Biodiversity and Ecosystem Services

Fabrice DeClerck

March 24, 2015, - ARCAD


npr

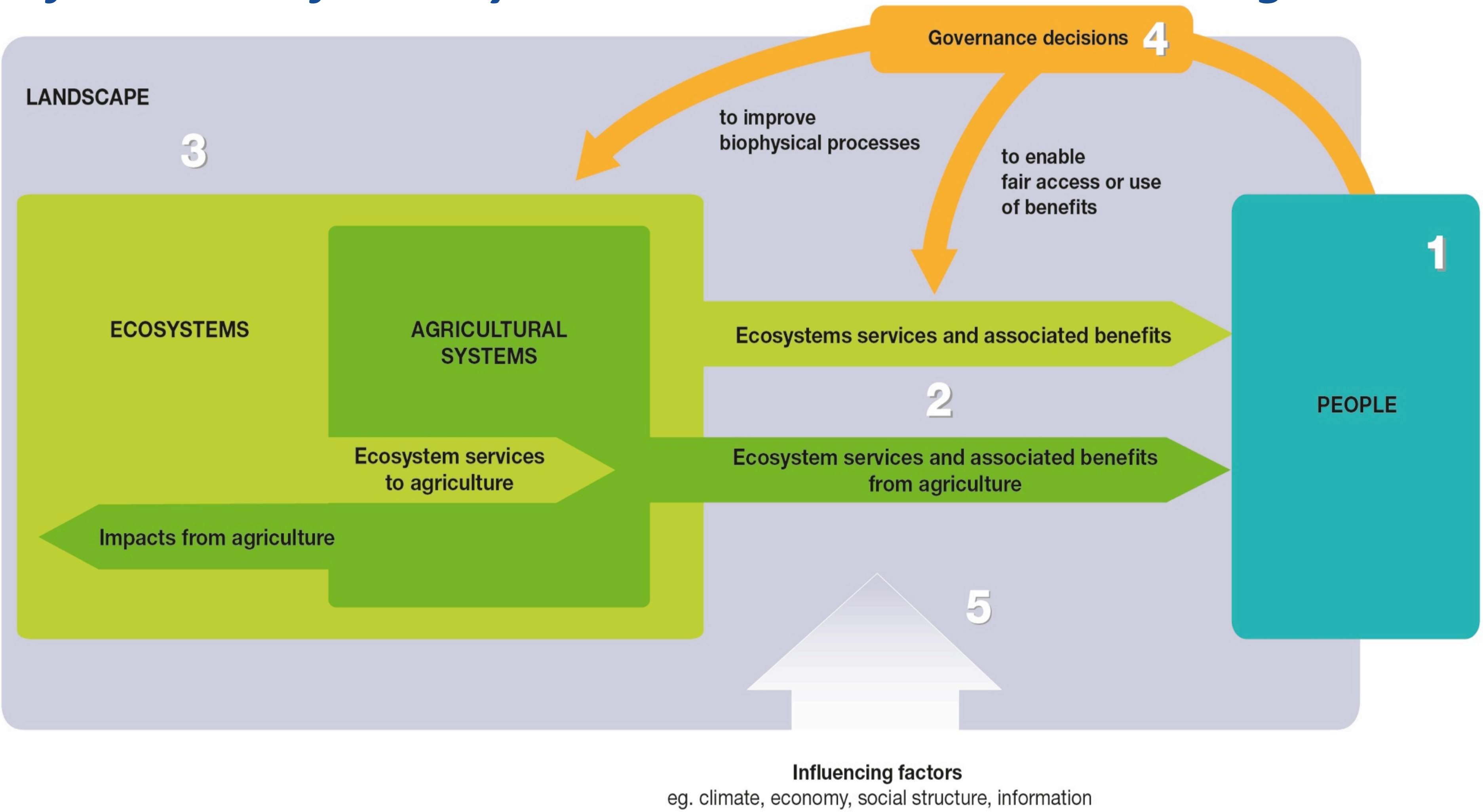
Ecosystem Services

The conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life.

This includes both goods, and functions.

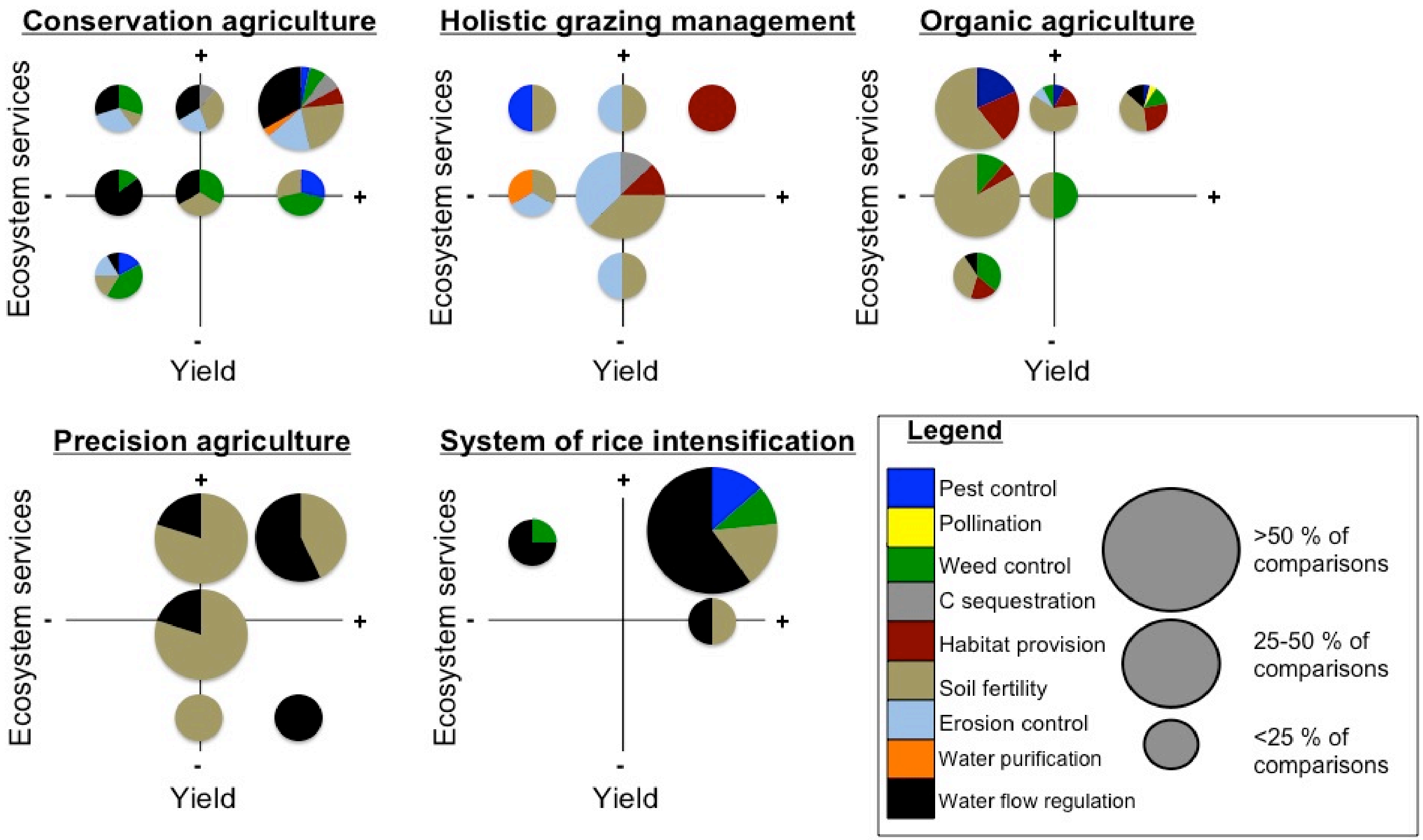
Daily 1997

A framework for Ecosystem Services and Resilience in Agriculture



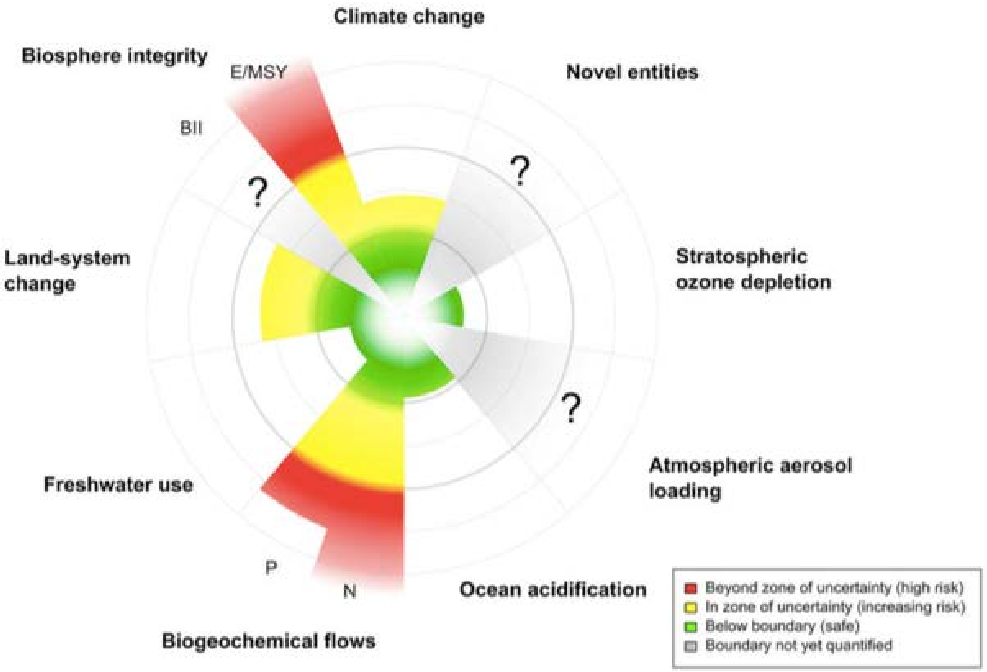
Moving Beyond Ideology to Close Yield Gaps and "Nature Gaps" in 21st Century Agriculture: A Review of the Multi-Functionality of Five Systems of Agroecological Intensification

Jeffrey C. Milder[1,2*†], Kelly Garbach[3*], Fabrice A.J. DeClerck[4*], Laura Driscoll[5], Maywa Montenegro[5], and Barbara Herren[6]



Planetary boundaries: Guiding human development on a changing planet

Will Steffen,[1,2*] Katherine Richardson,[3] Johan Rockström,[1] Sarah E. Cornell,[1] Ingo Fetzer,[1] Elena M. Bennett,[4] R. Biggs,[1,5] Stephen R Carpenter,[6] Wim de Vries,[7,8] Cynthia A. de Wit,[9] Carl Folke,[1,10] Dieter Gerten,[11] Jens Heinke,[11,12,13] Georgina M. Mace,[14] Linn M. Persson,[15] Veerabhadran Ramanathan,[16,17] B. Reyers,[1,18] Sverker Sörlin[19]



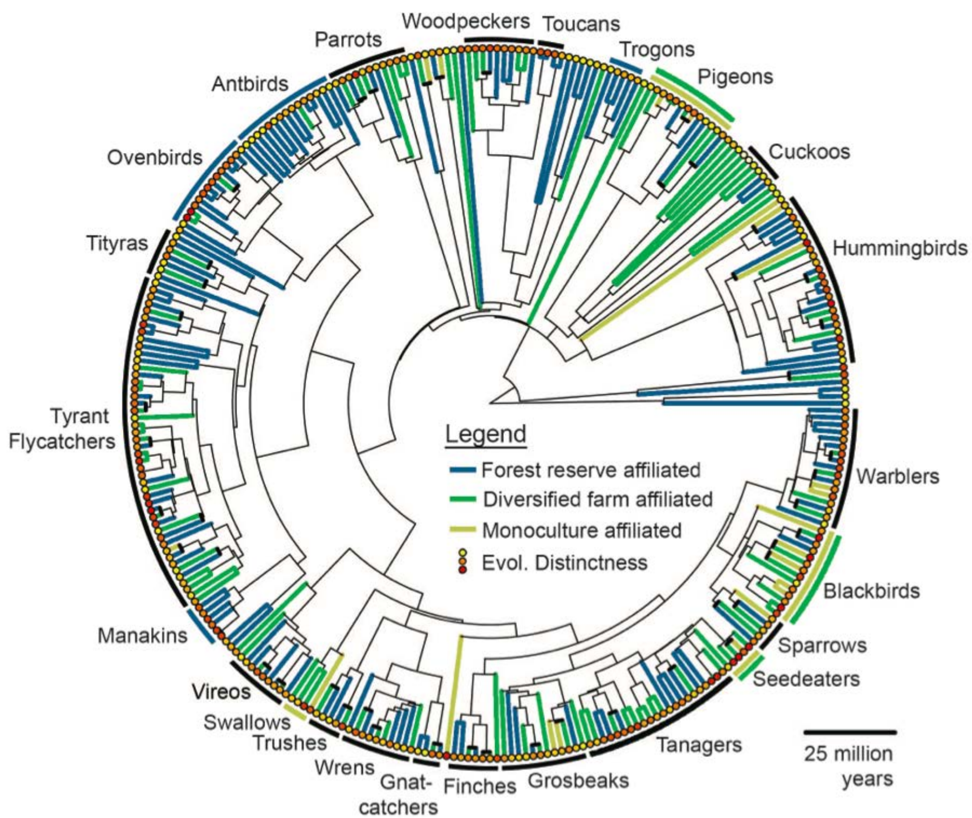
"**Biosphere integrity**" is one of two core boundaries along with climate change, "each of which has the potential on its own to drive the Earth System into a new state should they be substantially and persistently transgressed." Biodiversity is given special attention for two reasons: 1)*"the role of genetically unique material as the "information bank" that ultimately determines the potential for life to continue to co-evolve with the abiotic component of the Earth System in the most resilient way possible. Genetic diversity provides the long-term capacity of the biosphere to persist under and adapt to abrupt and gradual abiotic change."* And *"second capture(ing) the role of the biosphere in Earth System functioning through the value, range, distribution and relative abundance of the functional traits of the organisms present in an ecosystem or biota".*

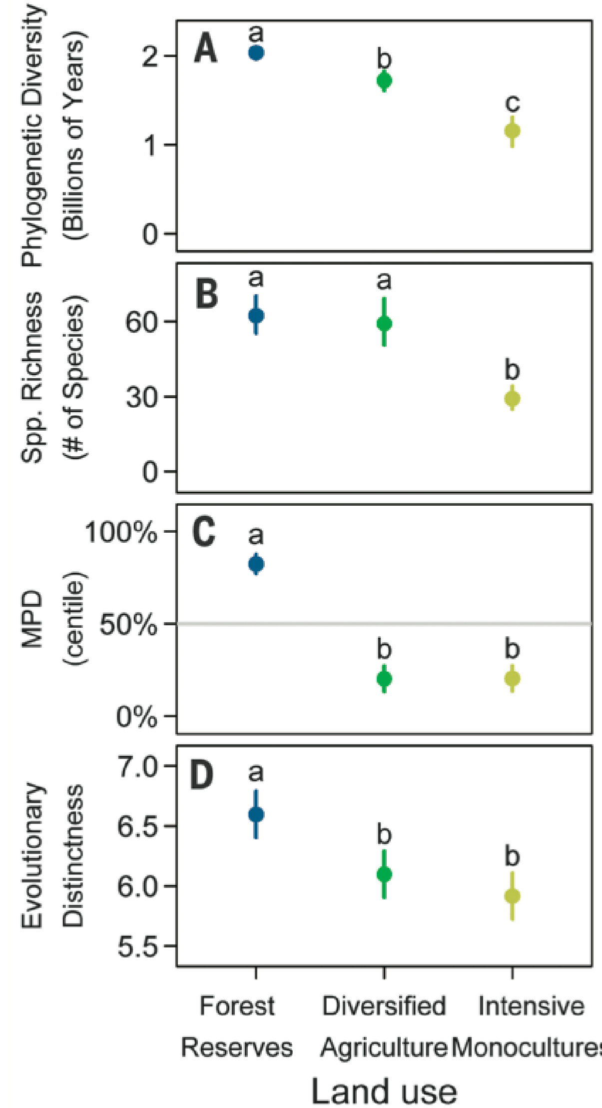
BIODIVERSITY LOSS

12 SEPTEMBER 2014 • VOL 345 ISSUE 6202

Loss of avian phylogenetic diversity in neotropical agricultural systems

Luke O. Frishkoff,[1,2*†] Daniel S. Karp,[3,4*†] Leithen K. M'Gonigle,[3]
Chase D. Mendenhall,[1,2] Jim Zook,[5] Claire Kremen,[3]
Elizabeth A. Hadly,[1] Gretchen C. Daily[1,2,6,7,8]





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**number of species may be greater than 100 million*

3 mechanisms, 3 questions:

1) Sampling Effect: one species outcompetes all others in a single function.

   Which is the best species (traits) for the job?

2) Complementary Effect: species interaction are greater than the sum of the individuals.

   What combination of species (traits) should be used?

3) Insurance Effect: Greater diversity = greater resilience

   How much diversity is enough (and where)?

[Can these mechanisms interoperate at scale?]

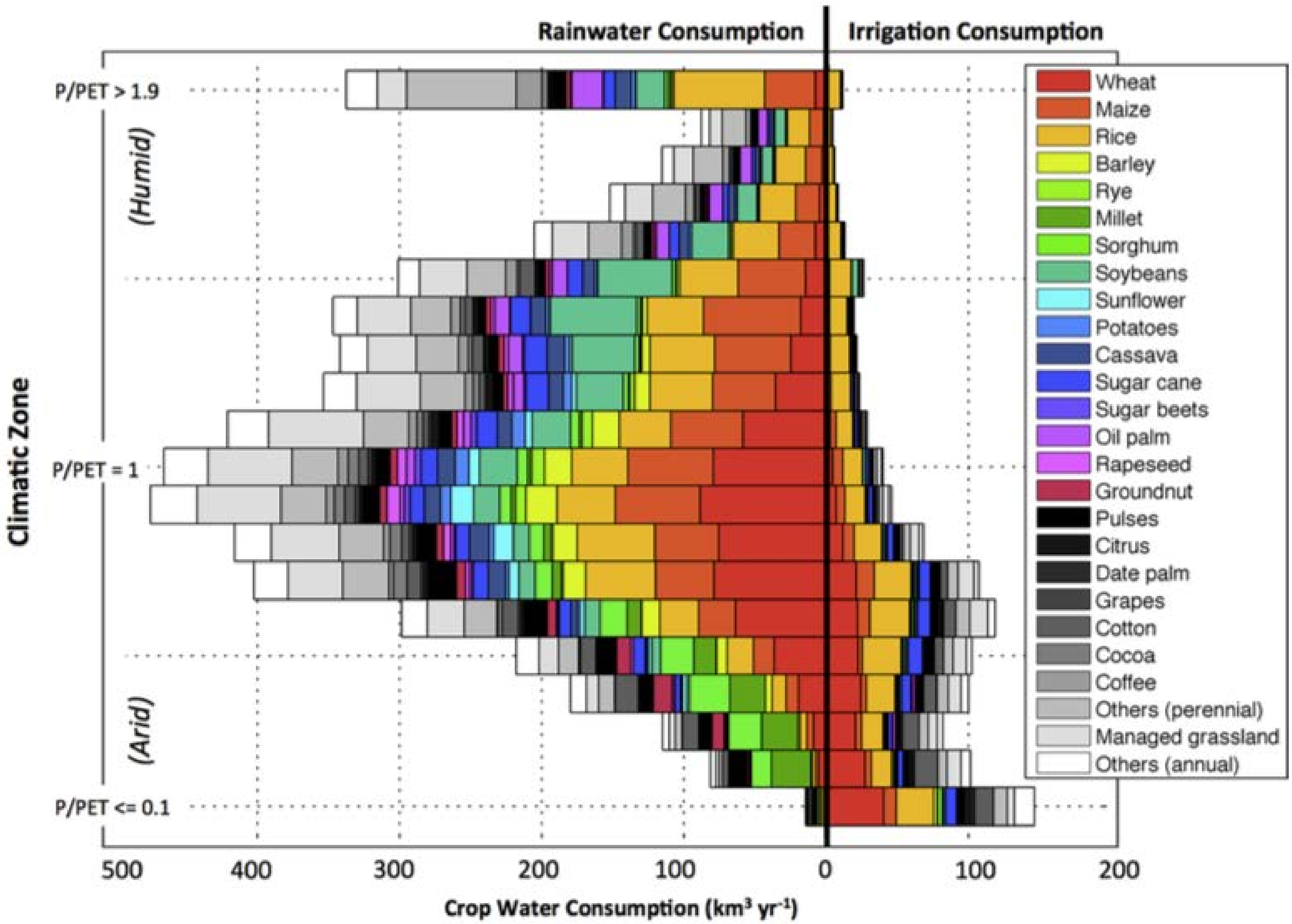
food for thought

Heat, Drought Draw Farmers Back To Sorghum, The 'Camel Of Crops'

by **DAN CHARLES**

October 31, 2013 4:56 PM

A test field of sorghum outside Manhattan, Kan., planted by Kansas State University.


Rainwater Consumption
Irrigation Consumption
P/PET > 1.9
(Humid)
Climatic Zone
P/PET = 1
(Arid)
P/PET <= 0.1
500
400
300
200
100
0
100
200
Crop Water Consumption (km³ yr⁻¹)
Wheat
Maize
Rice
Barley
Rye
Millet
Sorghum
Soybeans
Sunflower
Potatoes
Cassava
Sugar cane
Sugar beets
Oil palm
Rapeseed
Groundnut
Pulses
Citrus
Date palm
Grapes
Cotton
Cocoa
Coffee
Others (perennial)
Managed grassland
Others (annual)

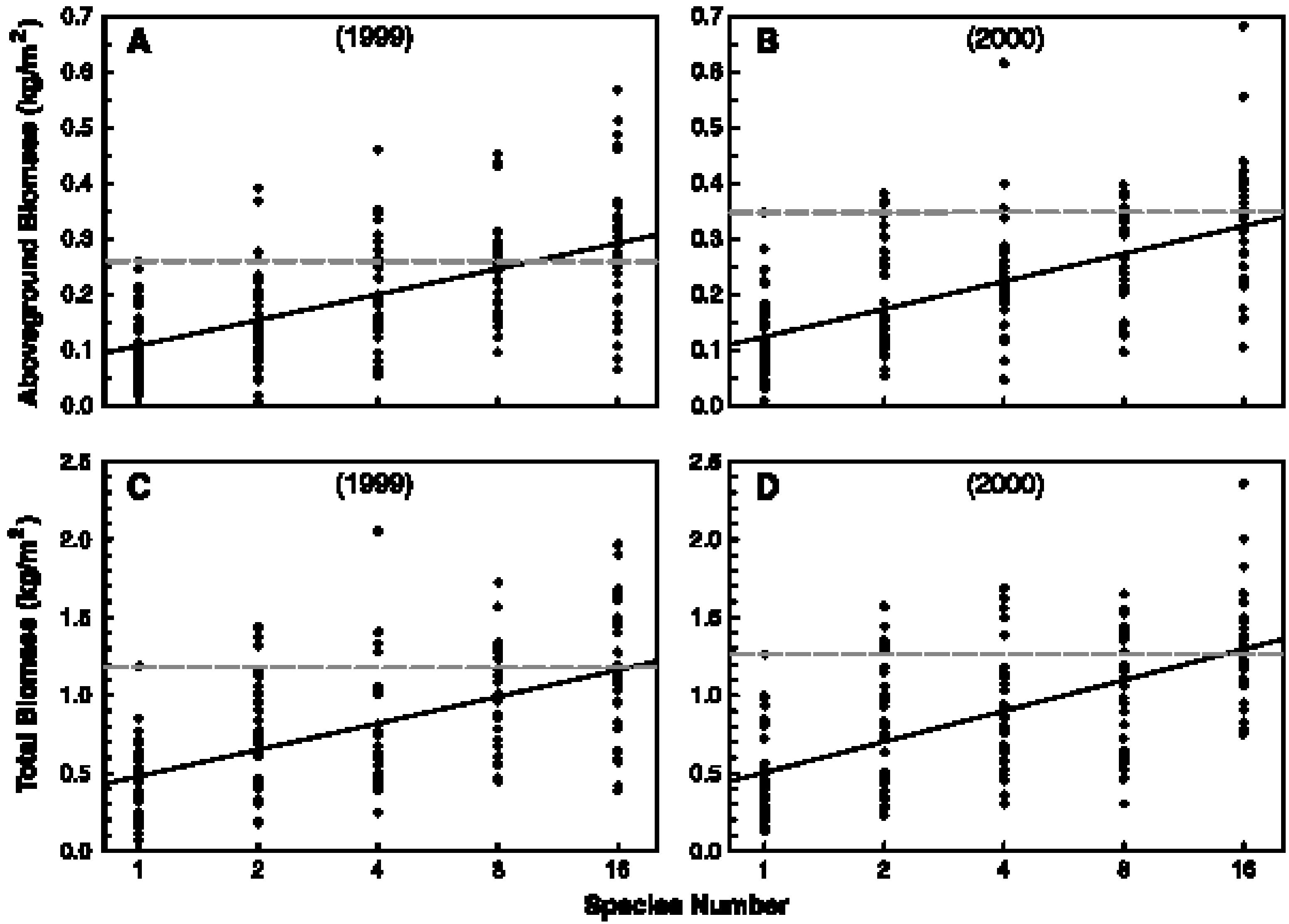


Fig. 2. The dependence of aboveground (**A** and **B**) and of total (**C** and **D**) biomass of each plot on planted species number for 1999 and 2000. The broken line shows the biomass of the top monoculture for a given year. The solid line is a regression of biomass on the logarithm of species number. Logarithm of species number was used in the figure because it gave slightly better fits, but was not used in Table 1 because it often gave slightly lower R^2 values than species number.

Tilman et al 1996

Time Is Running Out To Save Florida's Oranges

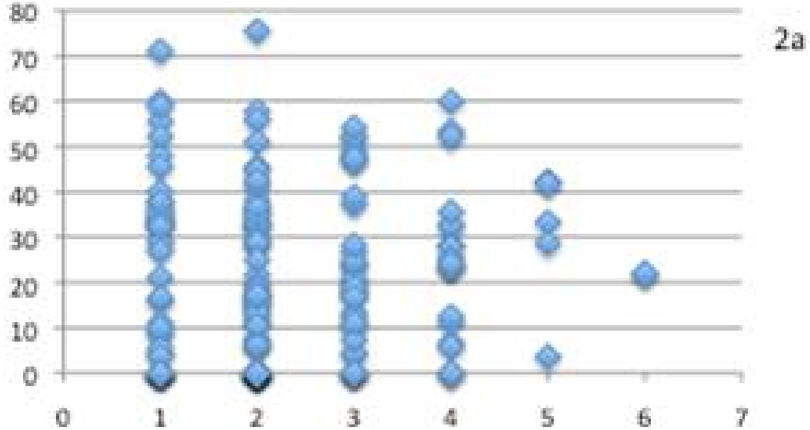
by **GREG ALLEN**

December 27, 2013 4:42 PM

Ripening fruit in a grove in Plant City, Fla., this month. Florida citrus growers are worried about citrus greening, which causes bacteria to grow on the leaf and fruit, eventually killing the tree.

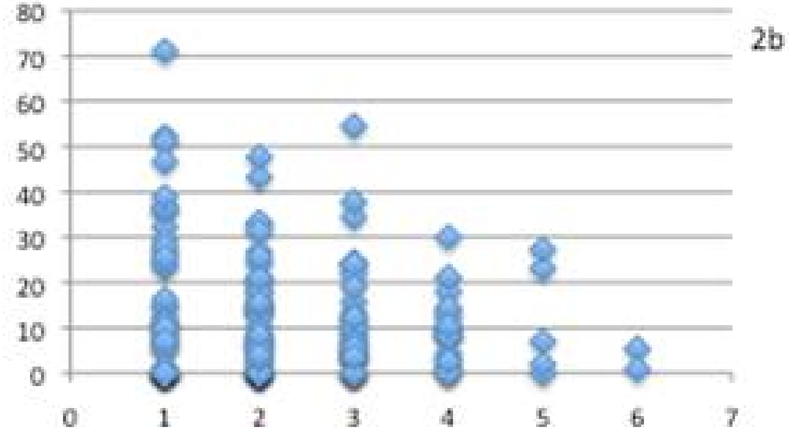
Success story: Relationship between richness and Weighted Damage Index (WDI = 0-100) – Common bean in Uganda

ALS



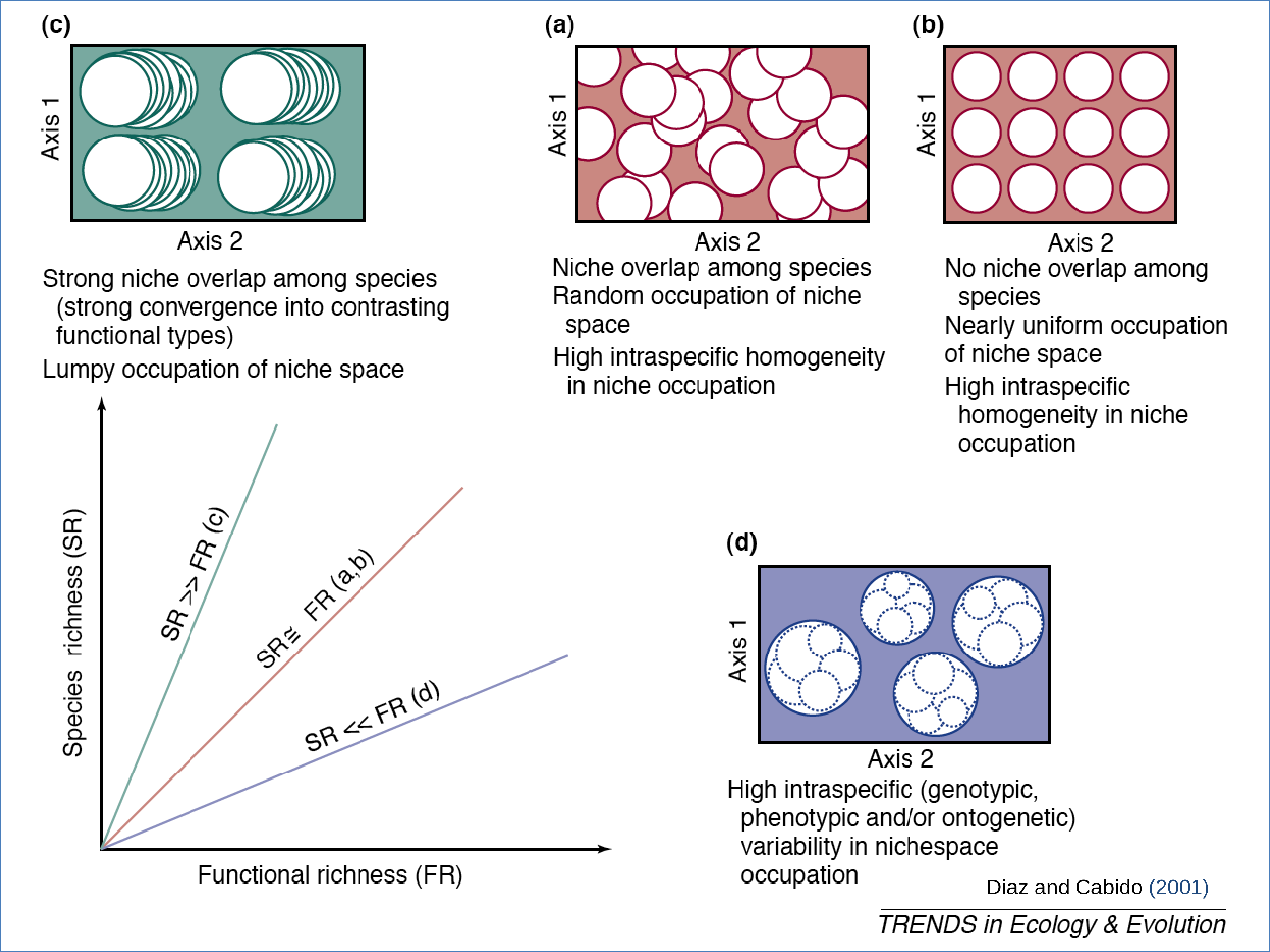
Richness

Anthracnose



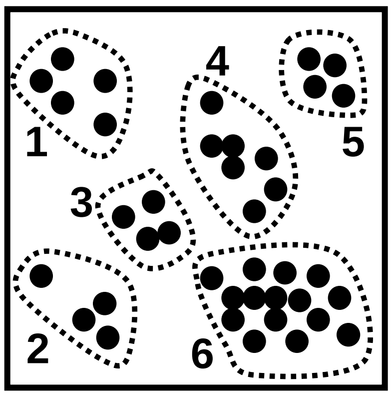
Richness

In times of higher disease incidence (Anthracnose) higher relationship of varietal diversity with reduced damage

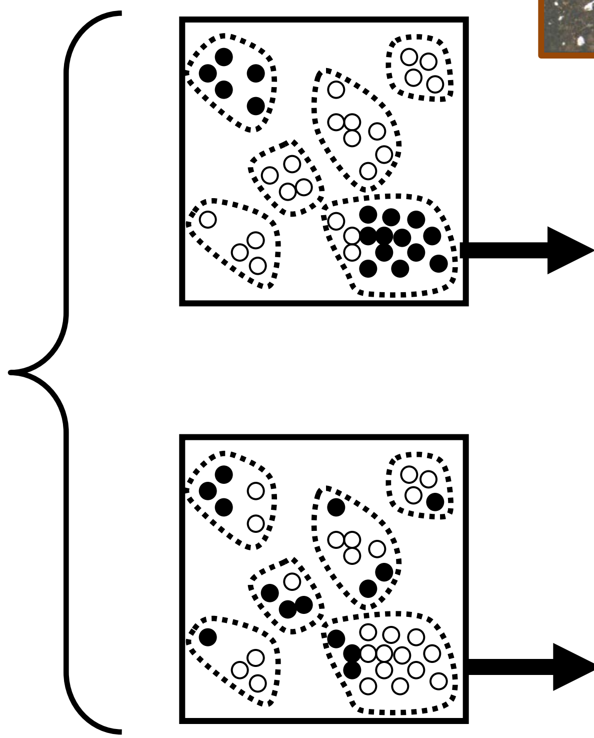

(c)
Axis 1
Axis 2
Strong niche overlap among species (strong convergence into contrasting functional types)
Lumpy occupation of niche space
(a)
Axis 1
Axis 2
Niche overlap among species
Random occupation of niche space
High intraspecific homogeneity in niche occupation
(b)
Axis 1
Axis 2
No niche overlap among species
Nearly uniform occupation of niche space
High intraspecific homogeneity in niche occupation
Species richness (SR)
SR >> FR (c)
SR≅ FR (a,b)
SR << FR (d)
Functional richness (FR)
(d)
Axis 1
Axis 2
High intraspecific (genotypic, phenotypic and/or ontogenetic) variability in nichespace occupation
Diaz and Cabido (2001)
TRENDS in Ecology & Evolution

Functional Diversity

Ecological Community
House Hold Consumption



Functional Or Food Groups



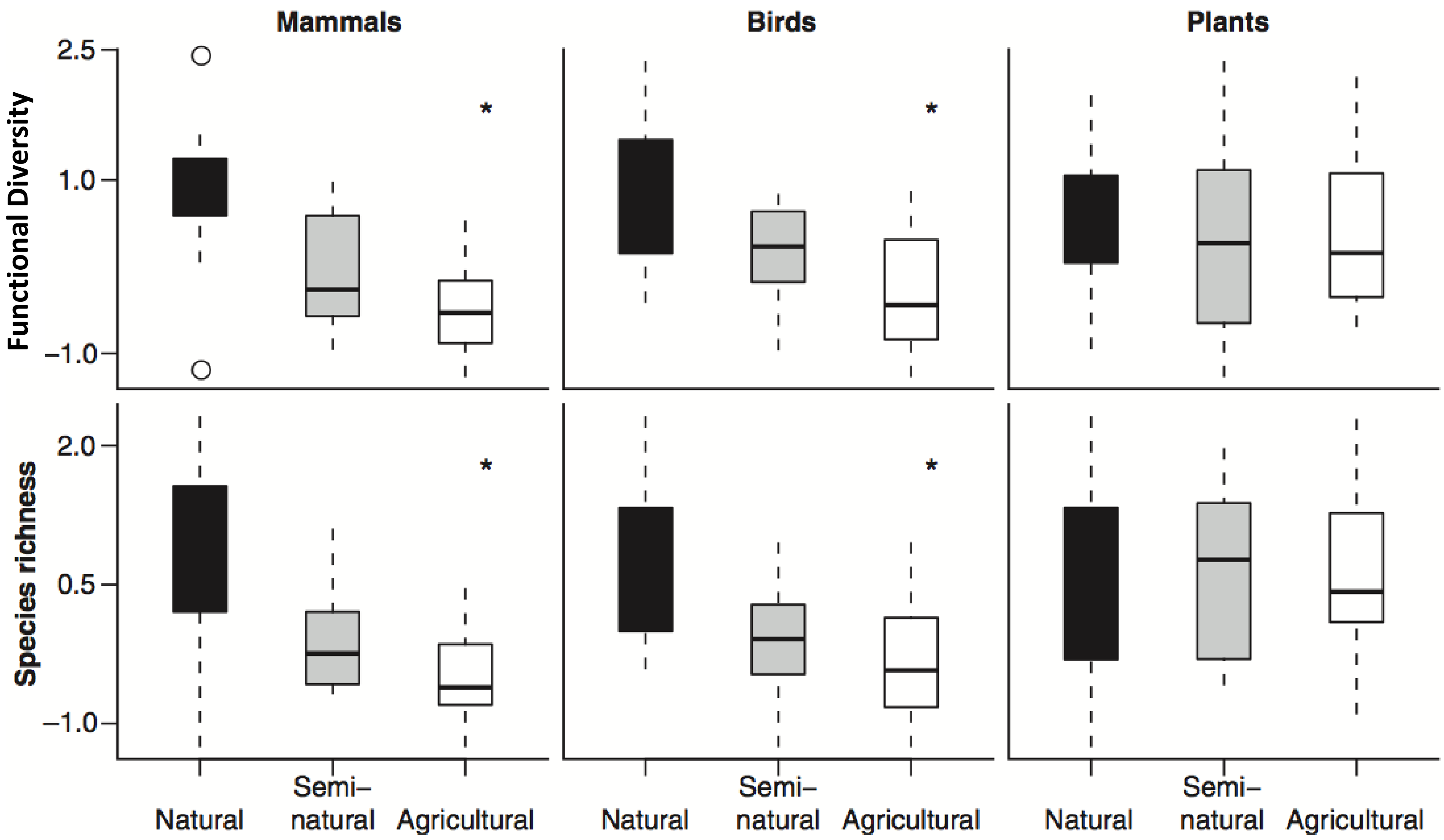
Low Functional Diversity

High Functional Diversity

Ecology Letters, (2009) **12**: 22–33 doi: 10.1111/j.1461-0248.2008.01255.x

LETTER

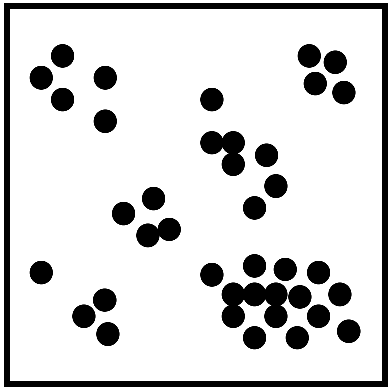
Loss of functional diversity under land use intensification across multiple taxa

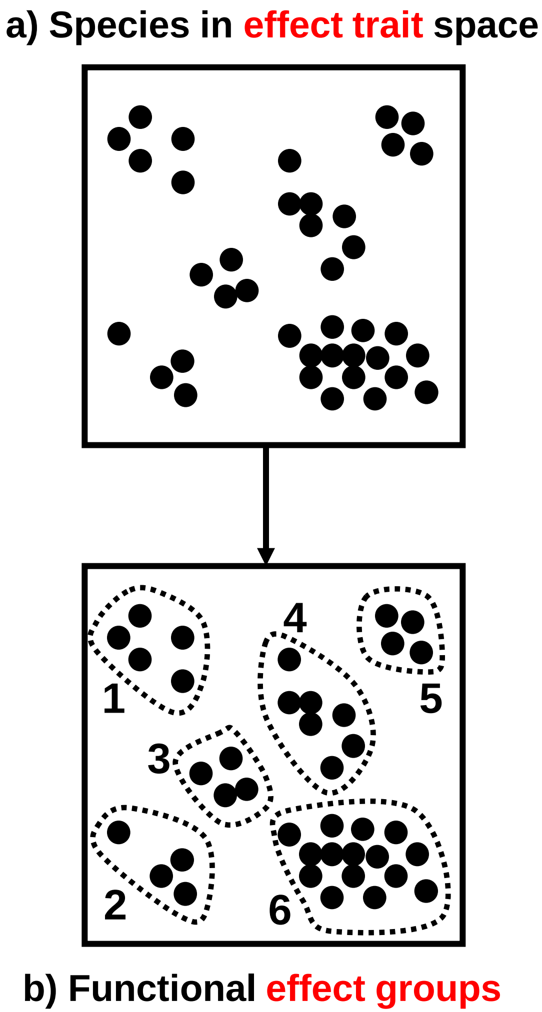


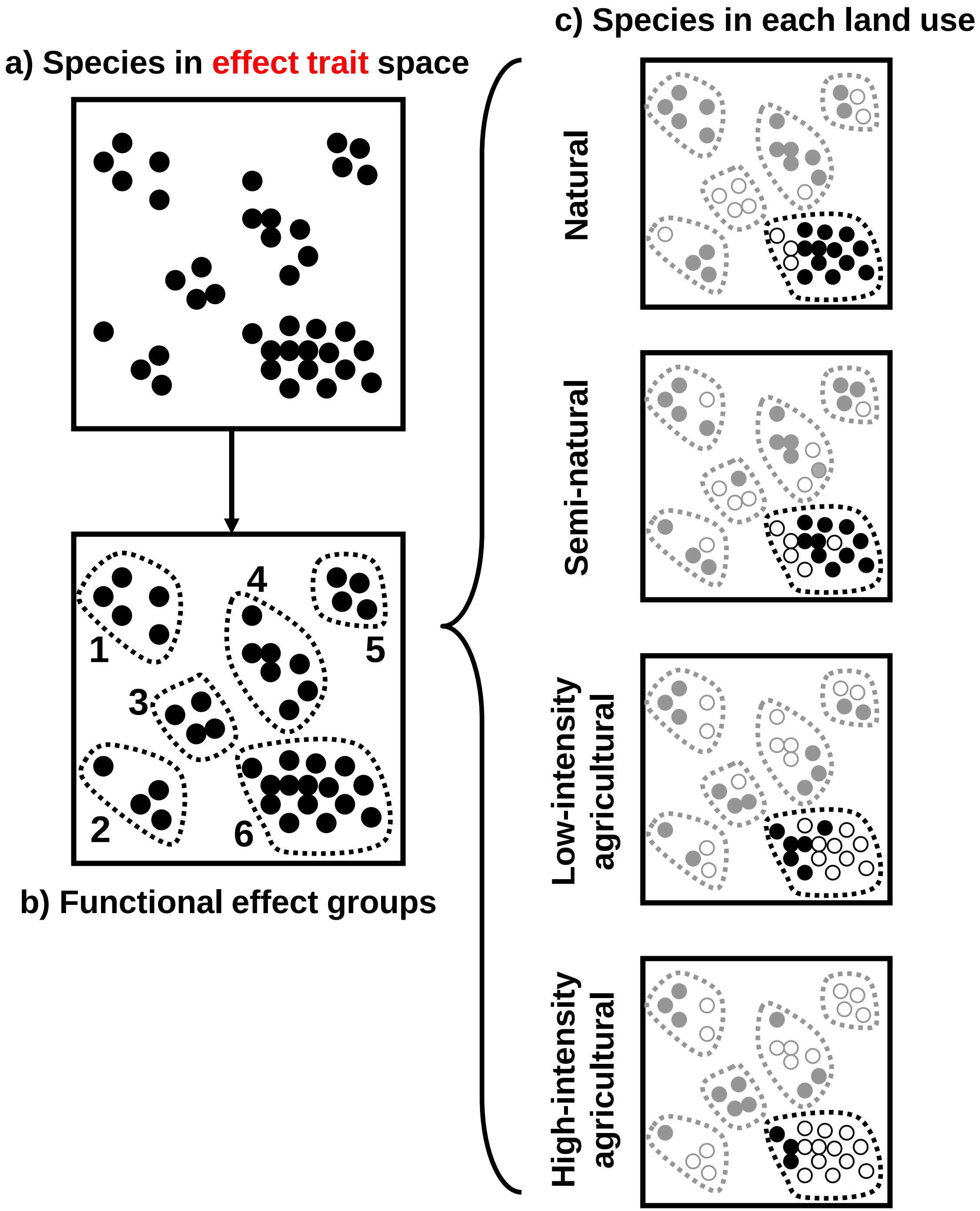
Bioversity International

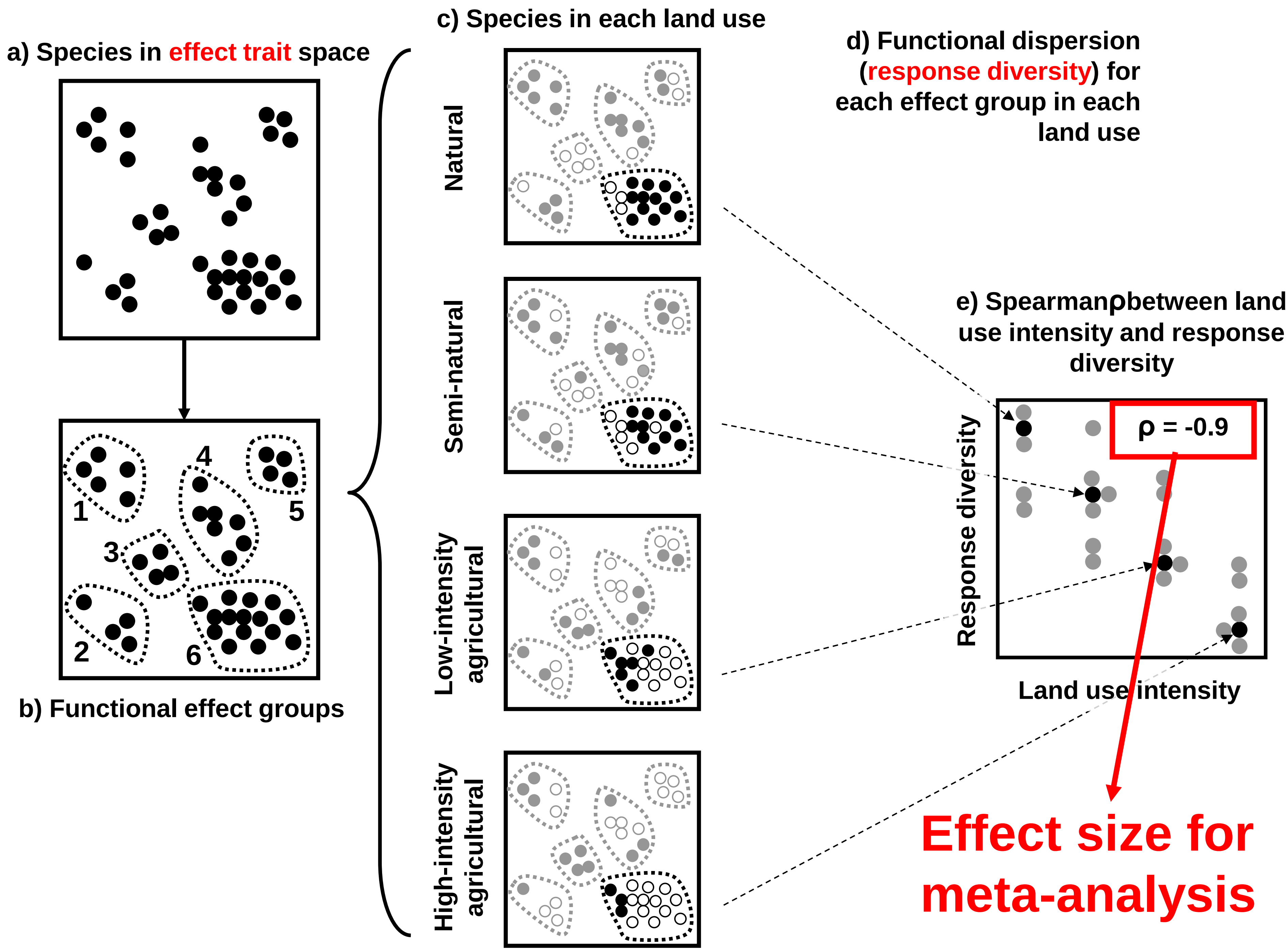
Functional trait	Effect	Response
Specific leaf area (SLA)	X	
Wood density	X	
Growth form	X	
Height	X	
Leaf phenology	X	X
Nutrient uptake strategy	X	X
Photosynthetic pathway	X	X
Raunkiaer life form		X
Clonality		X
Dispersal mode		X
Leaf size		X
Maximum propagule longevity		X
Physical defense		X
Pollination syndrome		X
Resprouting ability		X
Seed mass		X
Lifespan		X

a) Species in effect trait space

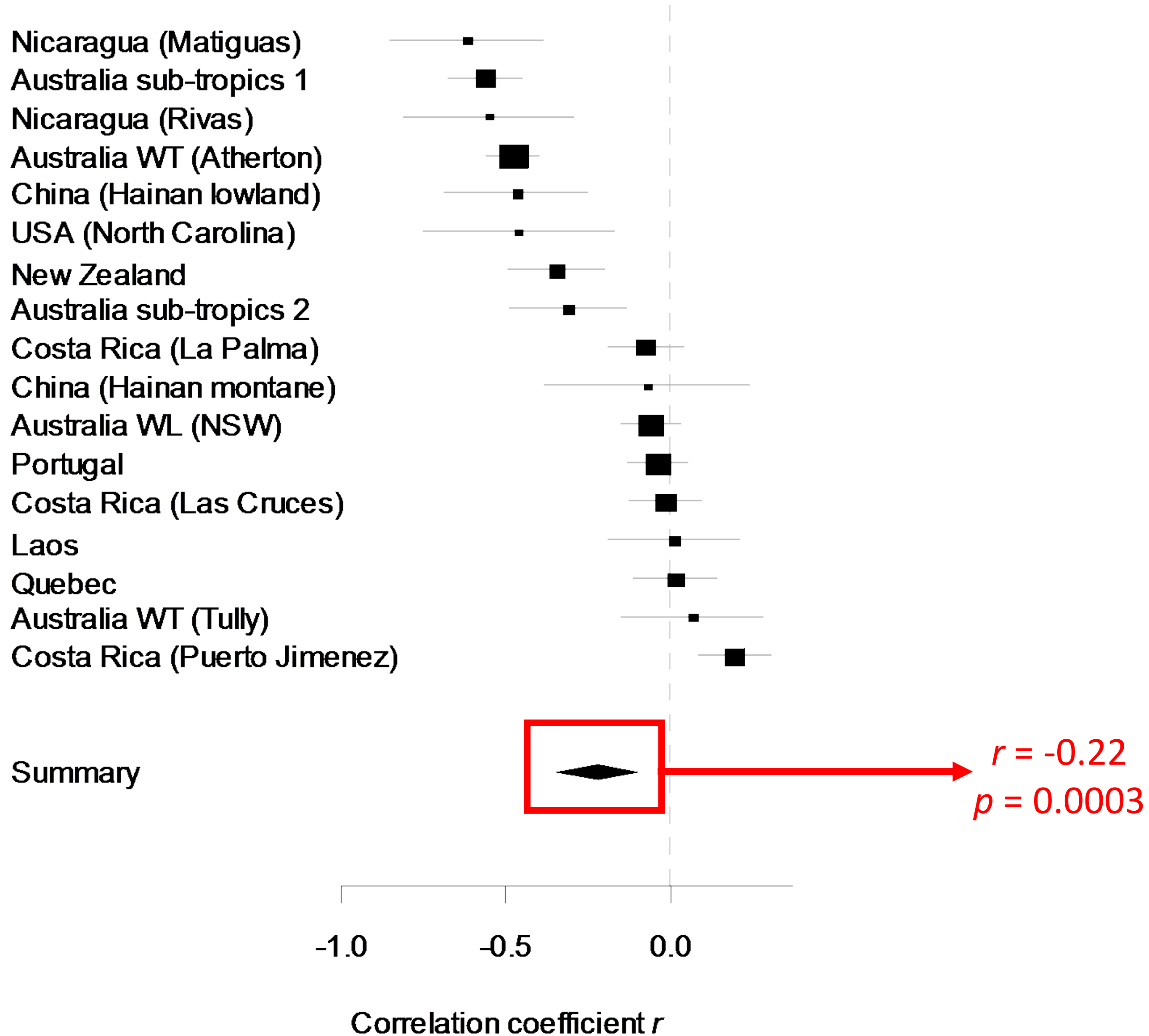



a) Species in effect trait space
1
2
3
4
5
6
b) Functional effect groups

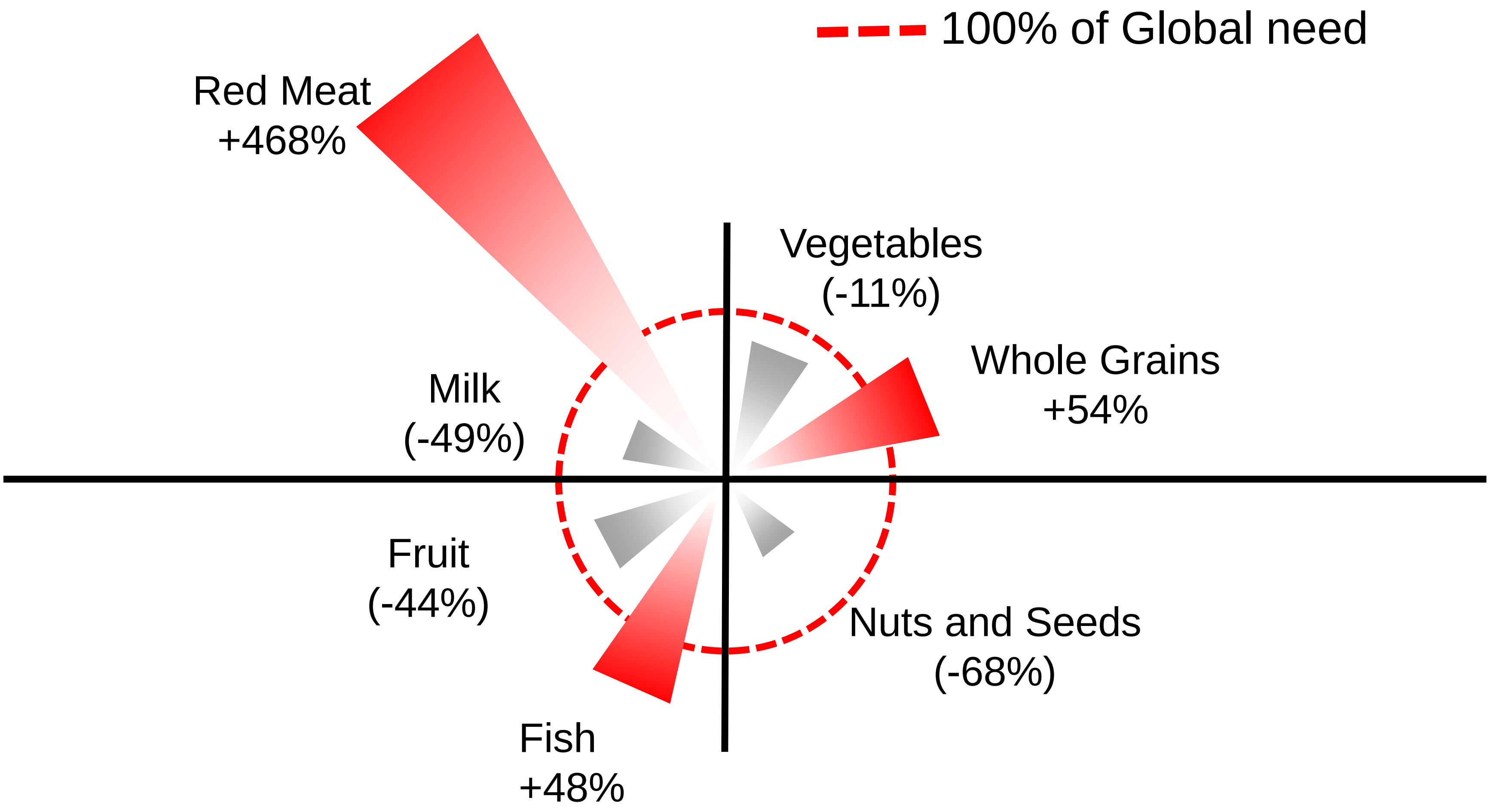

a) Species in effect trait space
b) Functional effect groups
1
2
3
4
5
6
c) Species in each land use
Natural
Semi-natural
Low-intensity agricultural
High-intensity agricultural


a) Species in effect trait space
b) Functional effect groups
1
2
3
4
5
6
c) Species in each land use
Natural
Semi-natural
Low-intensity agricultural
High-intensity agricultural
d) Functional dispersion (response diversity) for each effect group in each land use
e) Spearman ρ between land use intensity and response diversity
ρ = -0.9
Response diversity
Land use intensity
Effect size for meta-analysis

Redundancy decreases with land use intensification



Can Agriculture Provide Nuritional Needs?

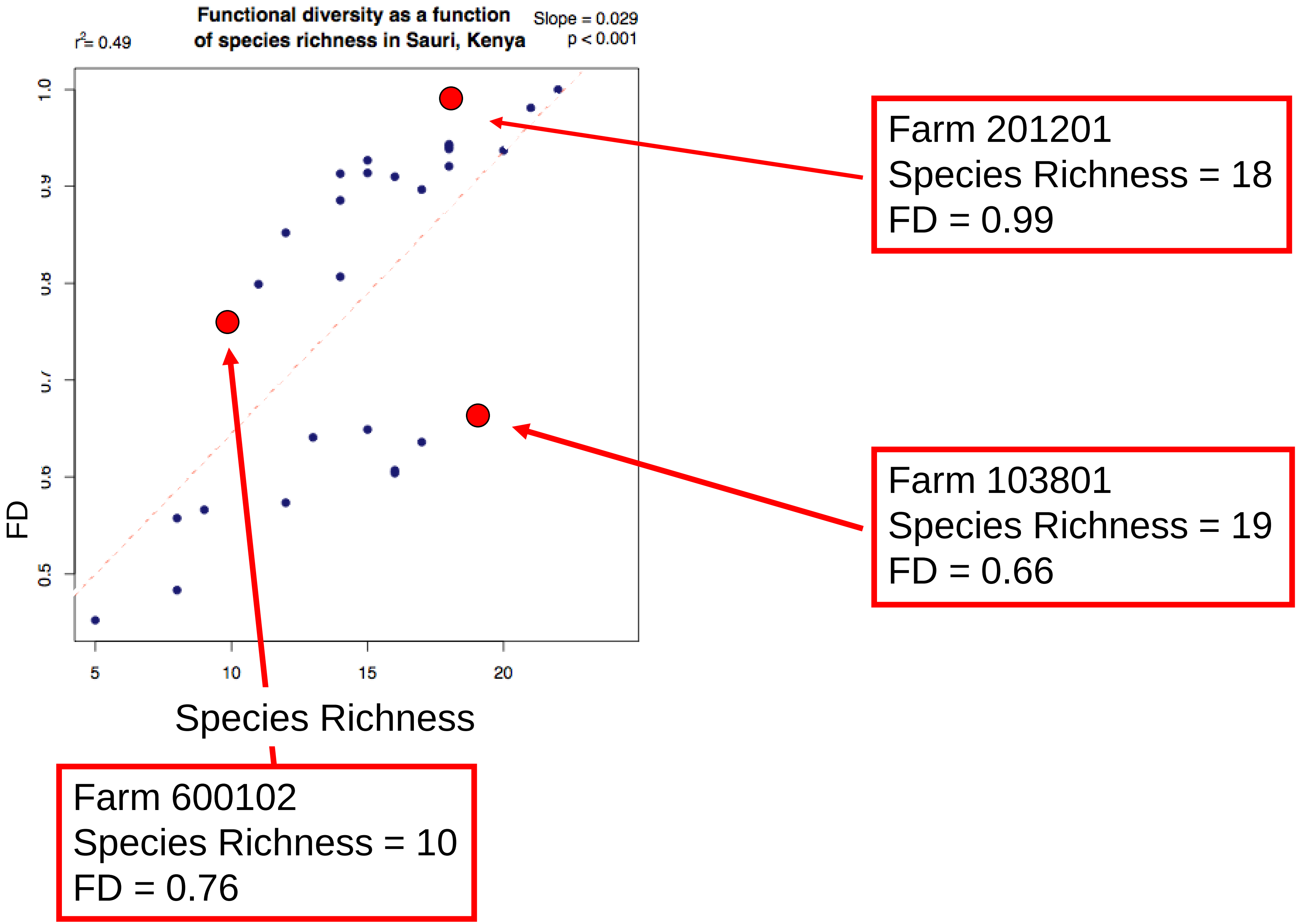


Adapted from Muray 2014

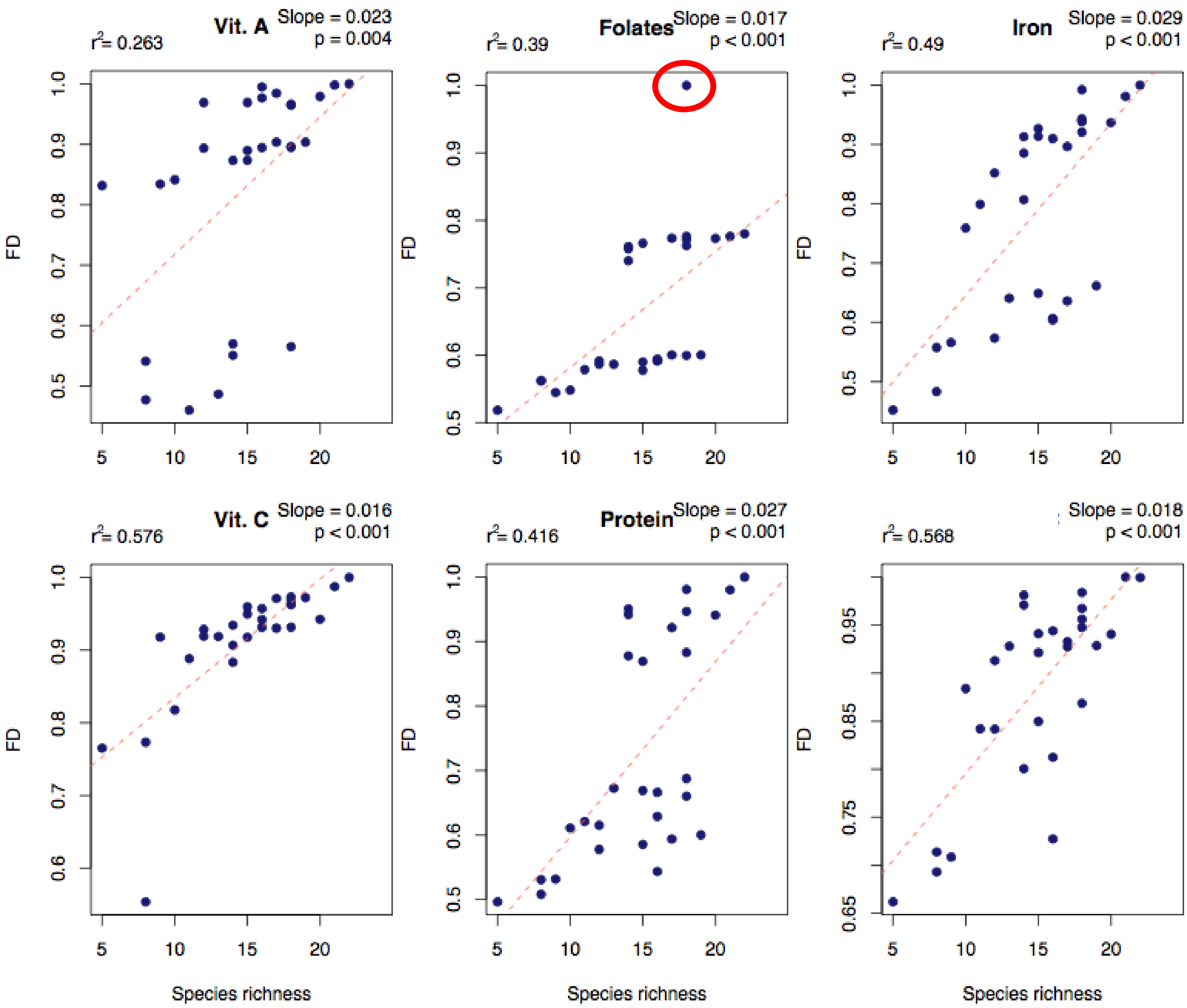
Table 1. Nutrients and nutrient groups taken into account for calculation of FD metrics. From the 51 required nutrients for human diets, 17 nutrients that are key for human diets and for which reliable plant composition data were available in the literature were selected. Because plants are not a proven source for Vitamin B12 and Vitamin D, these were not included.

Macronutrients	Minerals	Vitamins
Protein	Calcium (Ca)	Vitamin A
Carbohydrates	Iron (Fe)	Vitamin C
Dietary fibre	Potassium (K)	Thiamin
Fat	Magnesium (Mg)	Riboflavin
	Manganese (Mn)	Folate
	Zinc (Zn)	Niacin
	Sulfur (S)	

Remans, Flynn, DeClerck et al. ***PloS One*** (2010)



F. DeClerck, Remans, Fanzo and Palm (2010)



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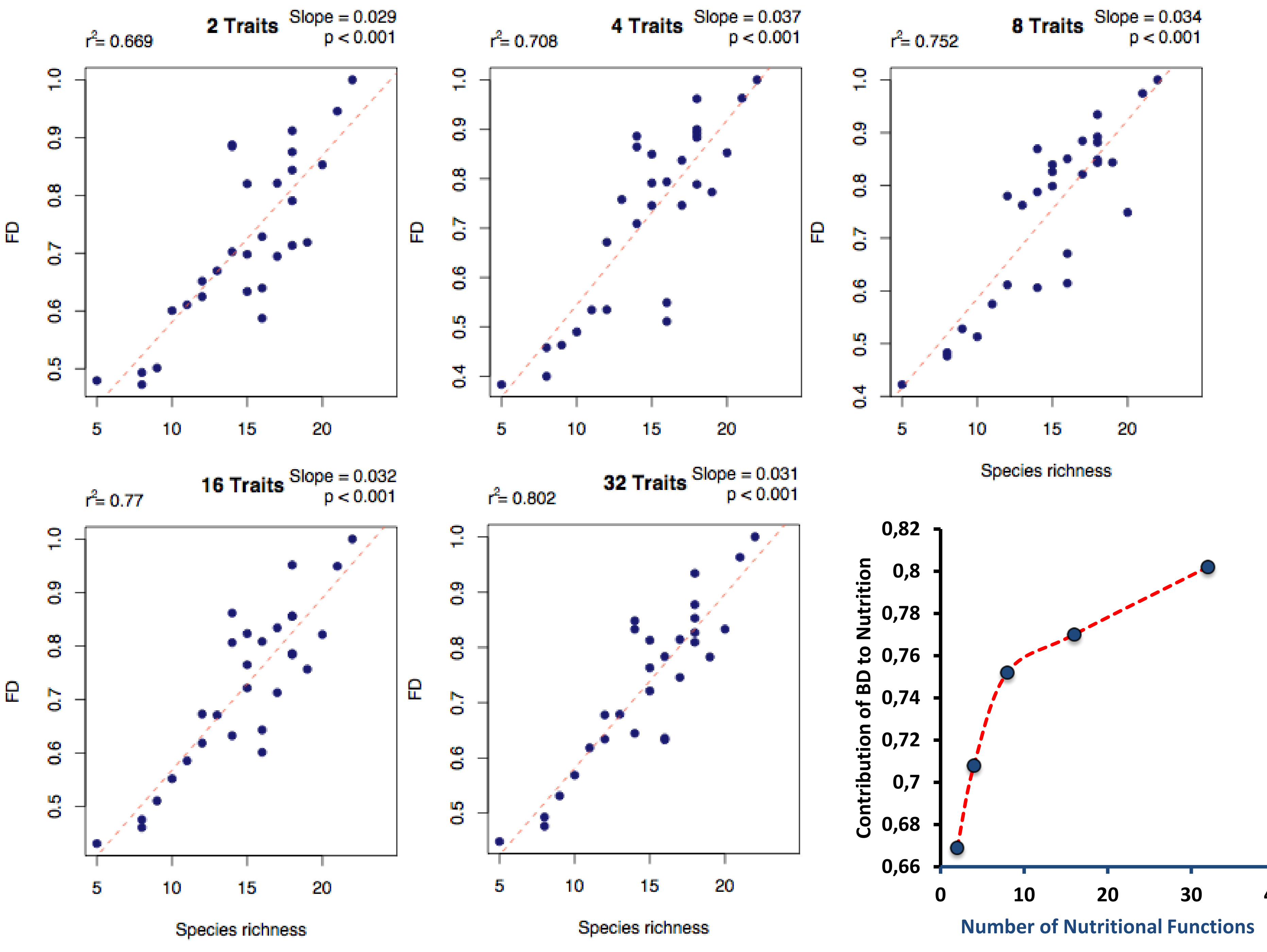
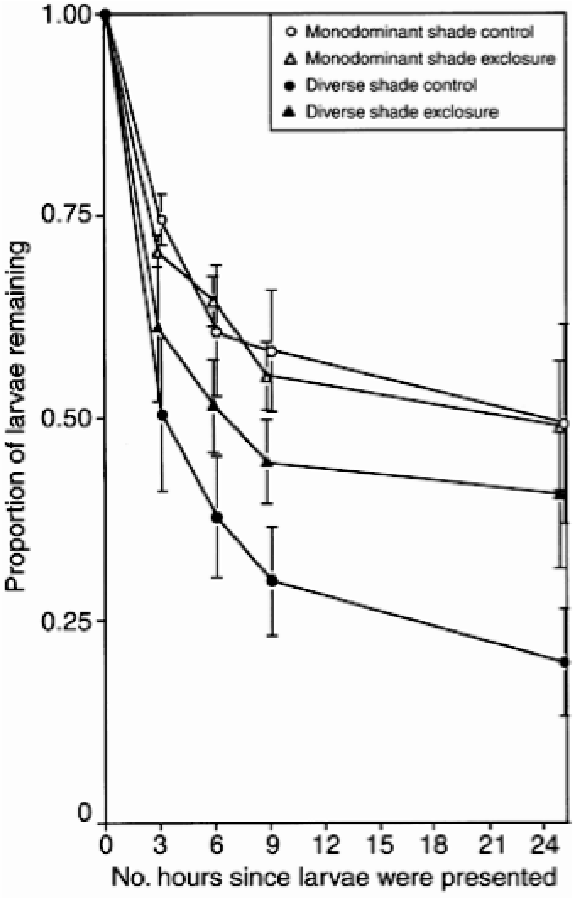


F. DeClerck, Remans, Fanzo and Palm (2010)

Evidence for a biodiversity and function relationship

Pest Control

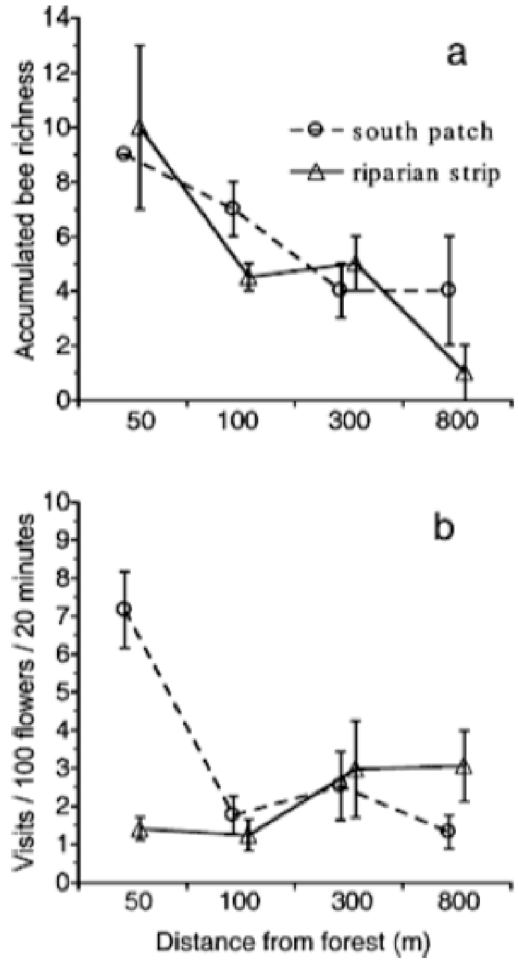
Perfecto et al. 2004



Agroforest stucture

Pollination

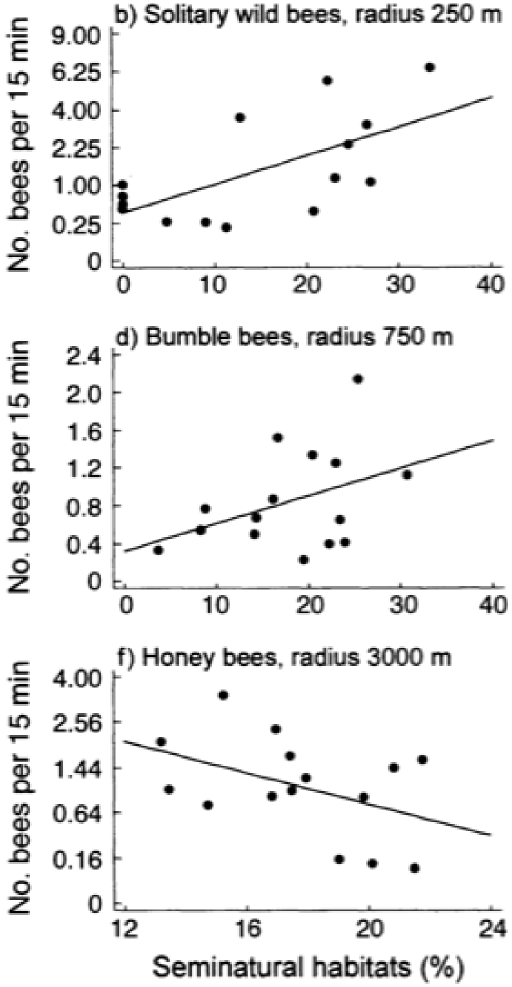
Ricketts et al. 2004



Distance from forest

Pollination

Steffan-Dewenter et al. 2002

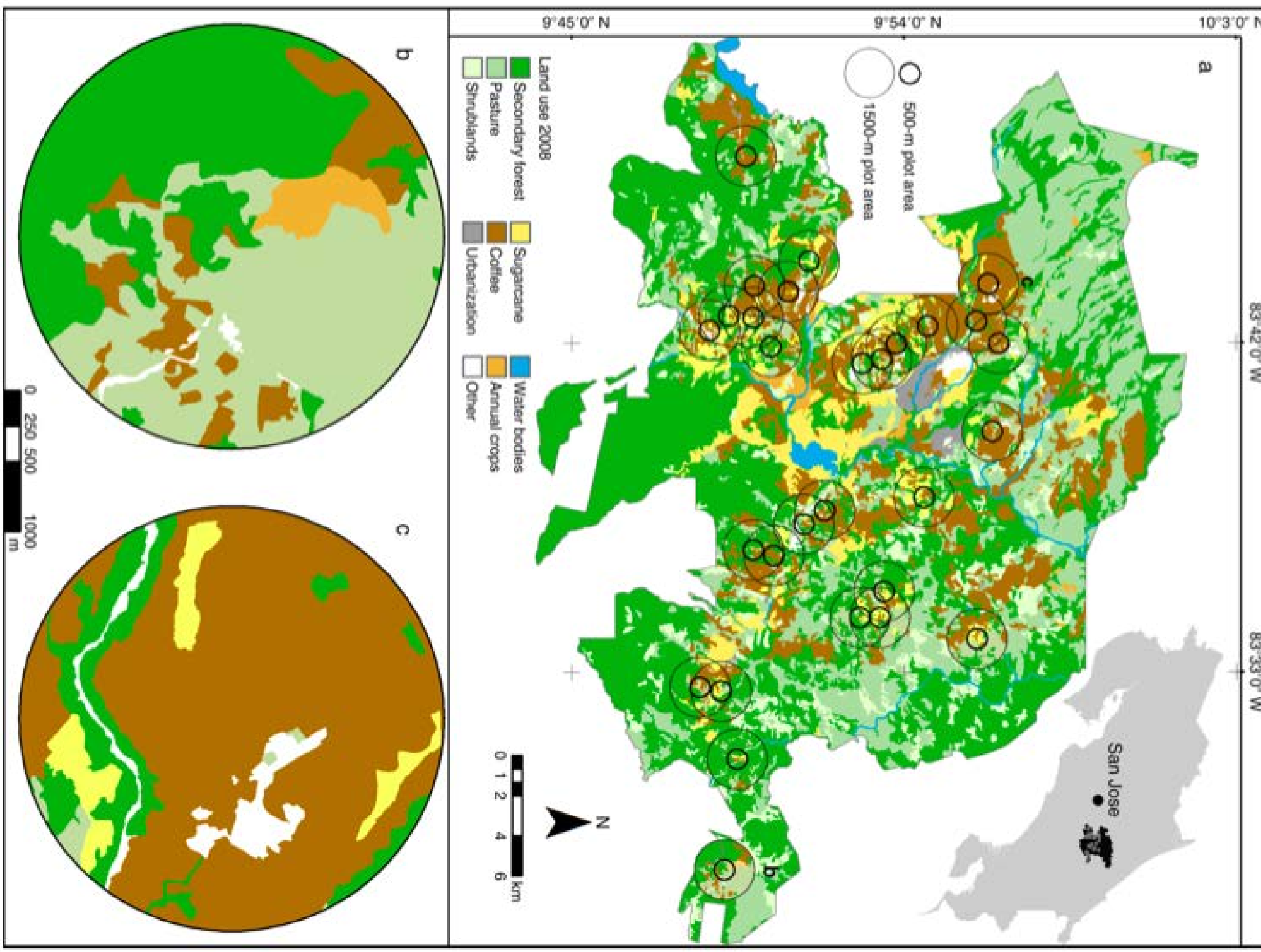


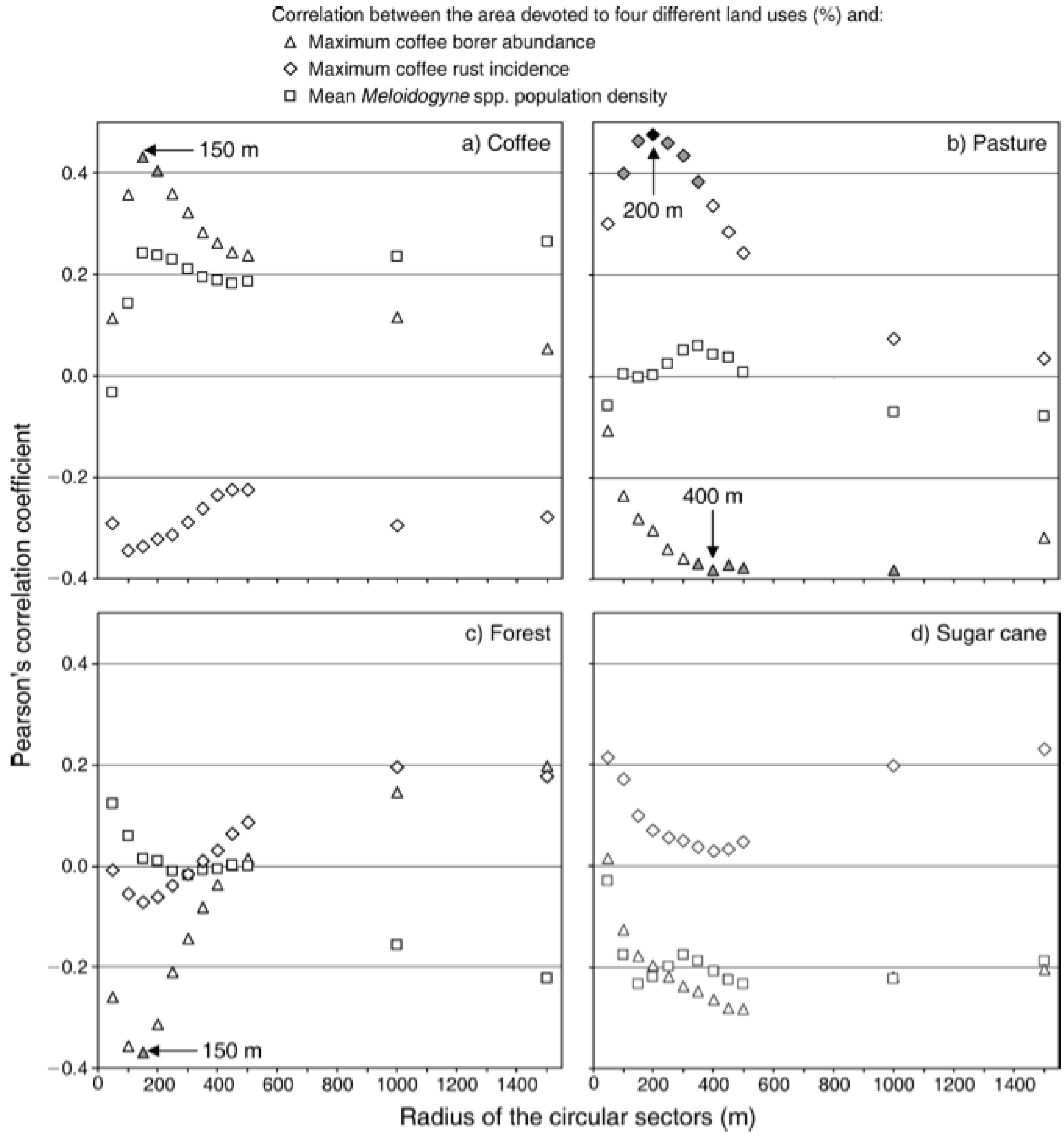
Seminatural habitat (%)

Ecological Applications, 22(2), 2012, pp. 584–596

Landscape context and scale differentially impact coffee leaf rust, coffee berry borer, and coffee root-knot nematodes

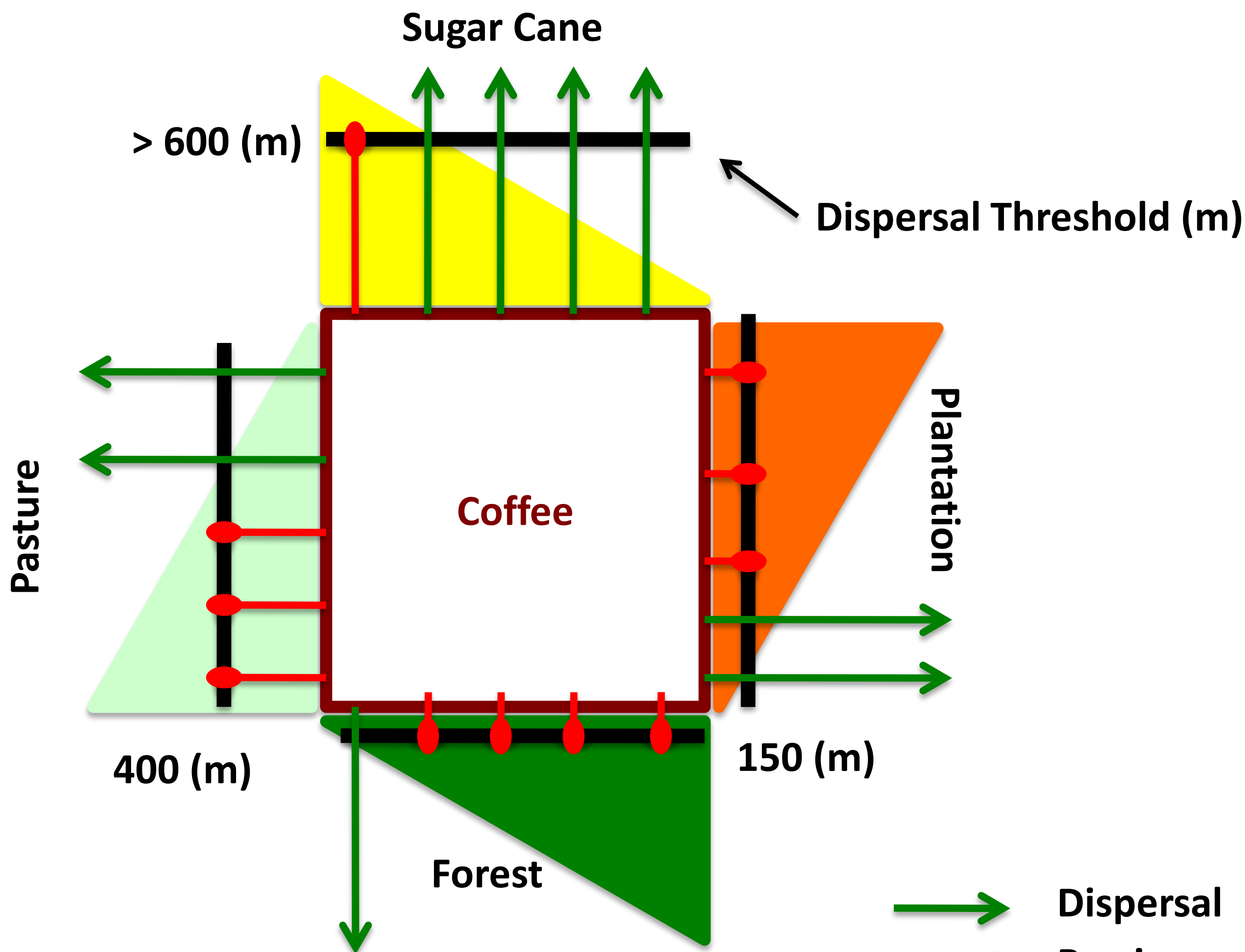
Jacques Avelino,[1,2,3,5] Alí Romero-Gurdián,[2] Héctor F. Cruz-Cuellar,[2,4] and Fabrice A. J. Declerck[2]



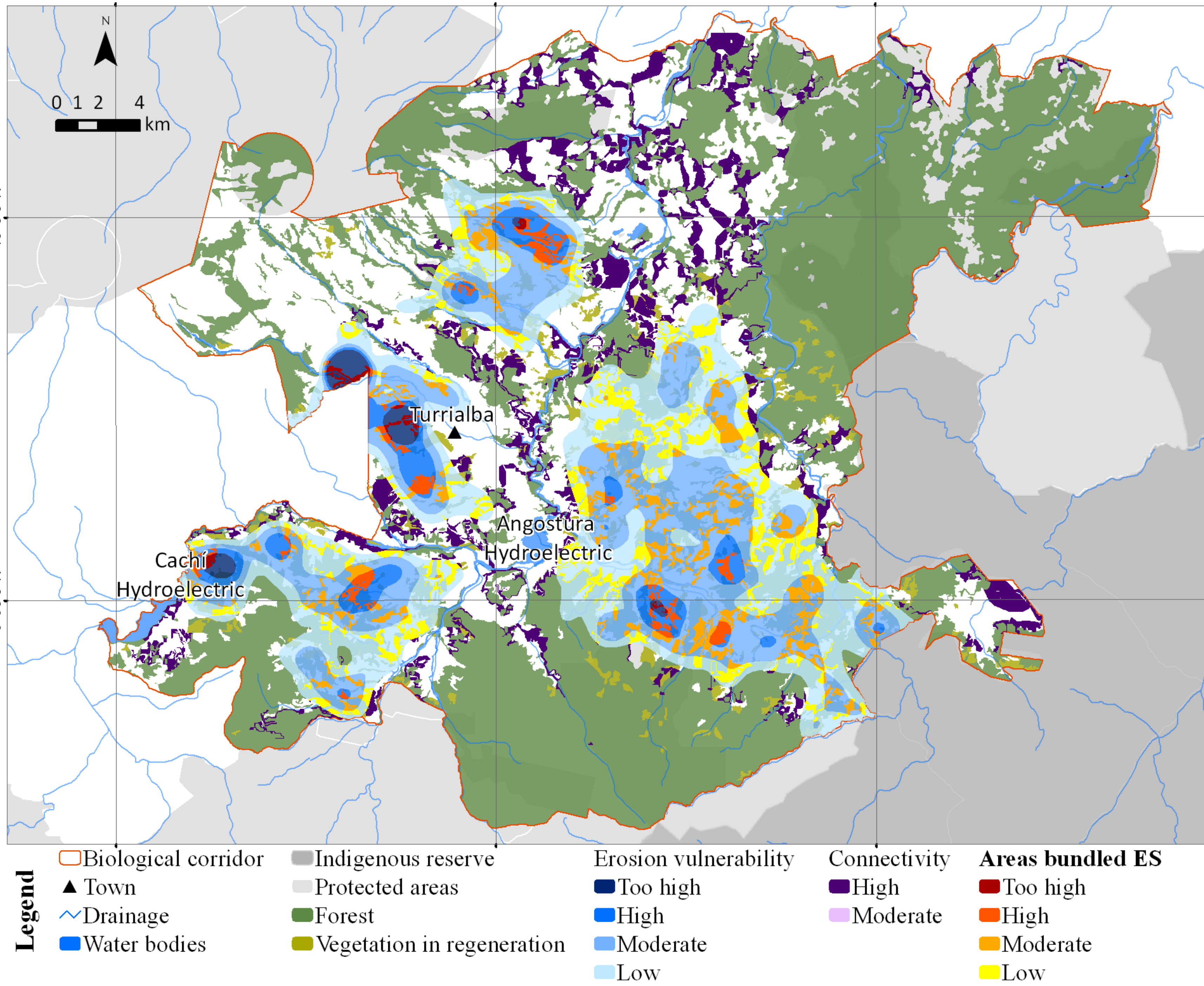


Avelino et al. 2012

Hypothetical Distance Weighted Dispersal Effects of Heterogenous Landuses



Based on work by F. DeClerck, Olivas, and J. Avelino



Estrada ad DeClerck (2011)

How reduce risks and failures

- Good agricultural practices
- Appropriate species (traits) choices (for functions)
- Genetic principles in selection of planting material (and maintaining diversity?)

Three Considerations

1. how multiple processes interact to provide a single function;
   - Genetic resistance
   - Habitat suitability
   - Immigration/emigration
   - Spillover effects
   - Functional diversity and its connectivity
2. the critical role of scale in (plot, field, landscape) in managing biodiversity for service provision and its interaction with farm management; and
3. Species traits: the what where and why.