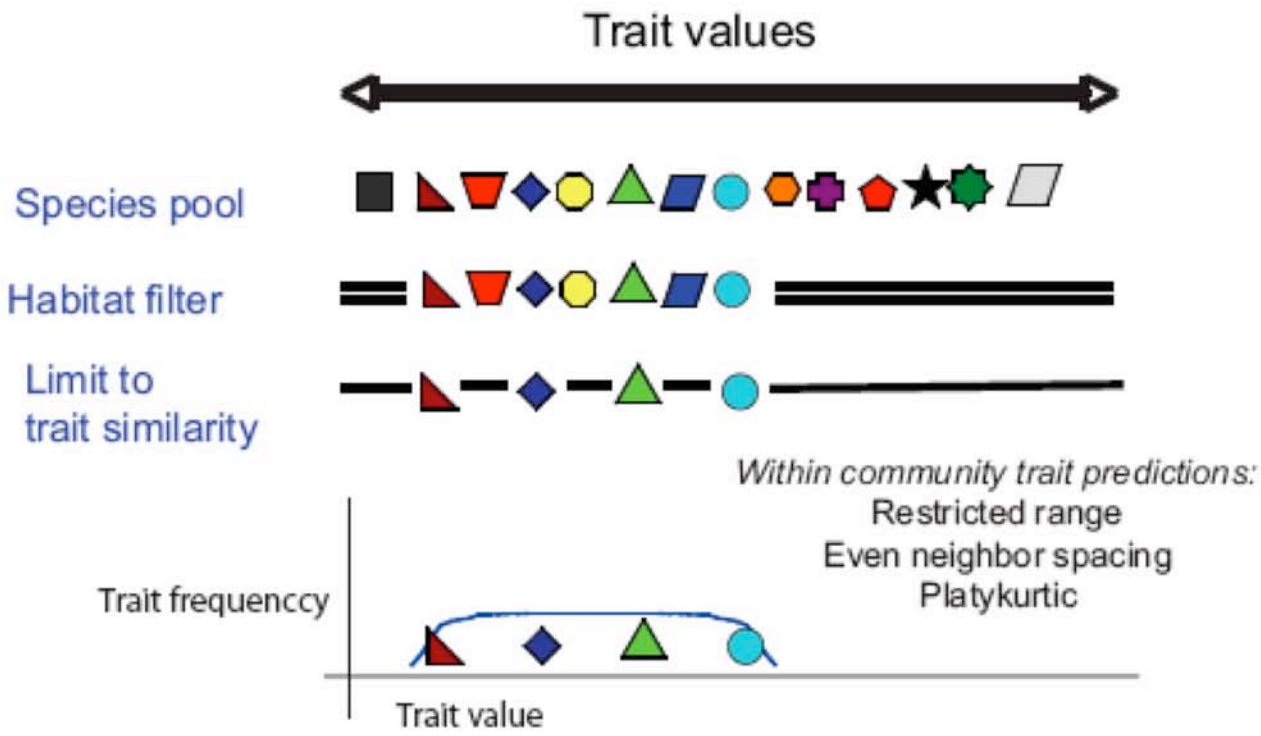
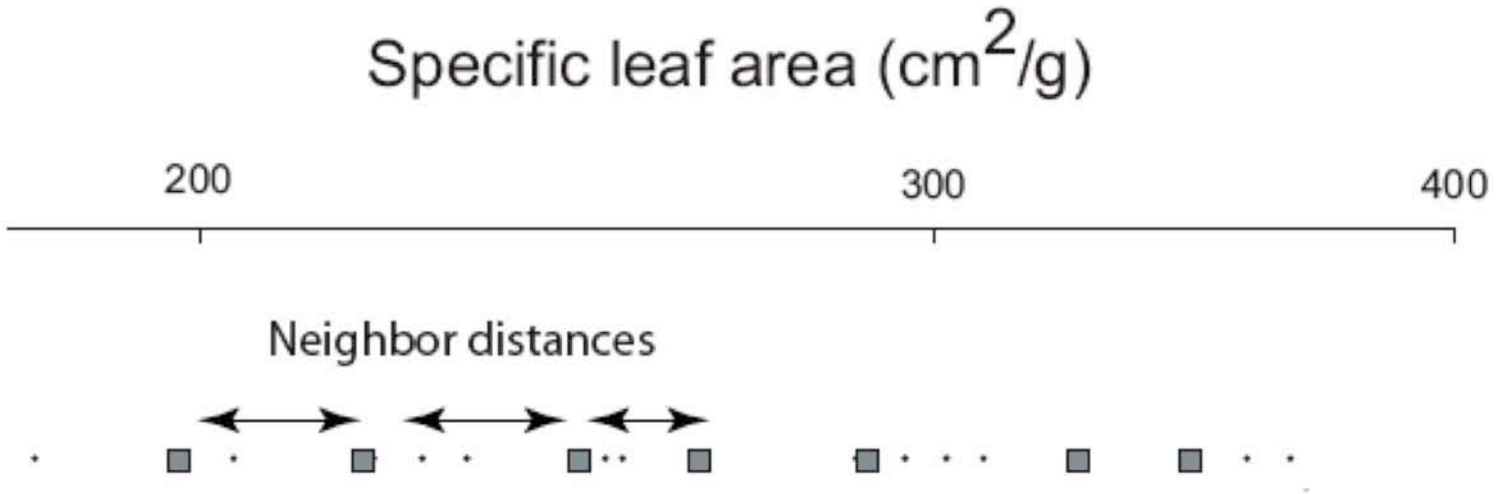


Figure 1: A hypothesis for assembly effects on within community trait distribution (following Diaz et al., 1998; Weiher et al., 1998). The strength of the habitat filter and limiting similarity is expected to depend on the identity of the trait in combination with the particular abiotic conditions at a site. Note that the variance of trait values is affected by both processes.

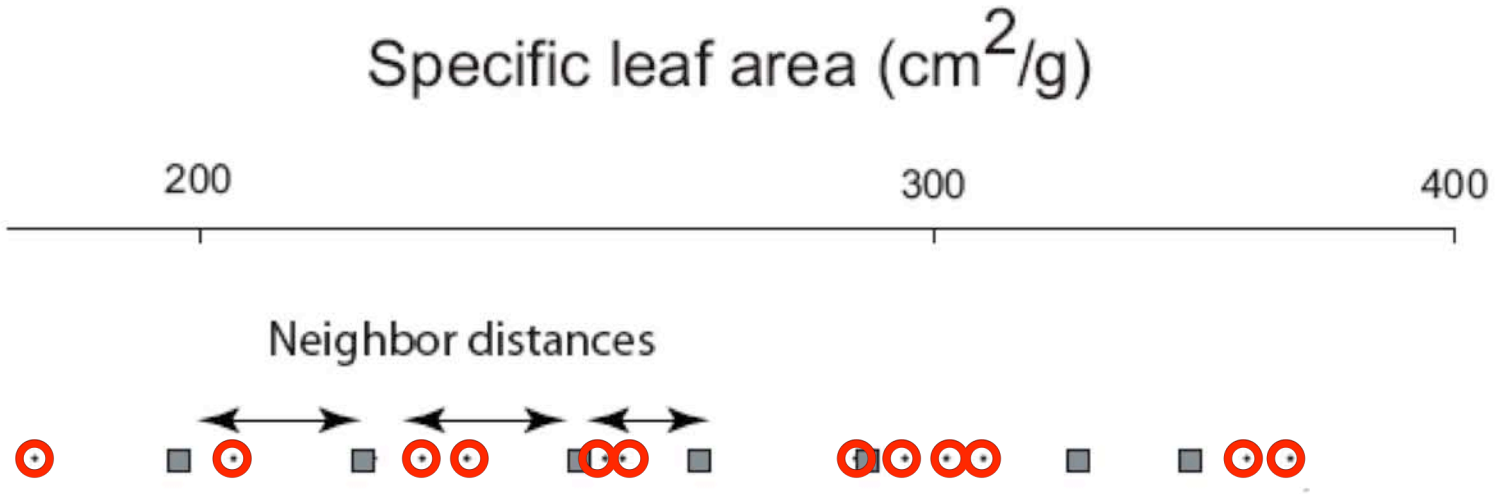
Cornwell and Ackerly, in revision



even spacing = low standard deviation of neighbor distances

squares: species present in community

Cornwell and Ackerly, in revision

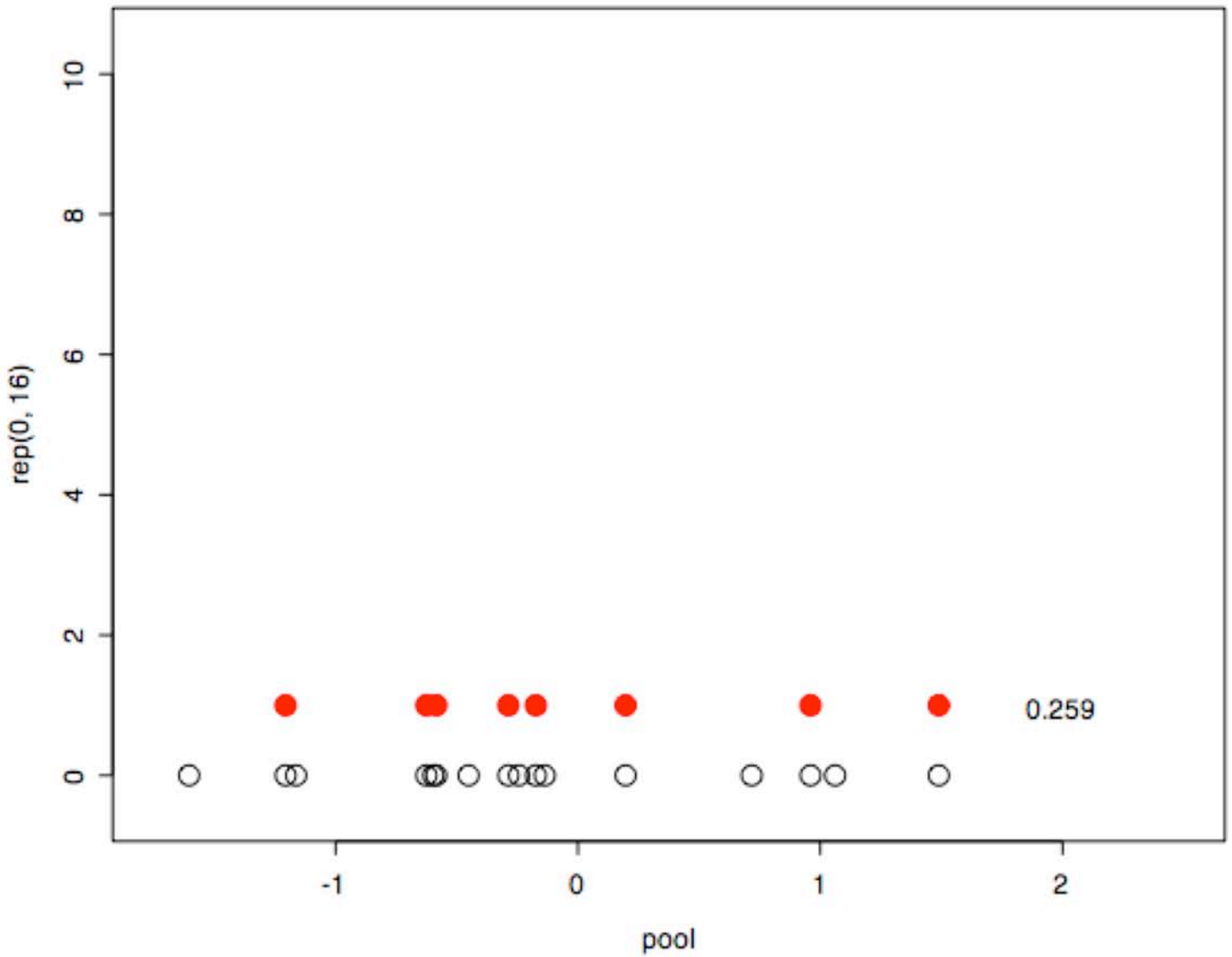


even spacing = low standard deviation of neighbor distances

squares: species present in community

red circles/dots: other species in local 'pool' that could be present in community

Cornwell and Ackerly, in revision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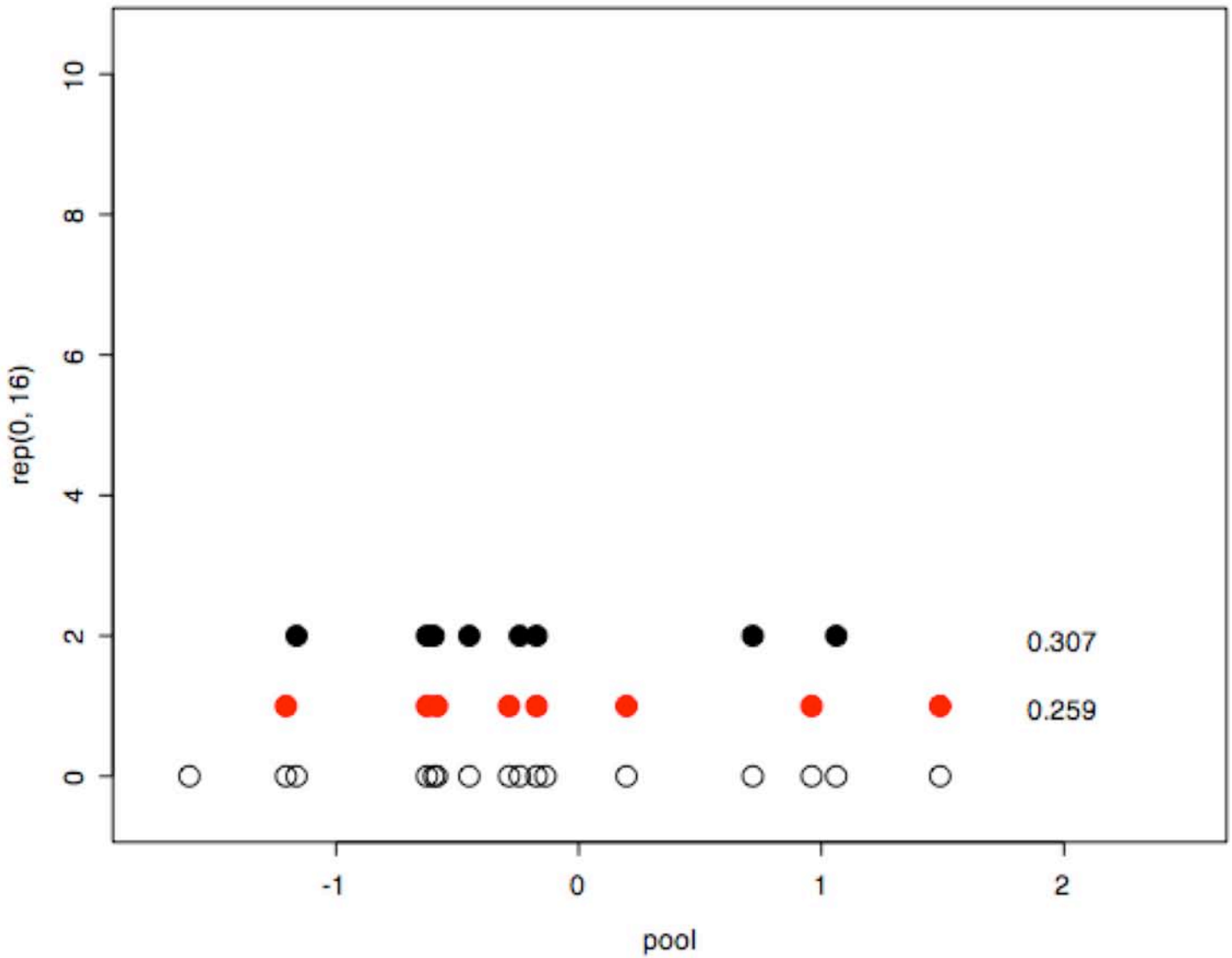
0
2
4
6
8
10
-1
0
1
2
pool
0.259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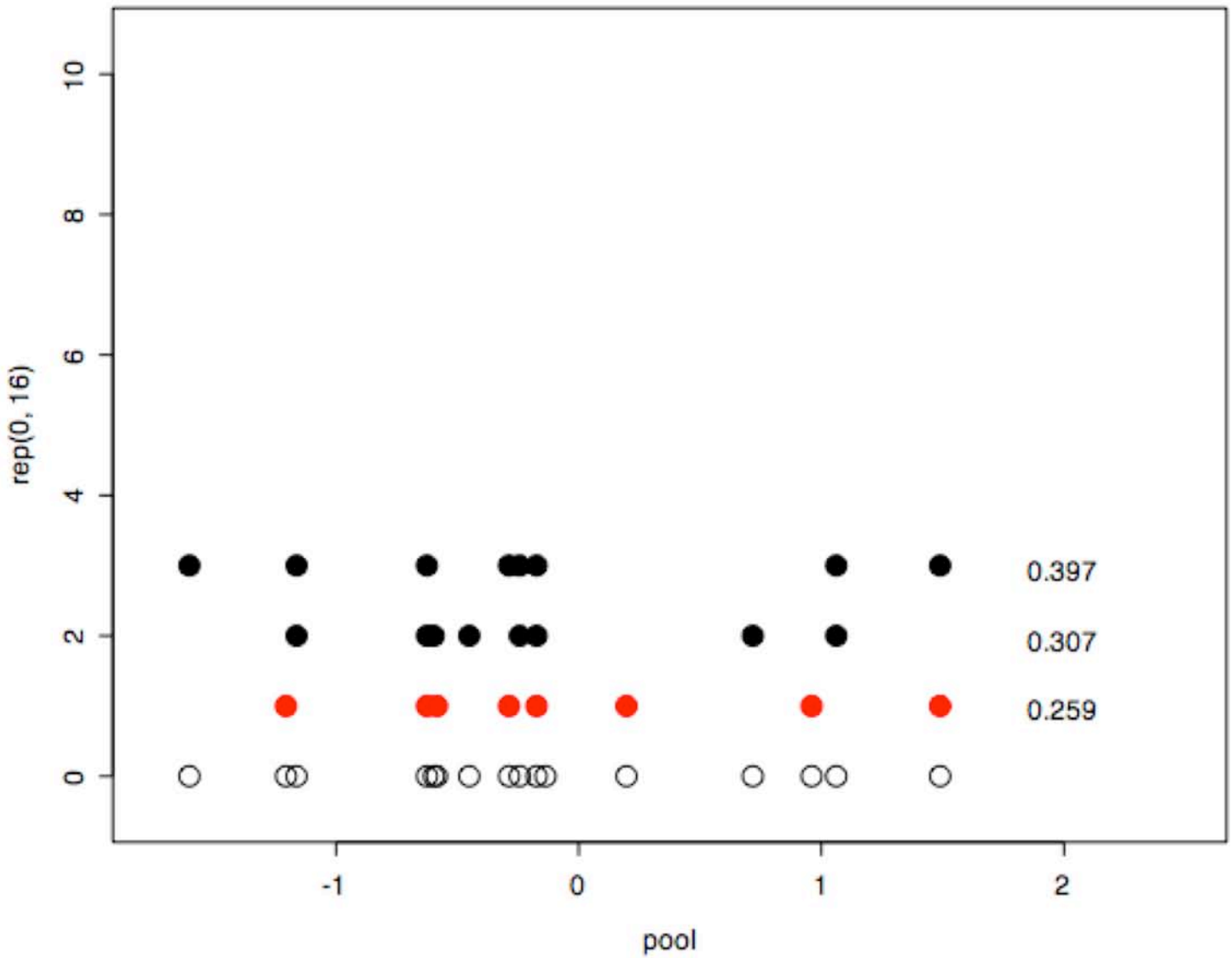
2
4
6
8
10
-1
0
1
2
pool
0.307
0.259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4
6
8
10
-1
0
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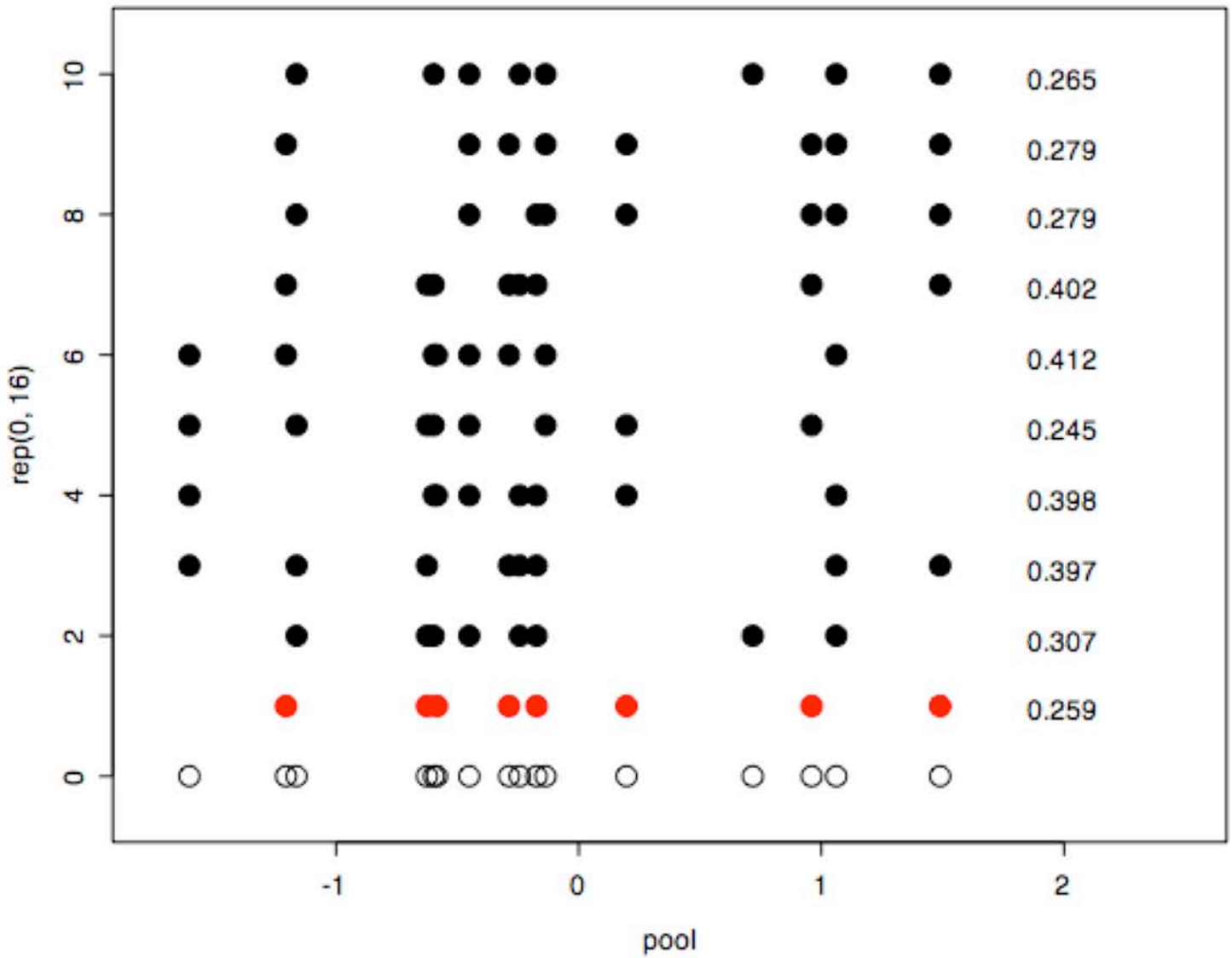
2
pool
0.397
0.307
0.259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2
4
6
8
10
-1
0
1
2
pool
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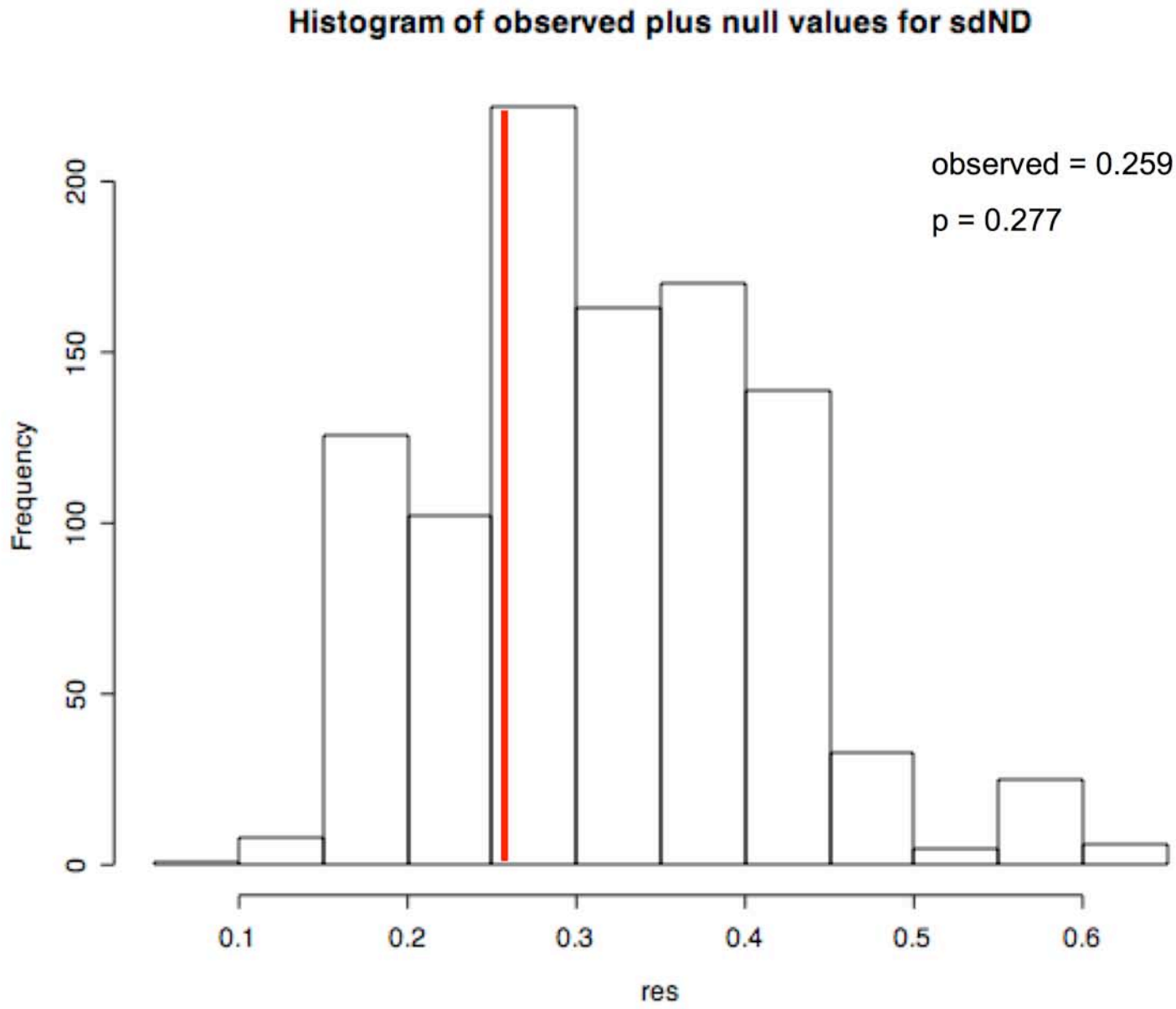
0.412
0.245
0.398
0.397
0.307
0.259

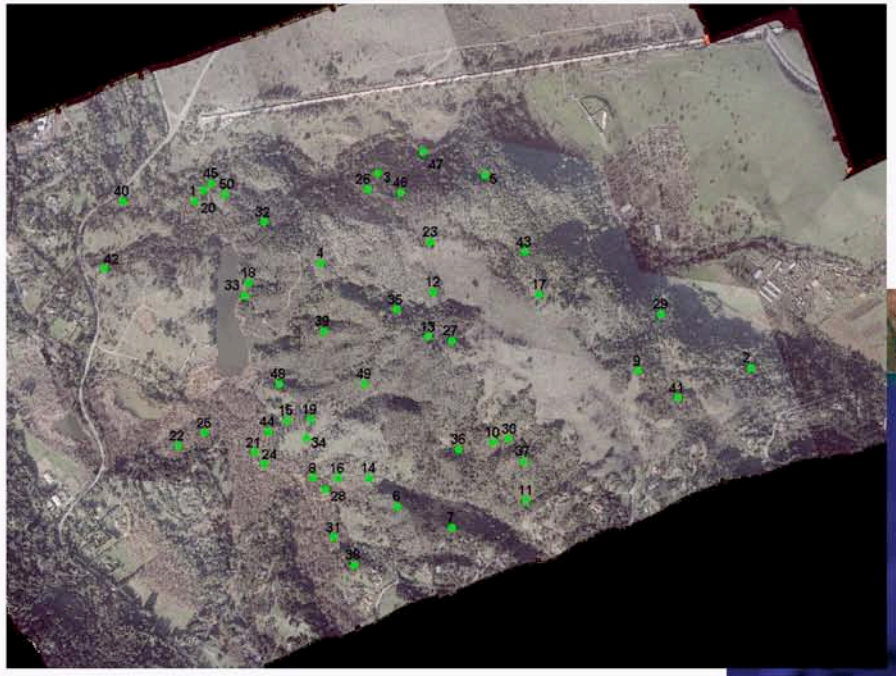

Histogram of observed plus null values for sdND
observed = 0.259
p = 0.277
Frequency
0
50
100
150
200
0.1
0.2
0.3
0.4
0.5
0.6
res

Cornwell data set: Woody plant species of coastal CA, across gradients in elevation and insolation

Sampling: 44 20 x 20 m plots randomly located across 5 vegetation types; relative abundance of all woody plants sampled

Species: 54 species total, 3-18 spp. per plot

Traits: 14 leaf, stem and root traits measured for (almost) all spp.; SLA and leaf size measured in situ in each plot



Will Cornwell, post-doc, Univ. British Columbia, wcornwell@gmail.com

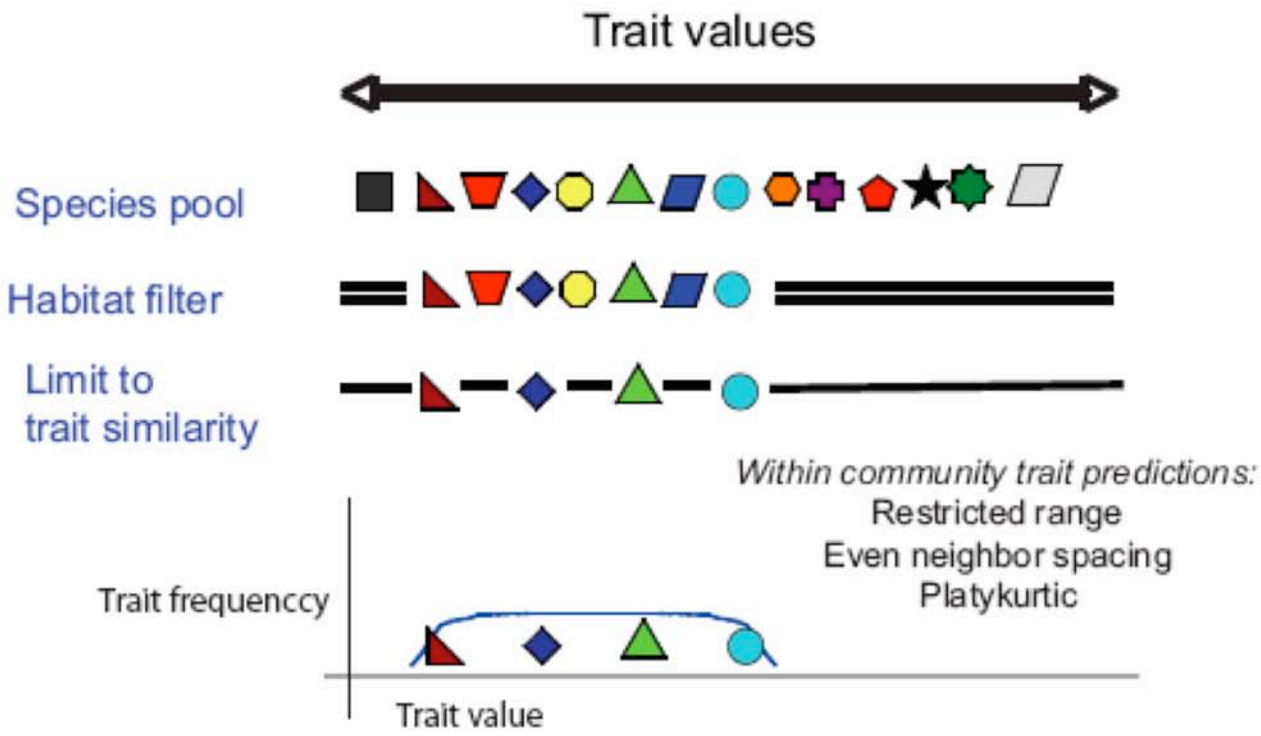
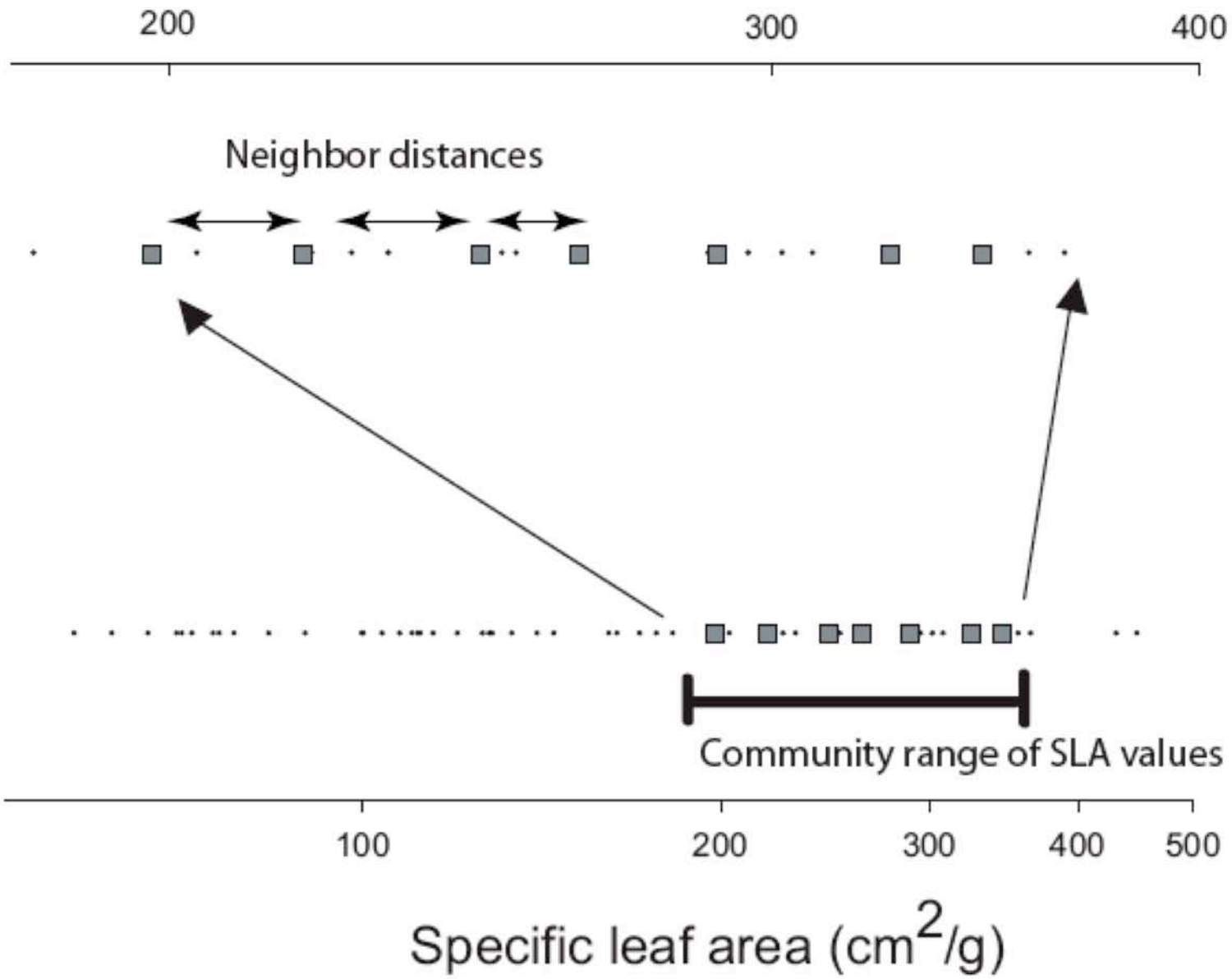


Figure 1: A hypothesis for assembly effects on within community trait distribution (following Diaz et al., 1998; Weiher et al., 1998). The strength of the habitat filter and limiting similarity is expected to depend on the identity of the trait in combination with the particular abiotic conditions at a site. Note that the variance of trait values is affected by both processes.

Cornwell and Ackerly, in revision

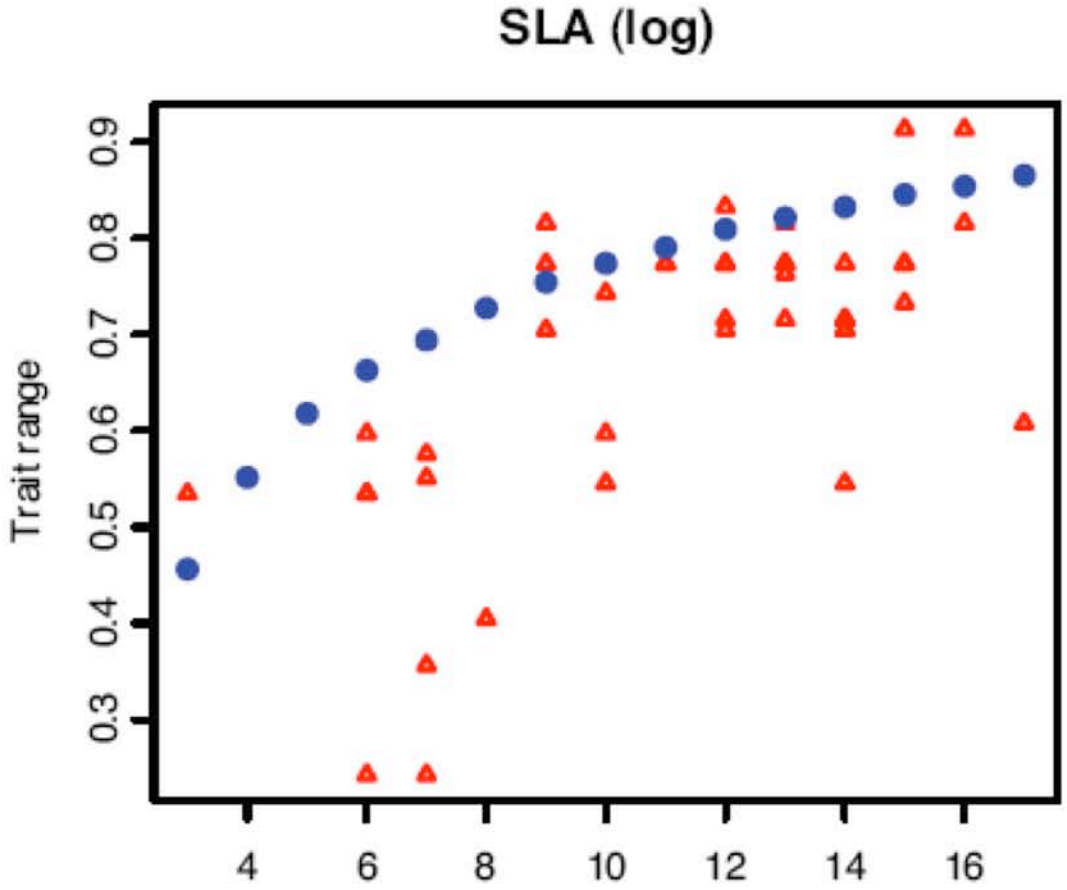


Cornwell and Ackerly, in revision

Test for restricted range

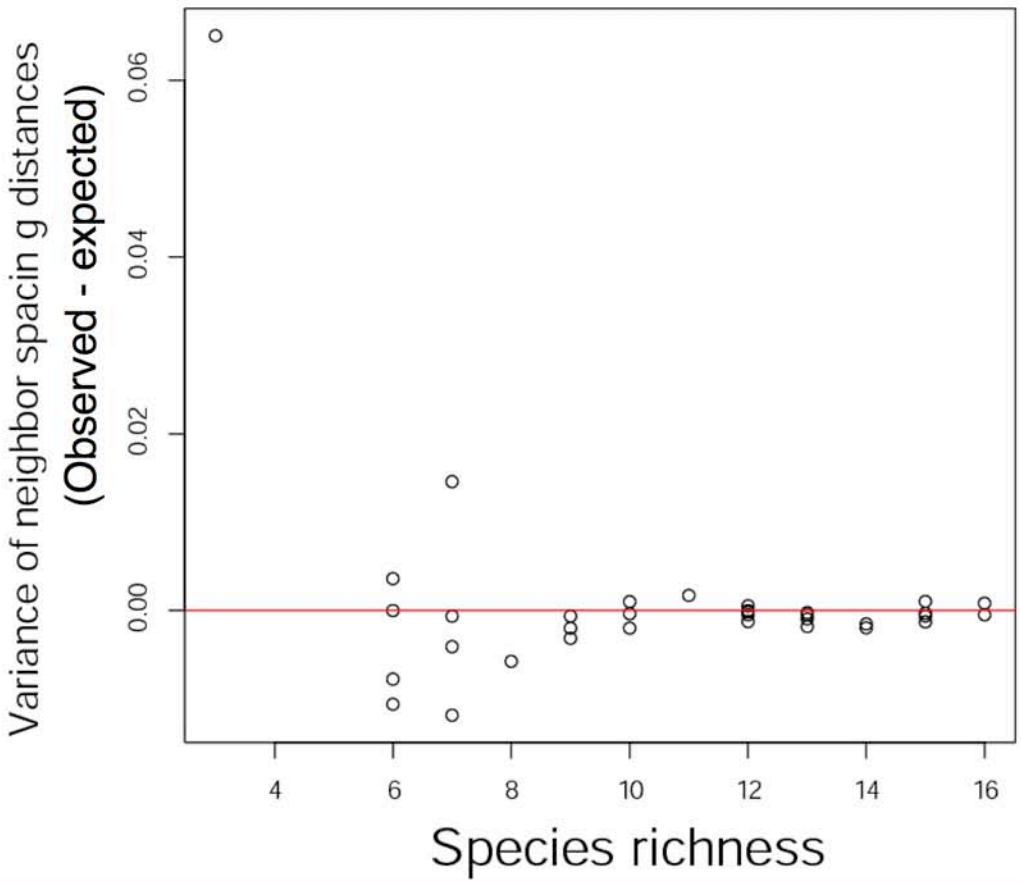
triangles: observed SLA range in each of 44 plots

circles: expected range based on 999 null communities of same diversity, drawn from full species pool



Cornwell and Ackerly, in revision

Even spacing in trait space—limiting similarity



Spacing more even than expected (P=0.02)

Tests for limiting similarity (Stubbs and Wilson 2004)

1,4) Mean nearest-neighbor distance (1: multivariate; 4: single characters) (+)

2) Min/Max link distance on minimum spanning tree (+)

3) Minimum nearest-neighbor distance (+)

5) Weighted deviance (+?)

6) Variance of NN dist/range (-)

7) Mean niche overlap (-)

8) Maximum overlap (-)

9) Weighted adjacent neighbor overlap (-)

10) Variance in adjacent neighbor overlap (-)

(for more, see Ricklefs and Travis 1980, Weiher et al. 1998)

Yasuní Forest Dynamics Plot, Ecuador

Western Amazonian terra firme forest

aseasonal, 2800mm annual rainfall

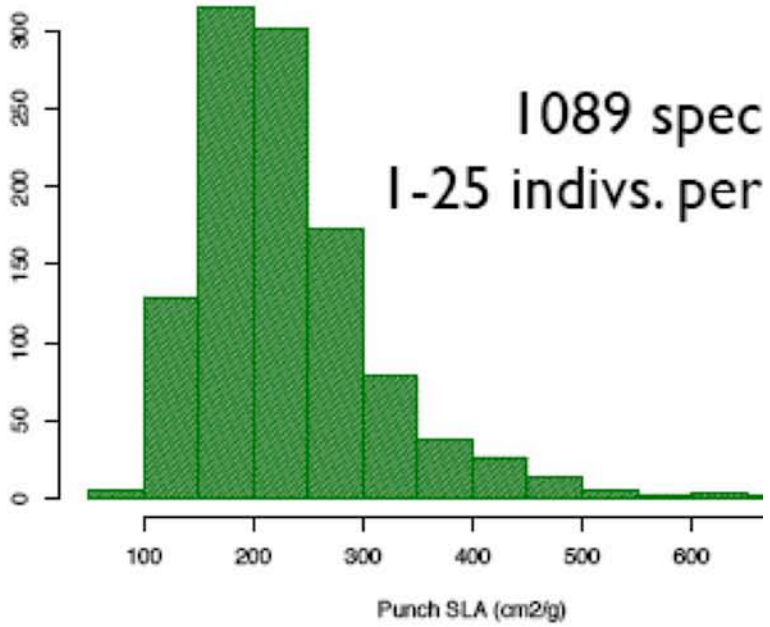
150,000+ stems over 1cm dbh

1,125 tree species in 25 hectares (Valencia et al. 2004)

How can so many species coexist?

Google Earth

Variation i
leaf traits



1089 spec
1-25 indivs. per

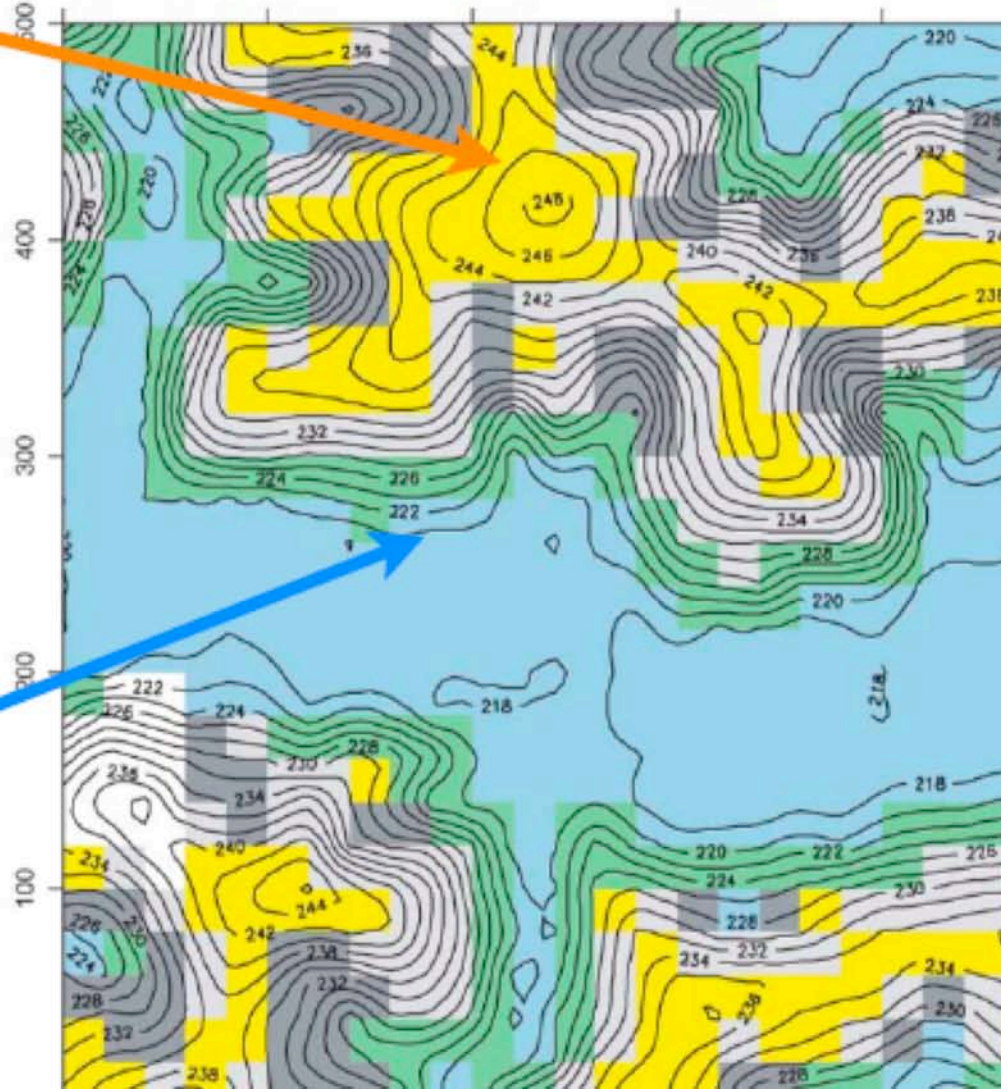
Nested ANOVA (SLA):

- **82%** of variation betwee
  species (13% indivs, 5% l

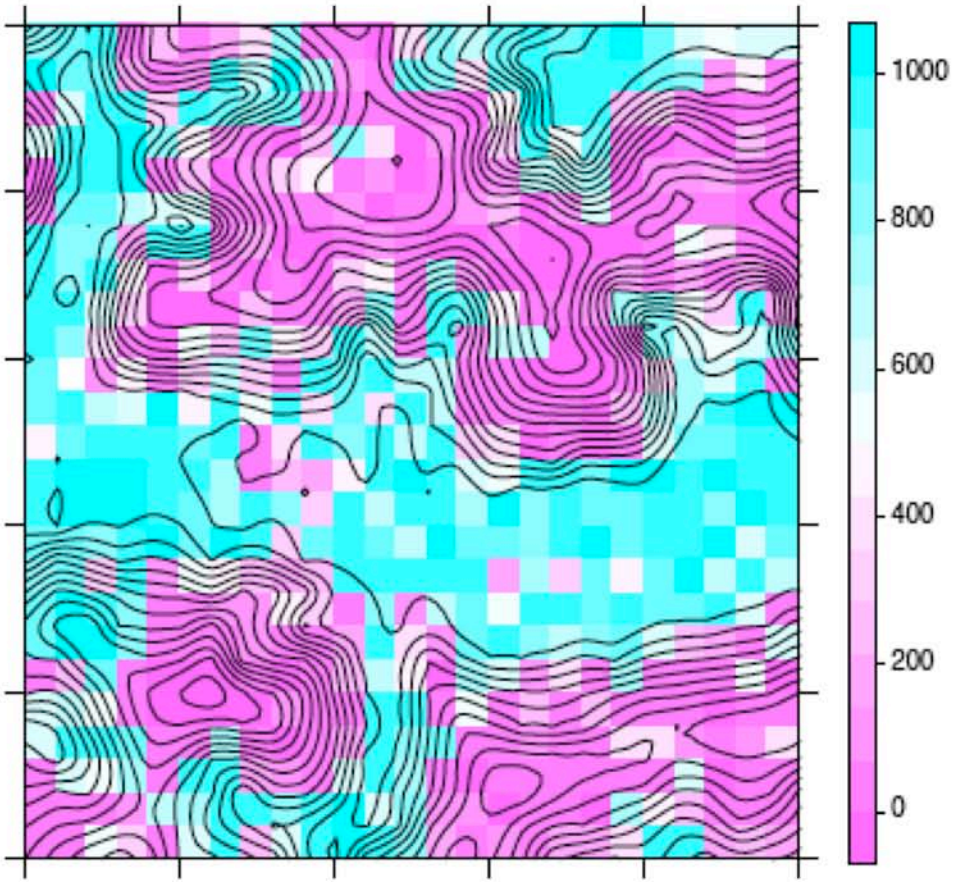
Ridgetops (N=106)

Valley Bottom (N=197)

Habitat types identified by sl
and elevation at 20 x 20 m s

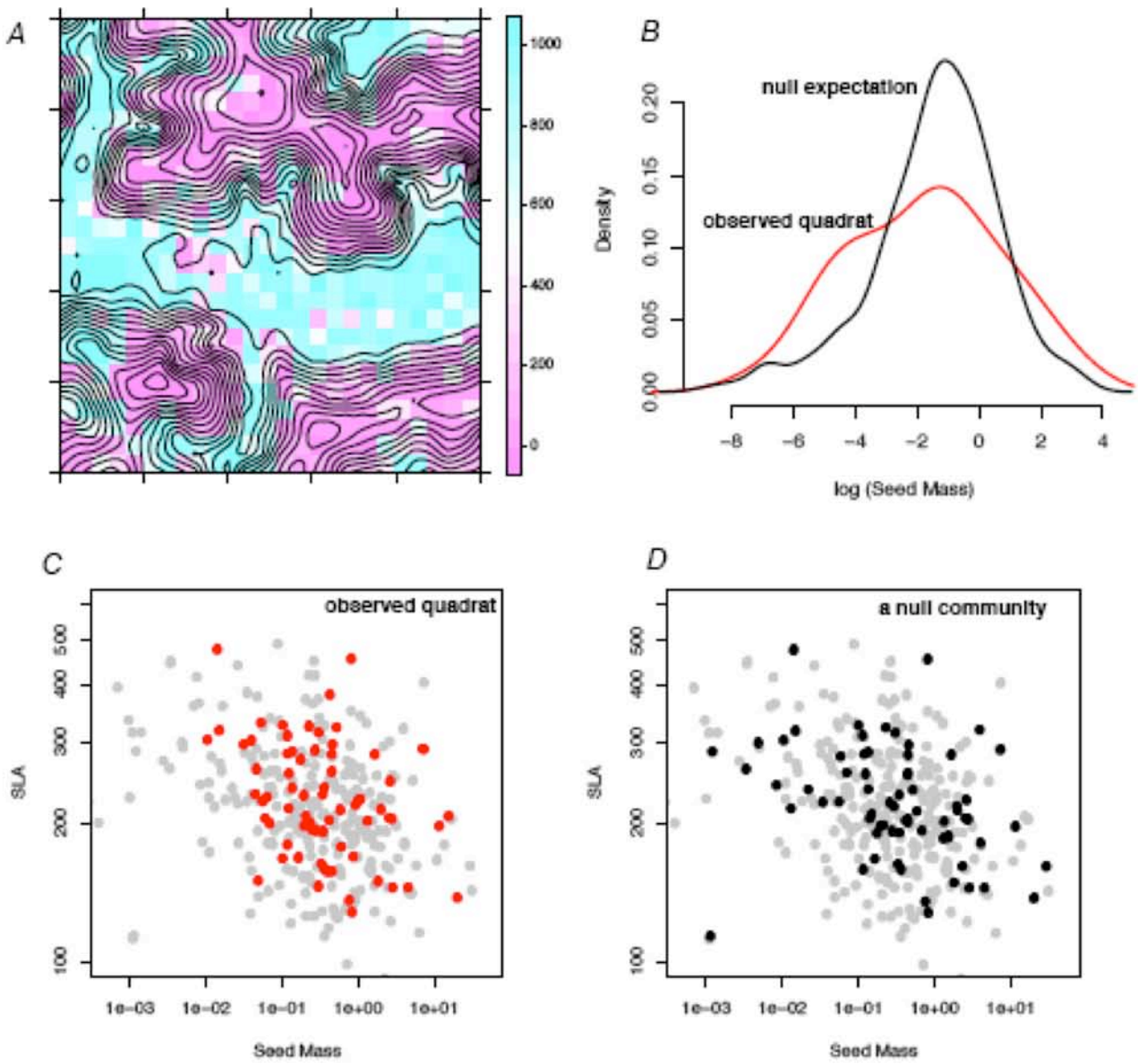


Species at Yasuni not distributed at random with respect to traits



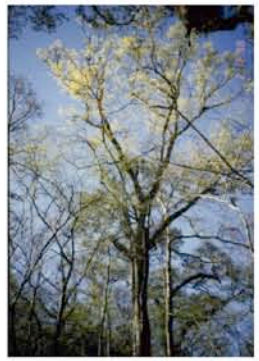
Mean SLA higher than expected

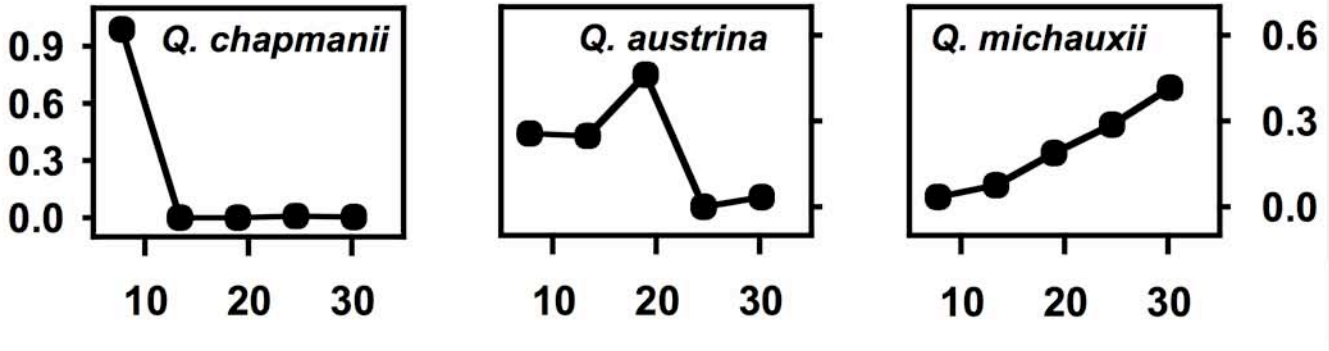
Mean SLA lower than expected


A
1000
800
600
400
200
0
B
null expectation
observed quadrat
Density
0.00
0.05
0.10
0.15
0.20
−8
−6
−4
−2
0
2
4
log (Seed Mass)
C
observed quadrat
SLA
100
200
300
400
500
1e−03
1e−02
1e−01
1e+00
1e+01
Seed Mass
D
a null community
SLA
100
200
300
400
500
1e−03
1e−02
1e−01
1e+00
1e+01
Seed Mass

Oaks of northern Florida

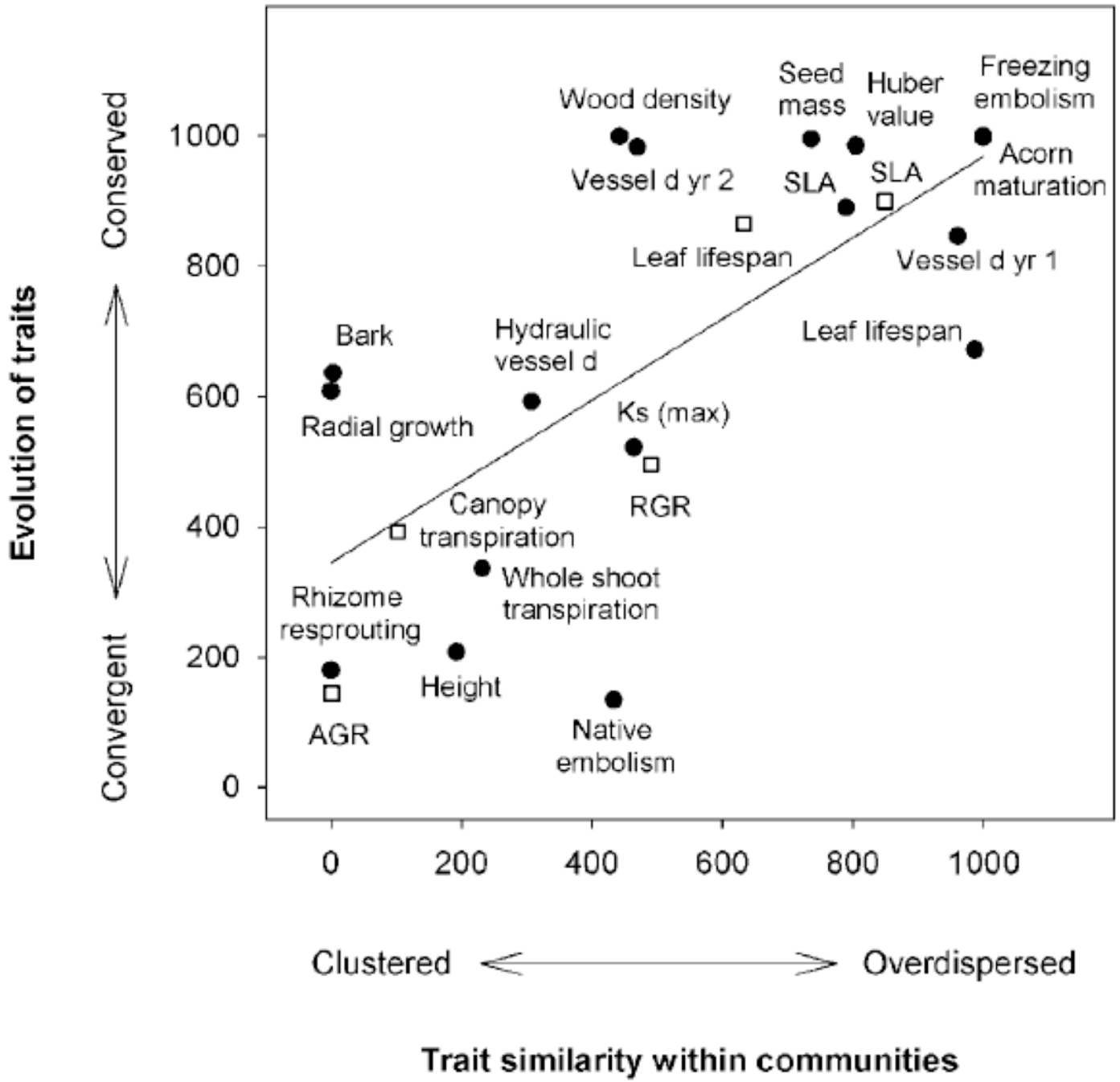
(J. Cavender-Bares et al.
2004a, Amer. Nat.;
2004b Ecol. Monogr.)





Soil Moisture

Traits
Communities
or Niches
Phenotypic clustering
Phenotypic overdispersion


Evolution of traits
Conserved
Convergent
1000
800
600
400
200
0
Wood density
Seed mass
Huber value
Freezing embolism
Vessel d yr 2
SLA
SLA
Acorn maturation
Leaf lifespan
Vessel d yr 1
Bark
Hydraulic vessel d
Leaf lifespan
Radial growth
Ks (max)
RGR
Canopy transpiration
Whole shoot transpiration
Rhizome resprouting
Height
AGR
Native embolism
0
200
400
600
800
1000
Clustered
Overdispersed
Trait similarity within communities

Synthesis of ‘convergence’ and ‘limiting similarity’ perspectives

- Individual traits can show both a limited range of values, and even spacing within that range
- One set of traits exhibits convergence and another exhibits even spacing