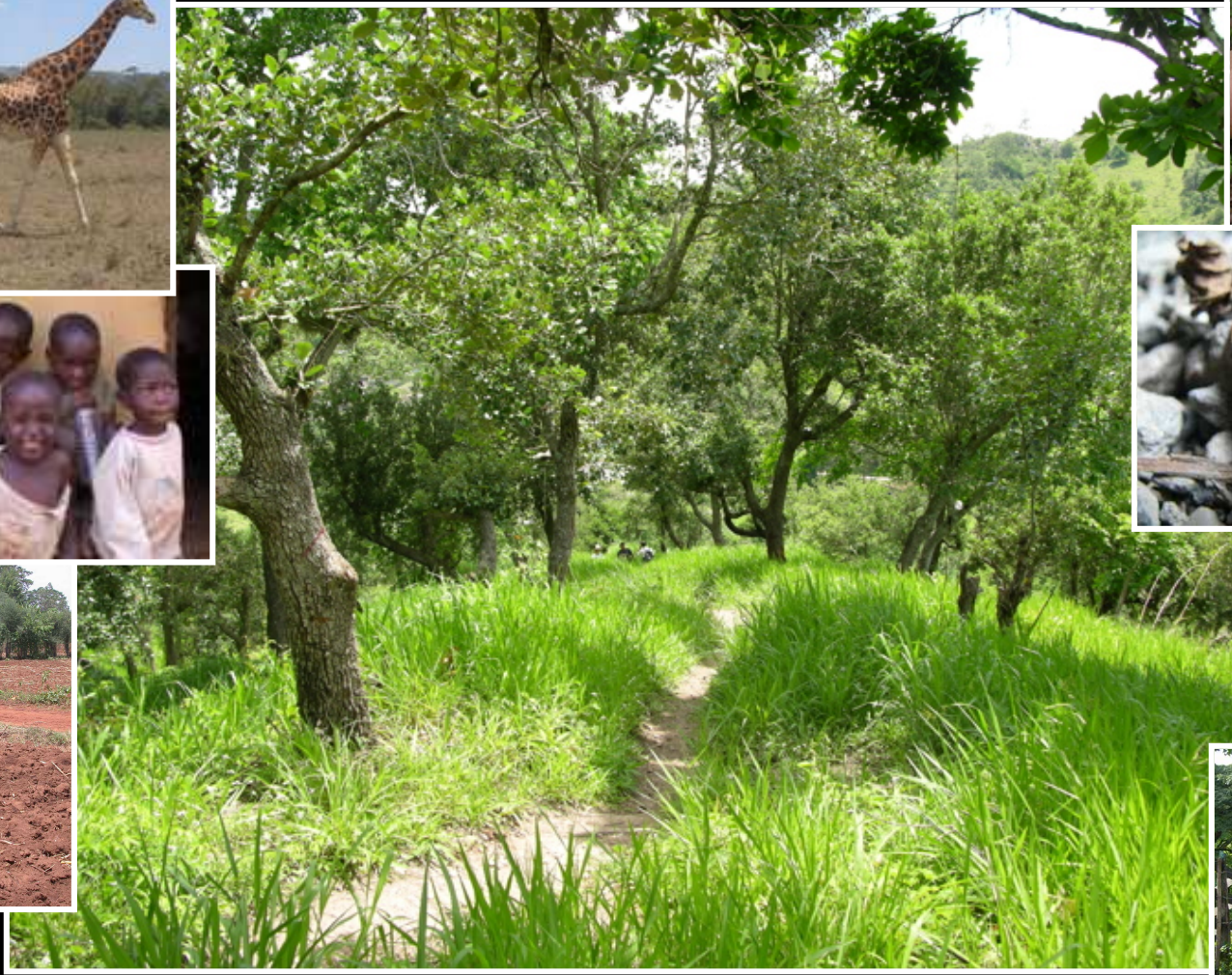
Integrating Biodiversity Conservation, Ecosystem Function in Agricultural Landscapes

Fabrice DeClerck





QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

CATIE

The Earth Institute AT COLUMBIA UNIVERSITY


What's poverty got to do with it?
M Sanjayan
P. Kareiva

Slide by Kareiva and Sanjayan

Where are conservation efforts most needed and most likely to improve the human condition?

Can we identify "*life raft ecosystems*" ?

= Areas with:

- high rates of poverty (% undernourished; n = 124)
- large portion of economy dependent upon nature (agriculture, fisheries, logging)
- severely degraded ecosystem services (%land cover cultivated, managed, urban)

The Millennium Development Goals:

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

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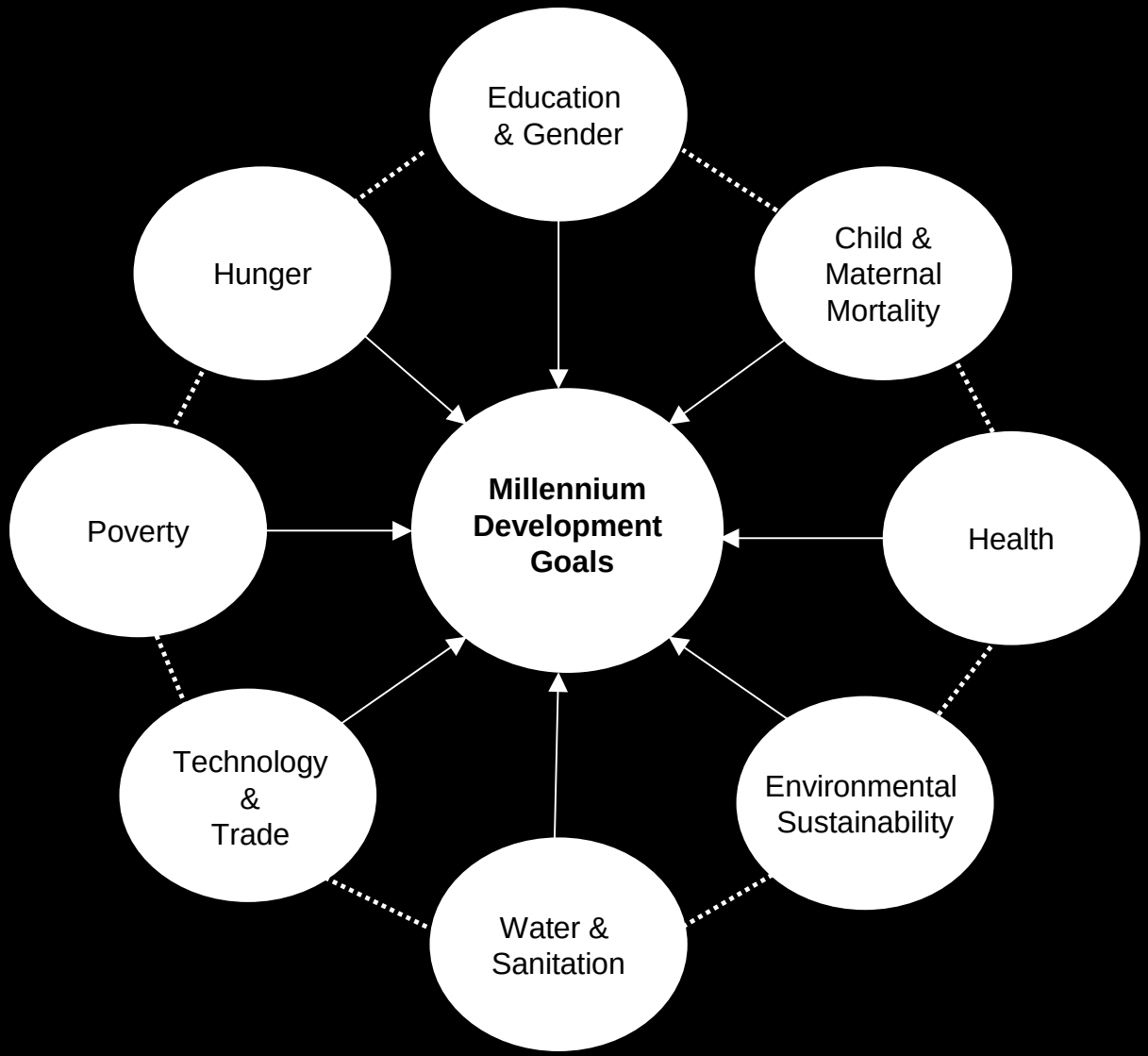

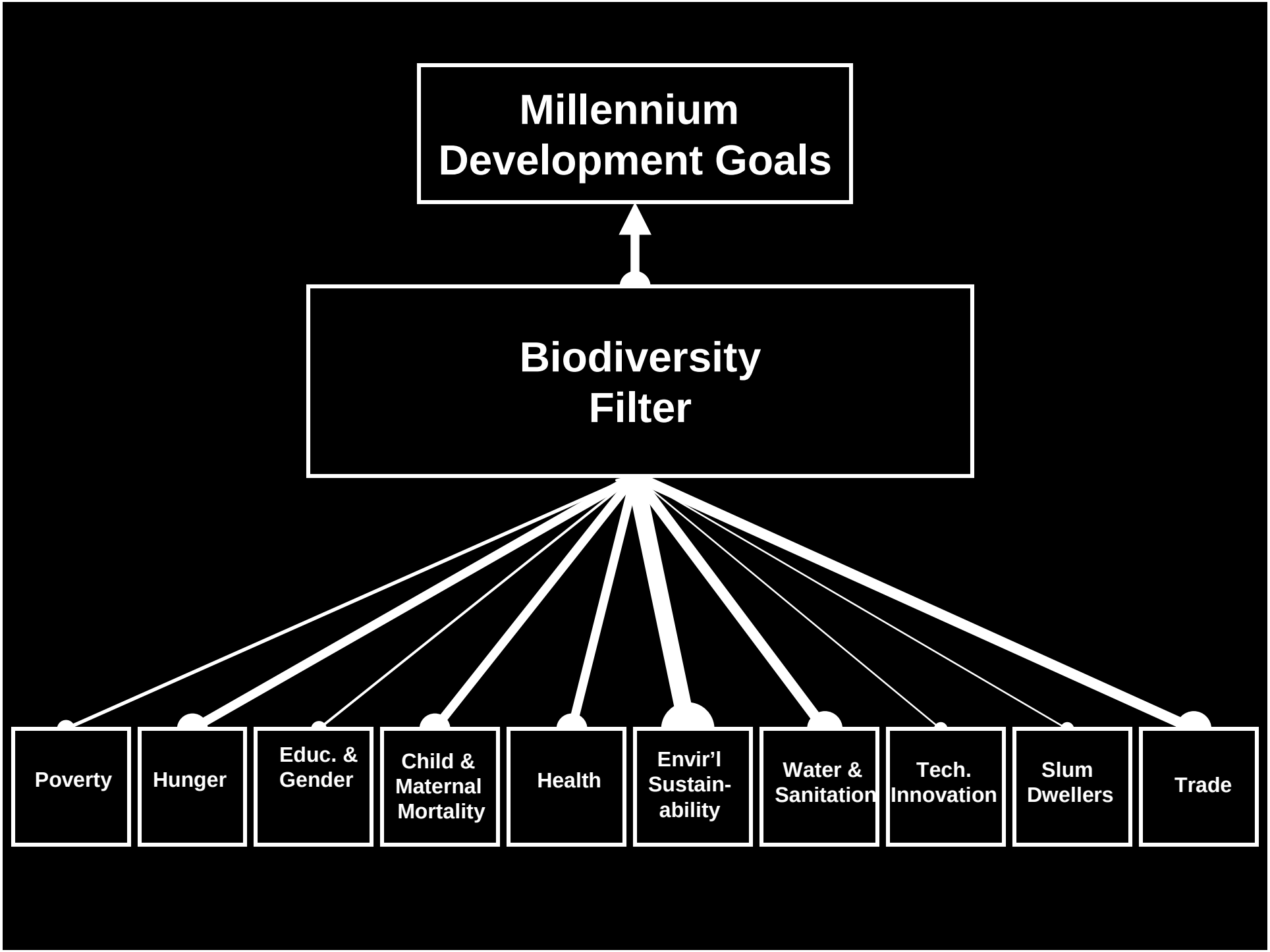
Millennium Development Goals
Biodiversity Filter
Poverty
Hunger
Educ. & Gender
Child & Maternal Mortality
Health
Envir'l Sustain-ability
Water & Sanitation
Tech. Innovation
Slum Dwellers
Trade

Biodiversity conservation as

a result of

poverty alleviation

Biodiversity conservation as

<u>means to</u>

poverty alleviation

What is BIODIVERSITY

- Species: number of species in a system
- Genetic: variability of genetic information in the system
- Vertical: distinct horizontal layers or levels
- Horizontal: pattern of spatial distribution
- Structural: number of (niches)
- Functional: number of species which serve different roles.
- Temporal: Degree of heterogeneity of cyclical changes (daily, seasonal) in the system.

The sum of these diversities equals ecological diversity

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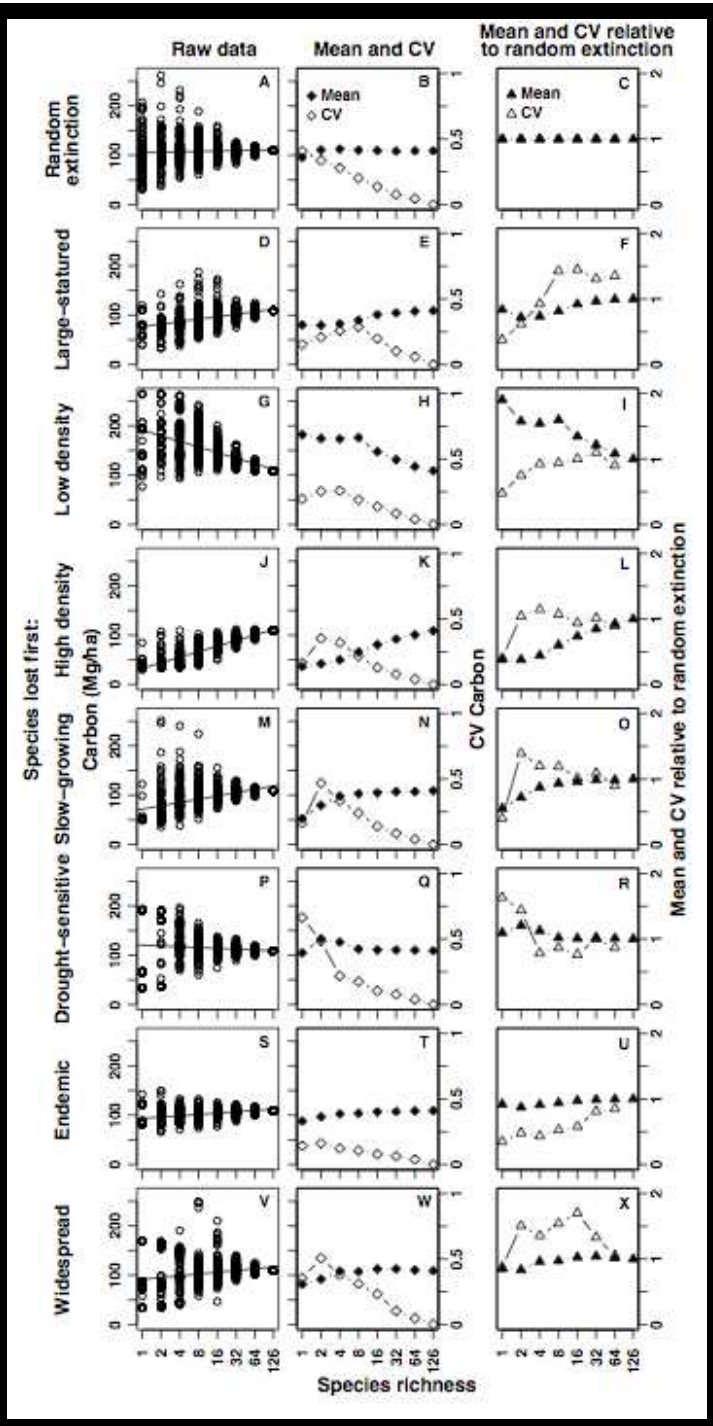
The sum of these diversities equals ecological diversity

Diversity Matters!!

When tree species are removed from a tropical forest, the amount of carbon stored by that forest can vary by as much as 600% depending on which species remain!!

Bunker, DeClerck and Naeem
Science 2006



Pollination in coffee Systems

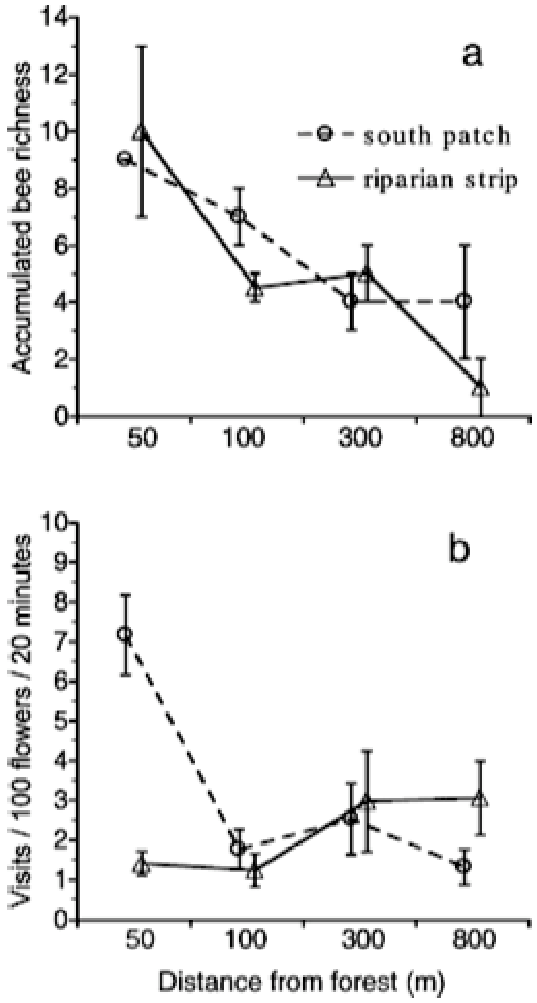


Figure 4. Measures of 2002 bee activity (mean ± SE) along distance gradients from south patch and from riparian strip (Fig. 1b): (a) accumulated bee richness (i.e., all samples per site pooled) and (b) rate of bee visitation (all species) to coffee flowers (for definition, see Results section).

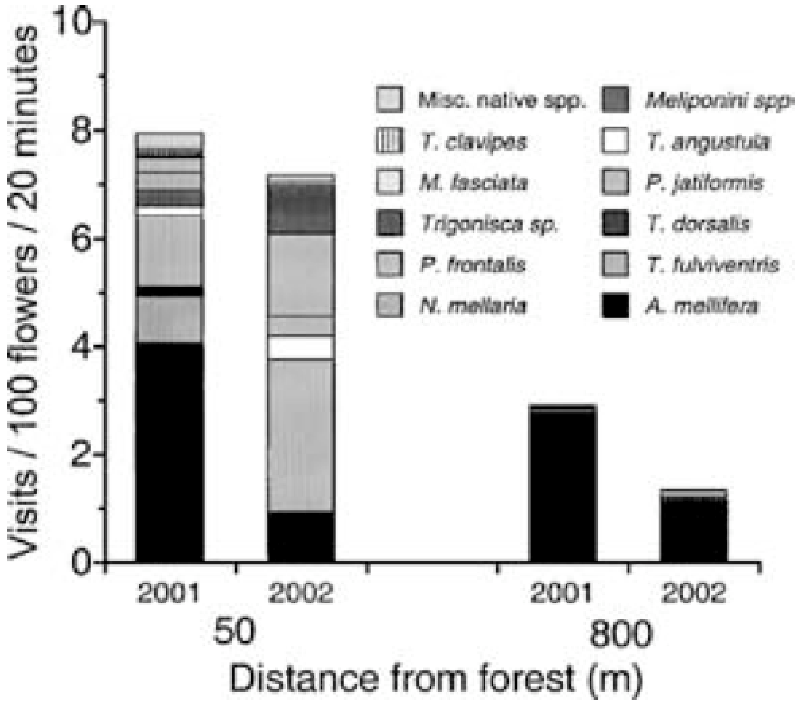


Figure 3. Rate of bee visitation to coffee flowers at 50- and 800-m distance classes from the south patch in 2001 and 2002. Each bar segment represents the mean visitation rate for the corresponding species (error bars are omitted for clarity). Species appear in the stacked bars in the same order as in the legend. Full names are provided in Table 1.

Ricketts al 2004

Productivity Increases with Diversity

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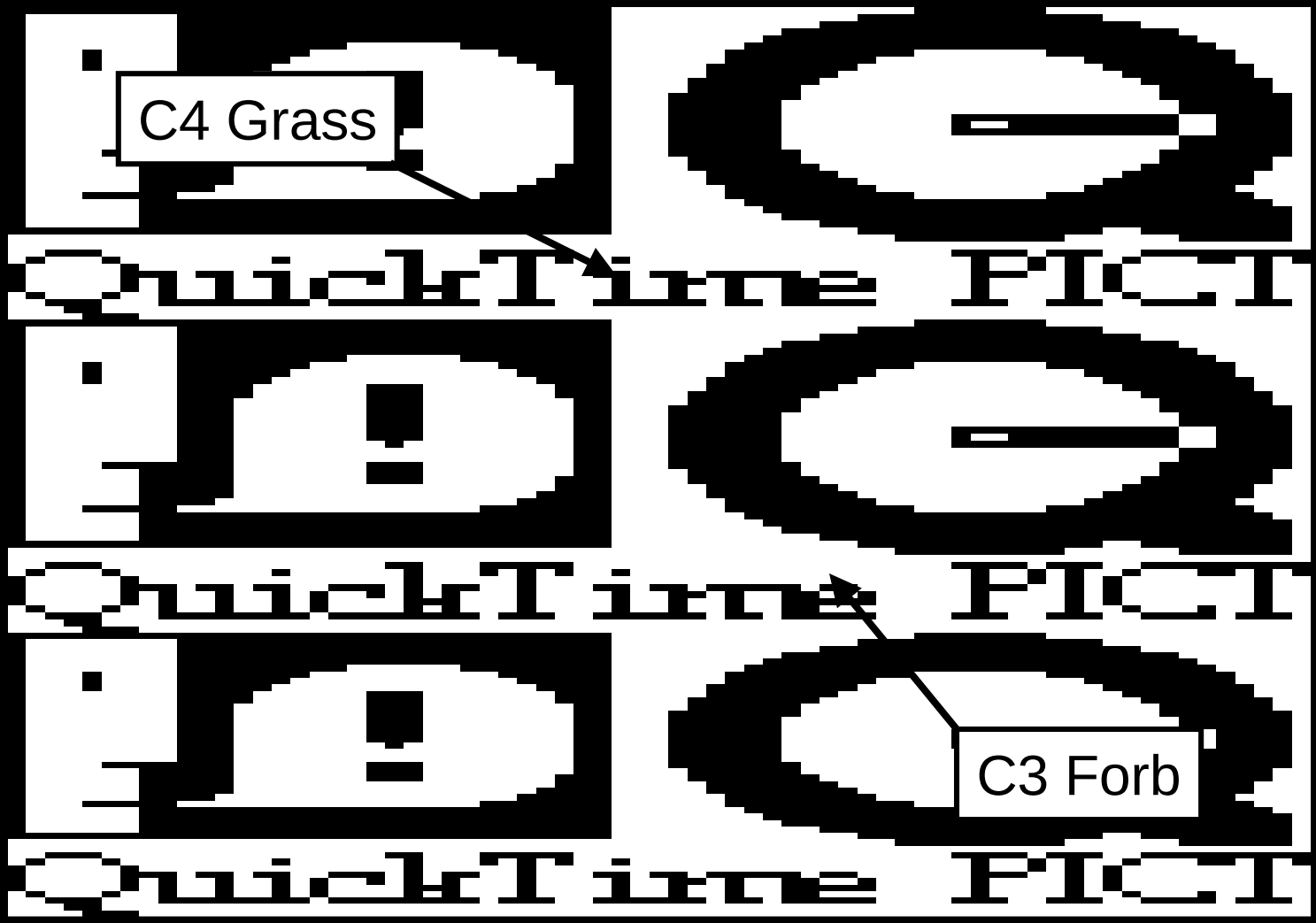


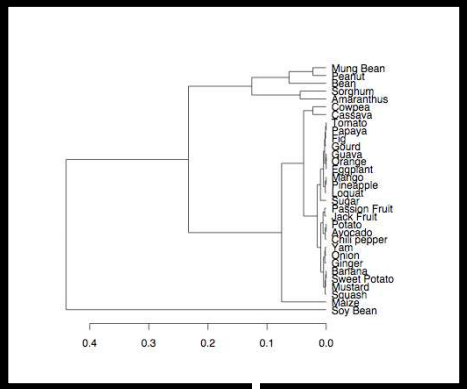
Productivity Increases with Diversity

Productivity Increases with Diversity

“Functional diversity, what an American concept, it doesn’t matter who you are, just what you do!” -Pedro Sanchez

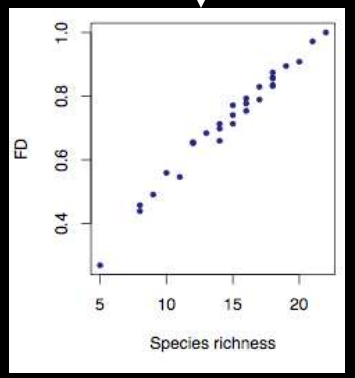
Functional Diversity (FD)

Species x Trait matrix

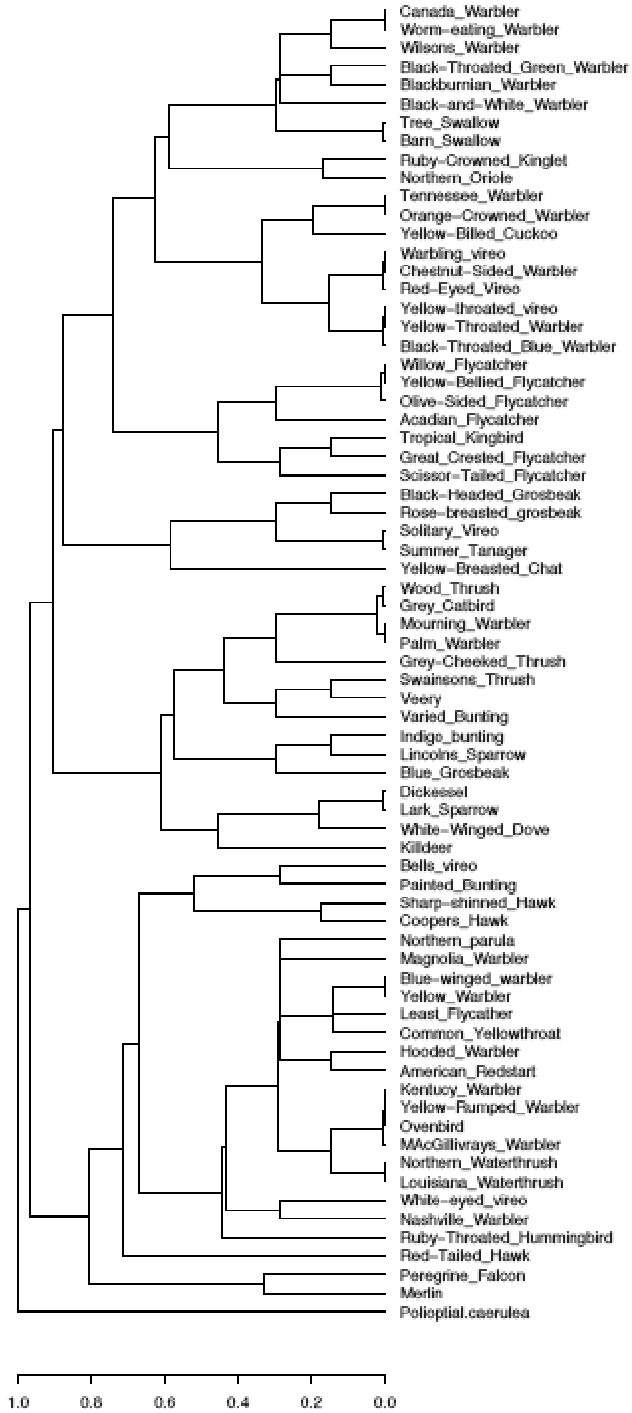


Species x Composition matrix

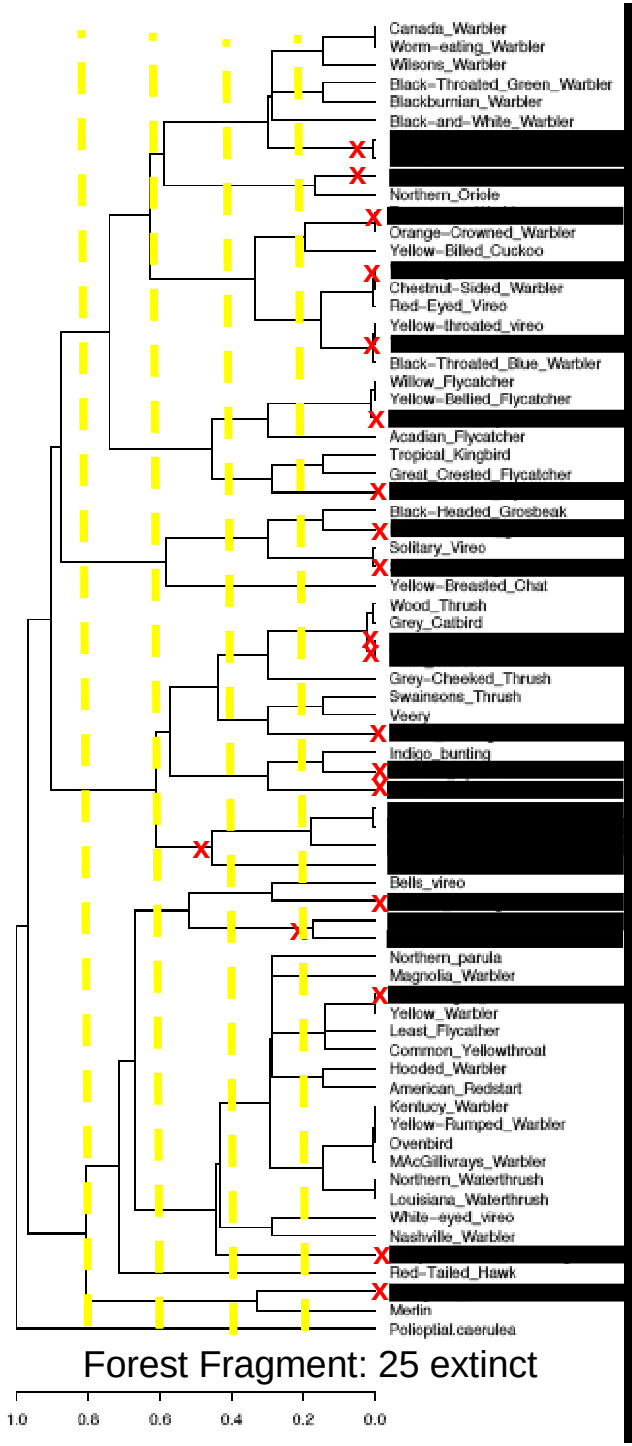
Community FD



F. DeClerck



What is functional redundancy within taxonomic groups with land use change?



Forest Fragment: 25 extinct

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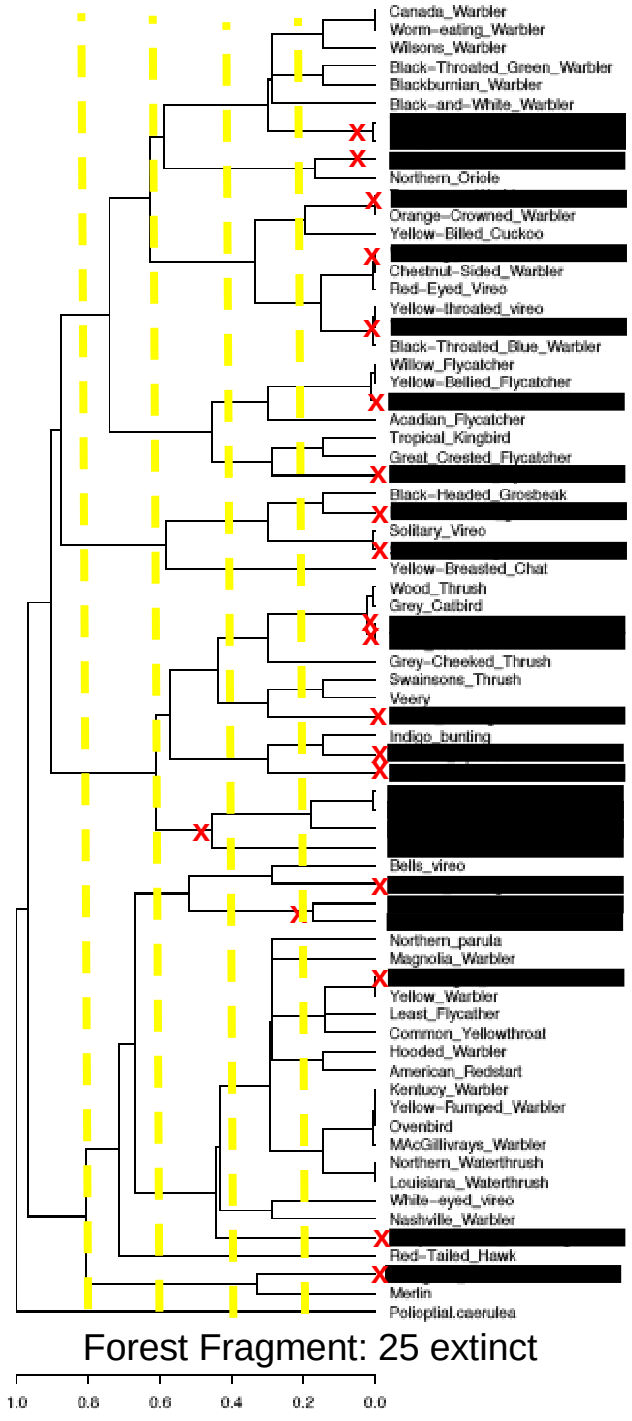
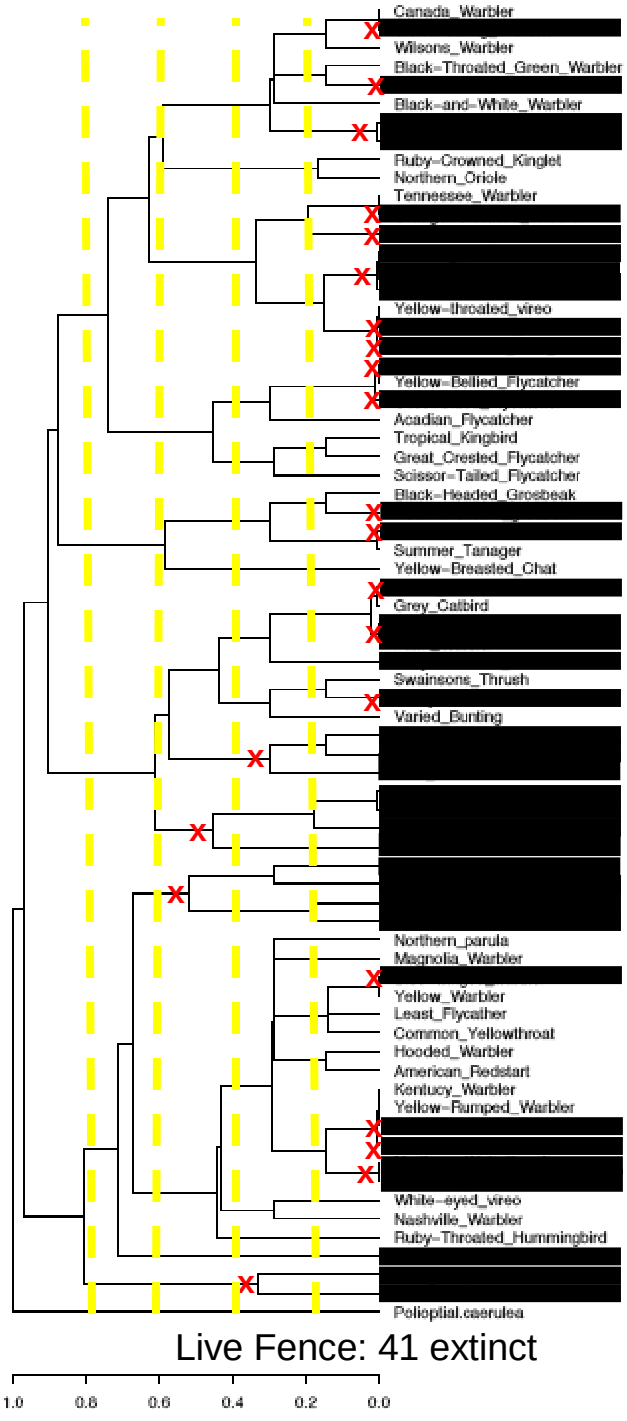
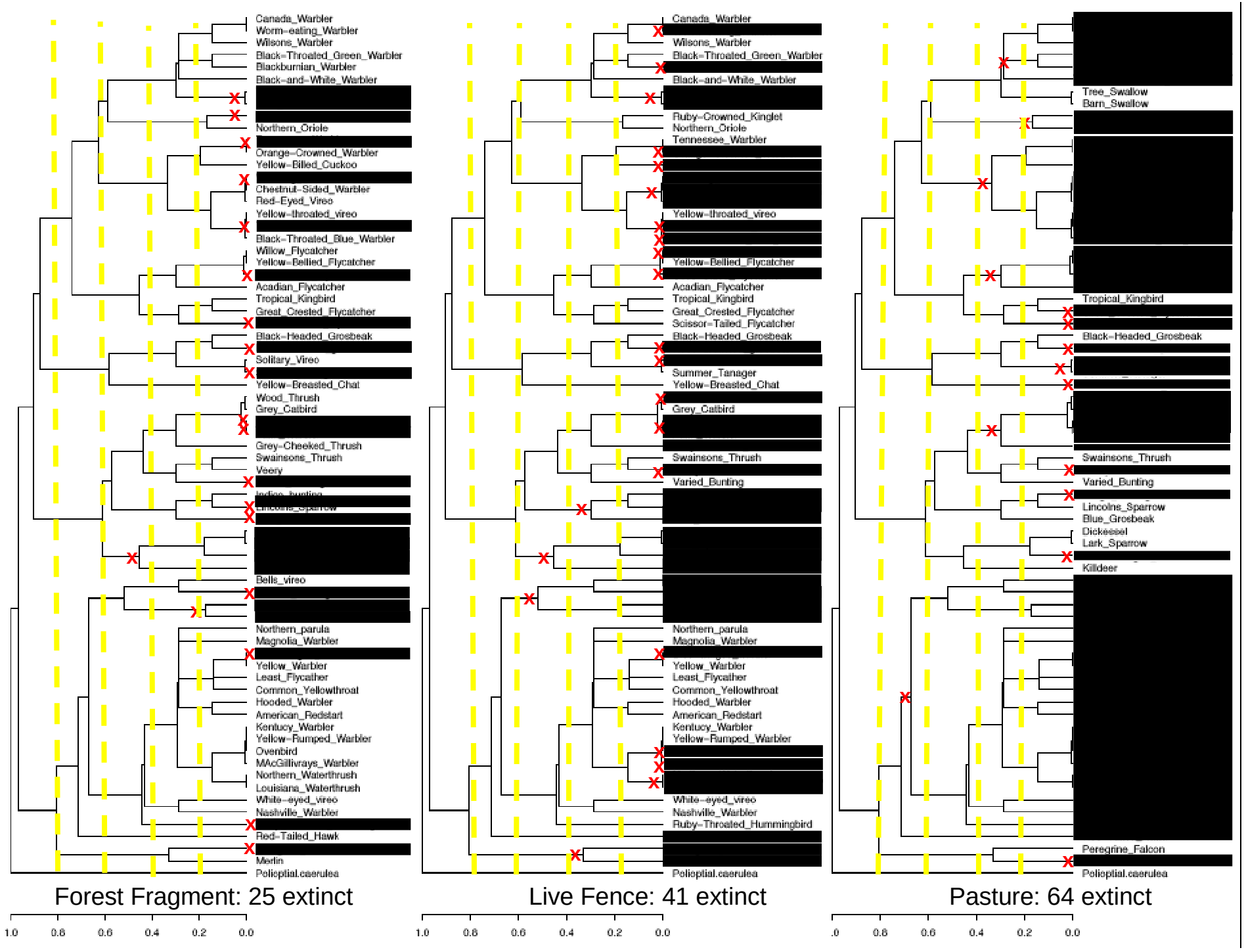


Forest Fragment: 25 extinct



Live Fence: 41 extinct


Canada_Warbler
Worm−eating_Warbler
Wilsons_Warbler
Black−Throated_Green_Warbler
Blackburnian_Warbler
Black−and−White_Warbler
Northern_Oriole
Orange−Crowned_Warbler
Yellow−Billed_Cuckoo
Chestnut−Sided_Warbler
Red−Eyed_Vireo
Yellow−throated_vireo
Black−Throated_Blue_Warbler
Willow_Flycatcher
Yellow−Bellied_Flycatcher
Acadian_Flycatcher
Tropical_Kingbird
Great_Crested_Flycatcher
Black−Headed_Grosbeak
Solitary_Vireo
Yellow−Breasted_Chat
Wood_Thrush
Grey_Catbird
Grey−Cheeked_Thrush
Swainsons_Thrush
Veery
Bells_vireo
Northern_parula
Magnolia_Warbler
Yellow_Warbler
Least_Flycather
Common_Yellowthroat
Hooded_Warbler
American_Redstart
Kentucy_Warbler
Yellow−Rumped_Warbler
Ovenbird
MAcGillivrays_Warbler
Northern_Waterthrush
Louisiana_Waterthrush
White−eyed_vireo
Nashville_Warbler
Red−Tailed_Hawk
Merlin
Polioptial.caerulea
Forest Fragment: 25 extinct
1.0
0.8
0.6
0.4
0.2
0.0
Canada_Warbler
Wilsons_Warbler
Black−Throated_Green_Warbler
Black−and−White_Warbler
Ruby−Crowned_Kinglet
Northern_Oriole
Tennessee_Warbler
Yellow−throated_vireo
Yellow−Bellied_Flycatcher
Acadian_Flycatcher
Tropical_Kingbird
Great_Crested_Flycatcher
Scissor−Tailed_Flycatcher
Black−Headed_Grosbeak
Summer_Tanager
Yellow−Breasted_Chat
Grey_Catbird
Swainsons_Thrush
Varied_Bunting
Northern_parula
Magnolia_Warbler
Yellow_Warbler
Least_Flycather
Common_Yellowthroat
Hooded_Warbler
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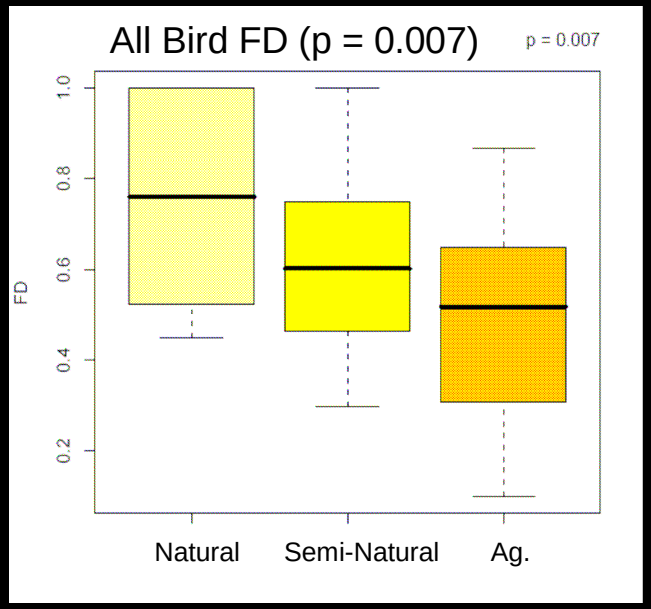
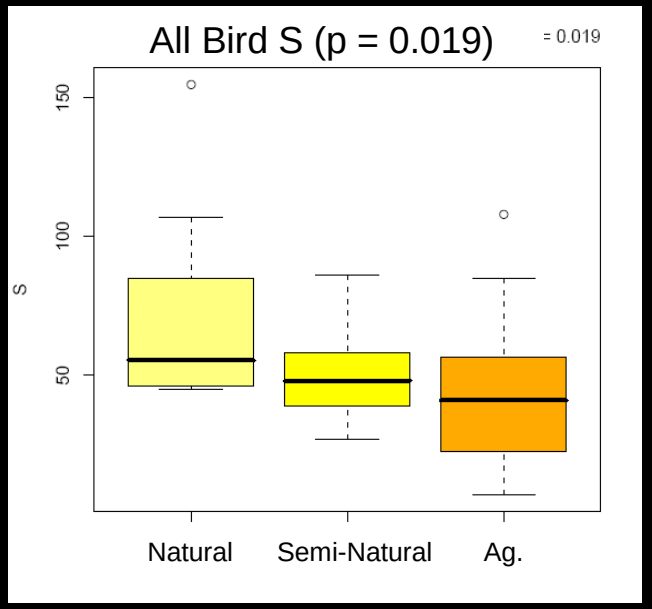
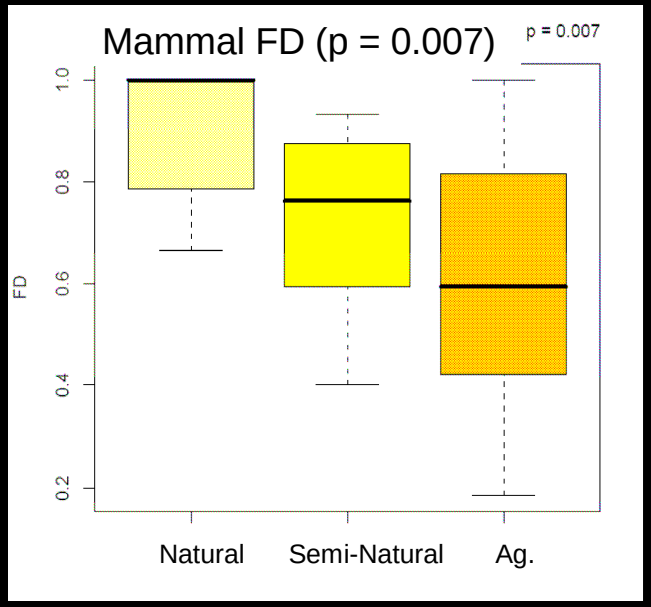
Polioptial.caerulea
Live Fence: 41 extinct
1.0
0.8
0.6
0.4
0.2
0.0
Tree_Swallow
Barn_Swallow
Tropical_Kingbird
Black−Headed_Grosbeak
Swainsons_Thrush
Varied_Bunting
Lincolns_Sparrow
Blue_Grosbeak
Dickeesel
Lark_Sparrow
Killdeer
Peregrine_Falcon
Polioptial.caerulea
Pasture: 64 extinct
.0
0.8
0.6
0.4
0.2
0.0

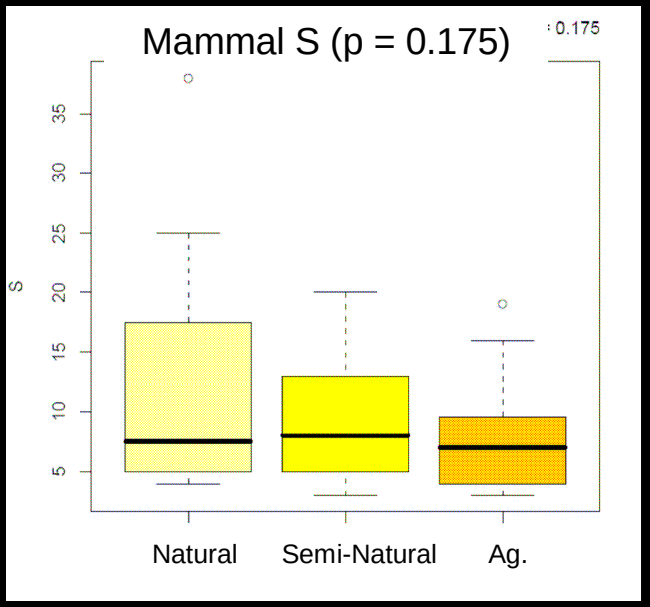
Relationship between loss of functional diversity and land use intensity? (birds)



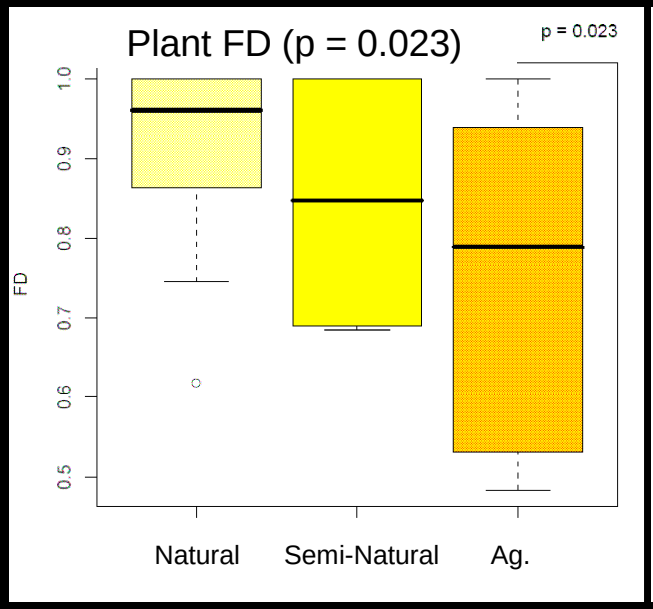


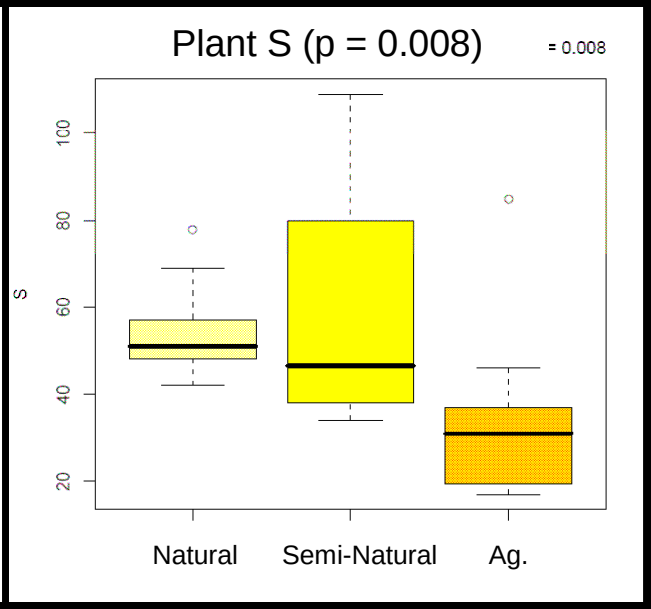
Relationship between loss of functional diversity and land use intensity? (mammals)

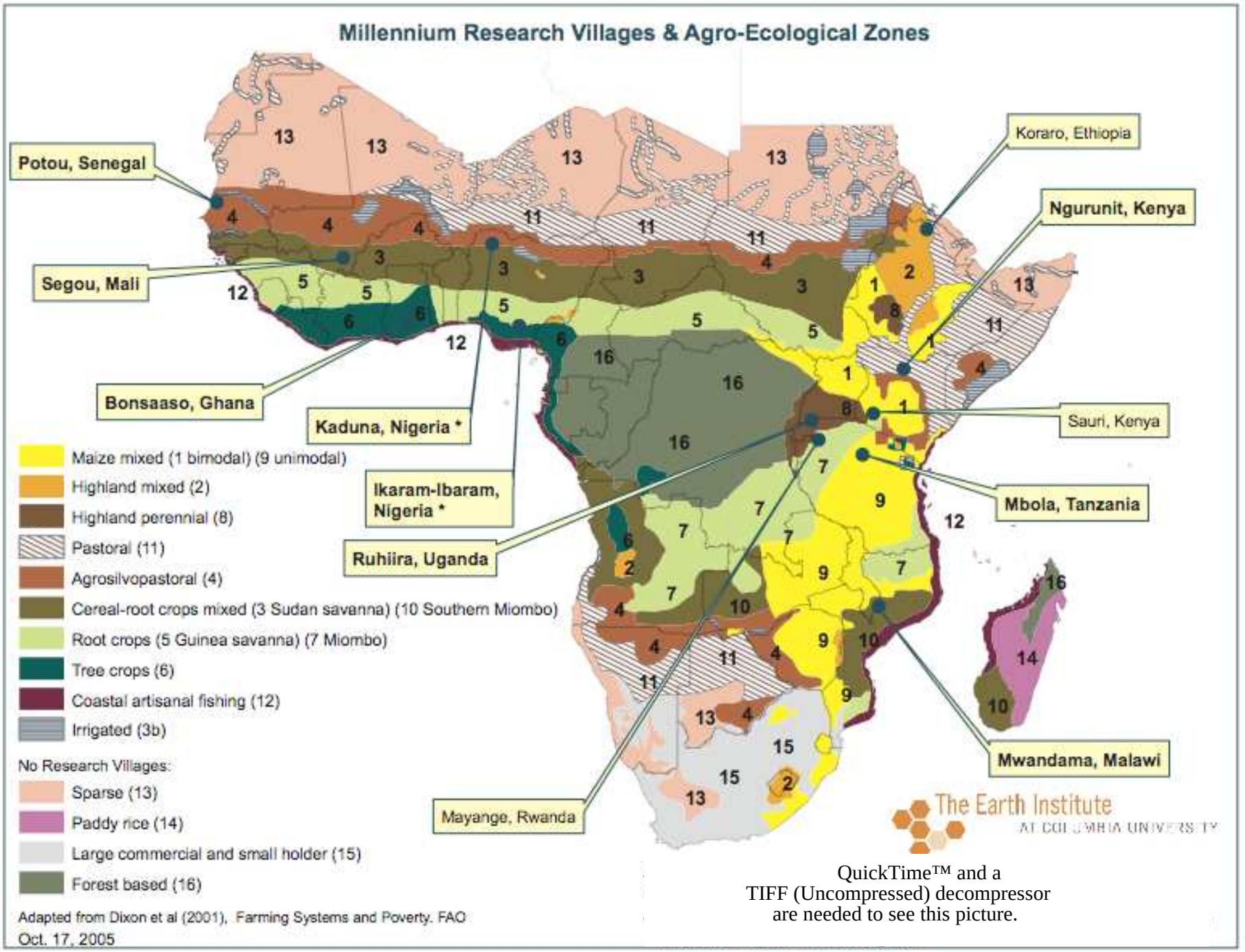




Relationship between loss of functional diversity and land use intensity? (plants)







QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

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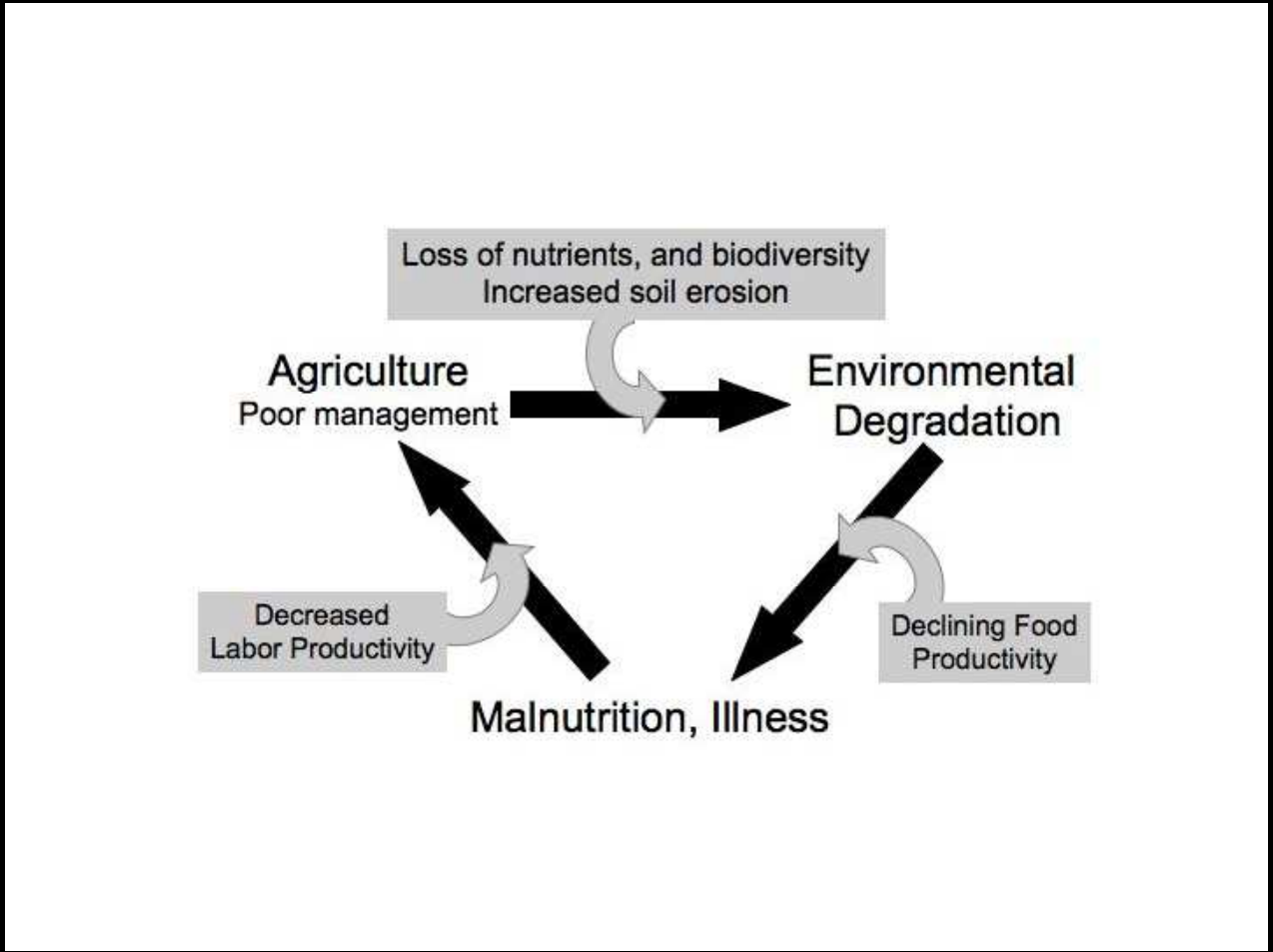
F. DeClerck

EcoNutrition: the interrelationships among nutrition and human health, agriculture and food production, environmental health and economic production



Deckelbaum, Palm, Mutuo and F. DeClerck

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Measure field biodiversity

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

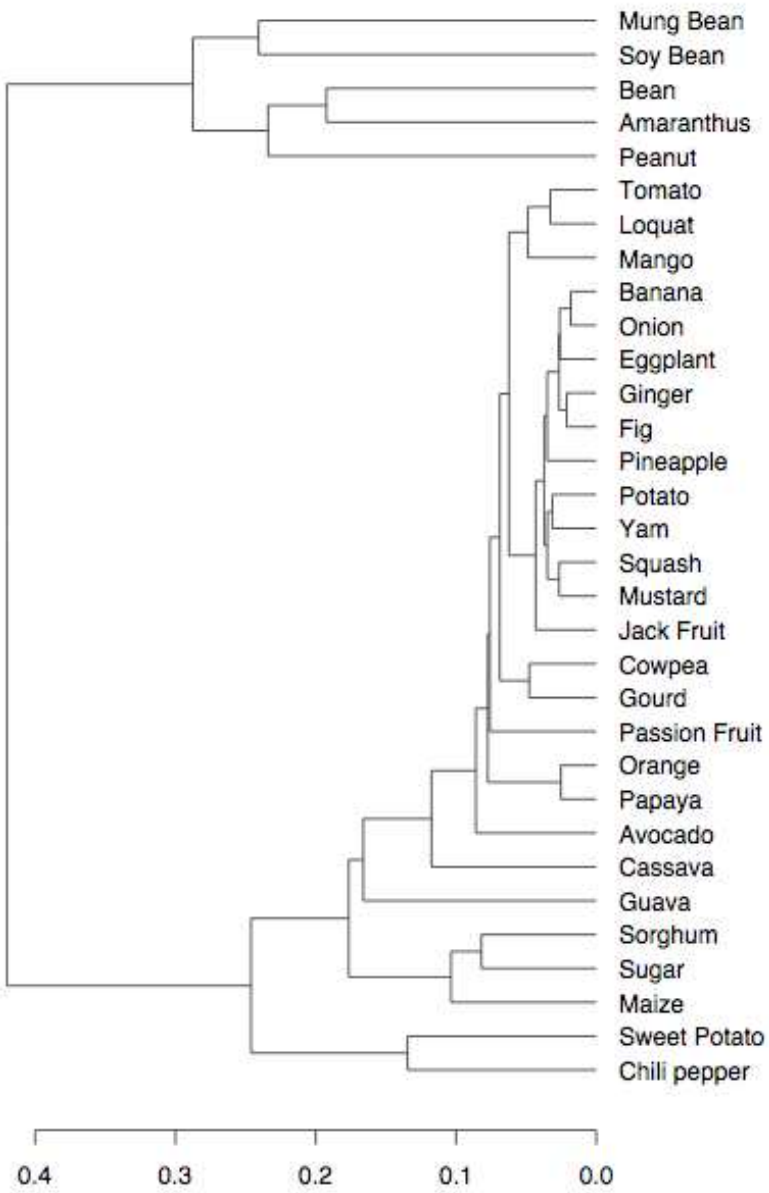
F. DeClerck

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Sauri Agrobiodiversity

- Over 146 plant species found
- 39 Edible Species
- Mean of 14 edible species per farm
- Ranging from 5 - 22 edible plant species
- Mean 1.5 cattle, half a sheep, a quarter goat and 7 chickens.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.



Seven Traits

1) Protein
2) Energy
3) Vitamin A
4) Vitamin C
5) Iron
6) Zinc

F. DeClerck

QuickTime™ and a
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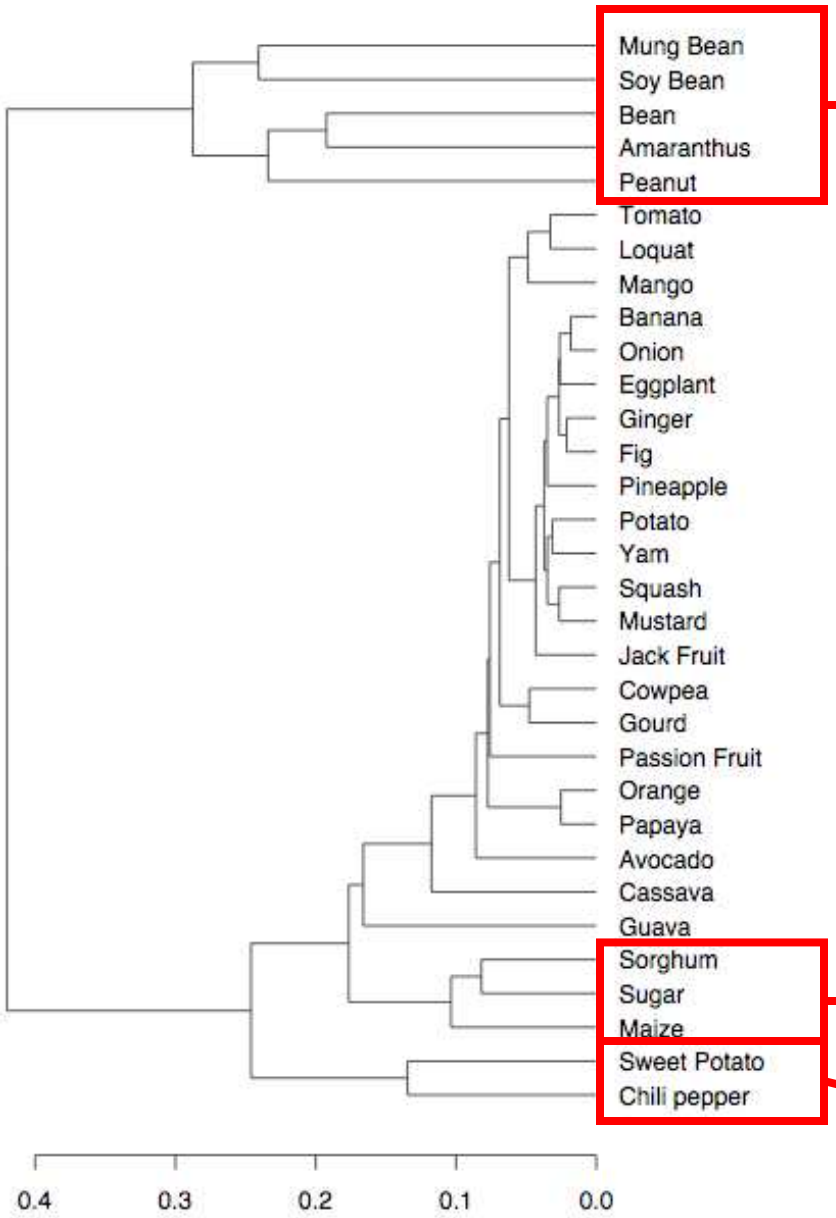
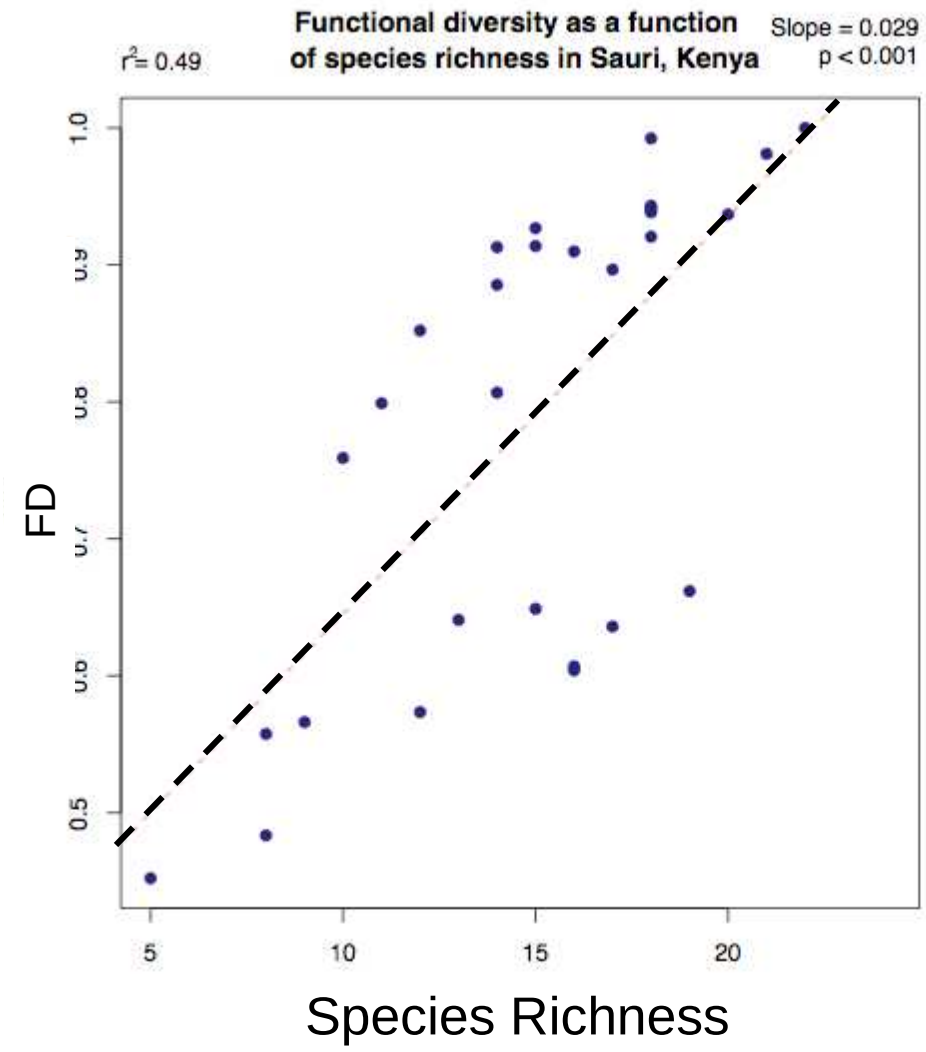


High Protein

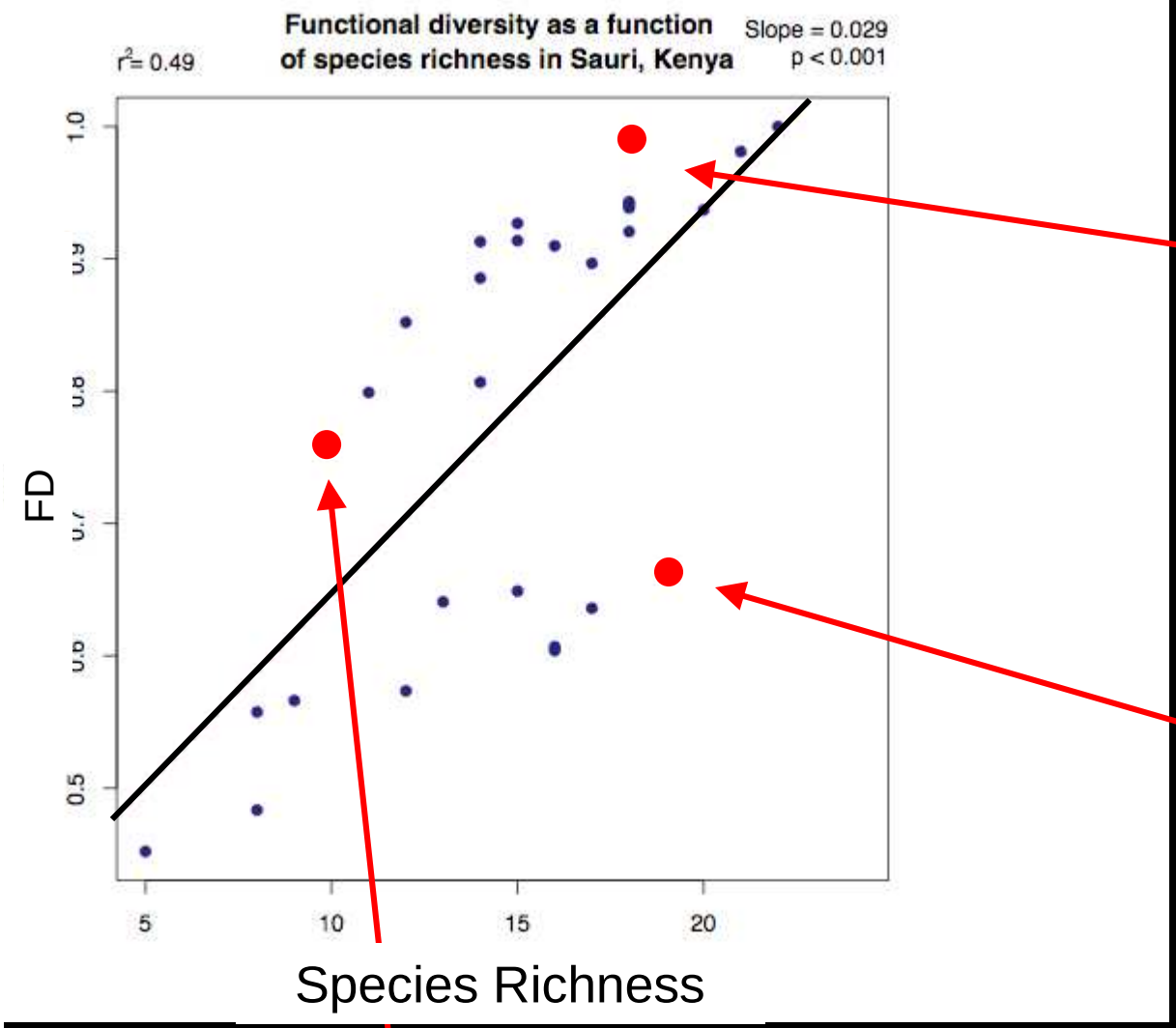
High Energy

High Vit A

F. DeClerck


Functional diversity as a function of species richness in Sauri, Kenya
r^2= 0.49
Slope = 0.029
p < 0.001
FD
1.0
0.9
0.8
0.7
0.6
0.5
5
10
15
20
Species Richness

F. DeClerck

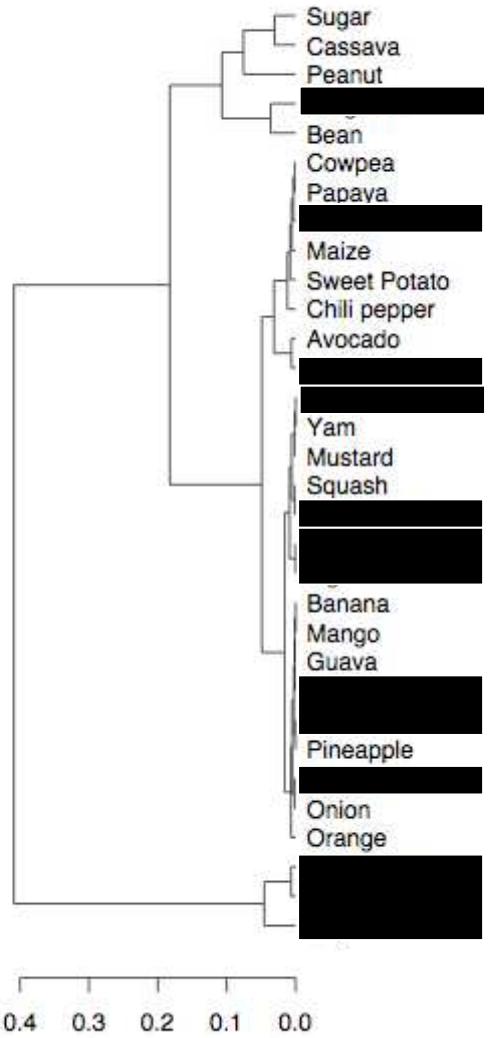


Farm 201201
Species Richness = 18
FD = 0.99

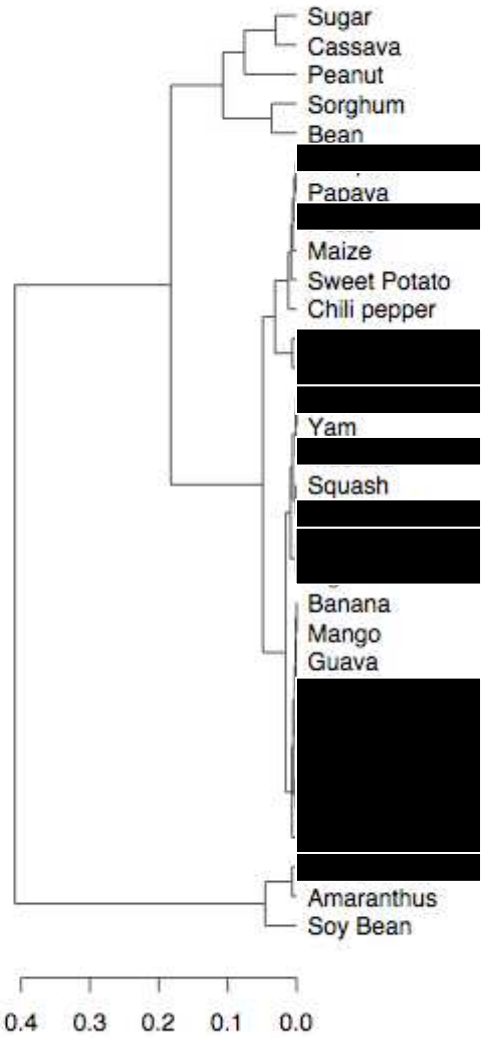
Farm 103801
Species Richness = 19
FD = 0.66

Farm 600102
Species Richness = 10
FD = 0.76

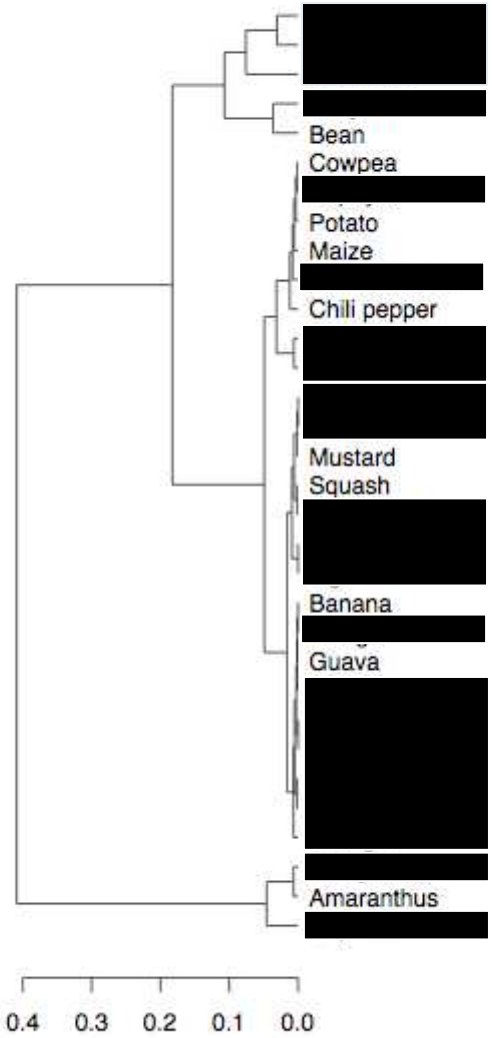
F. DeClerck



Farm 103801
Species Richness = 19
FD = 0.66

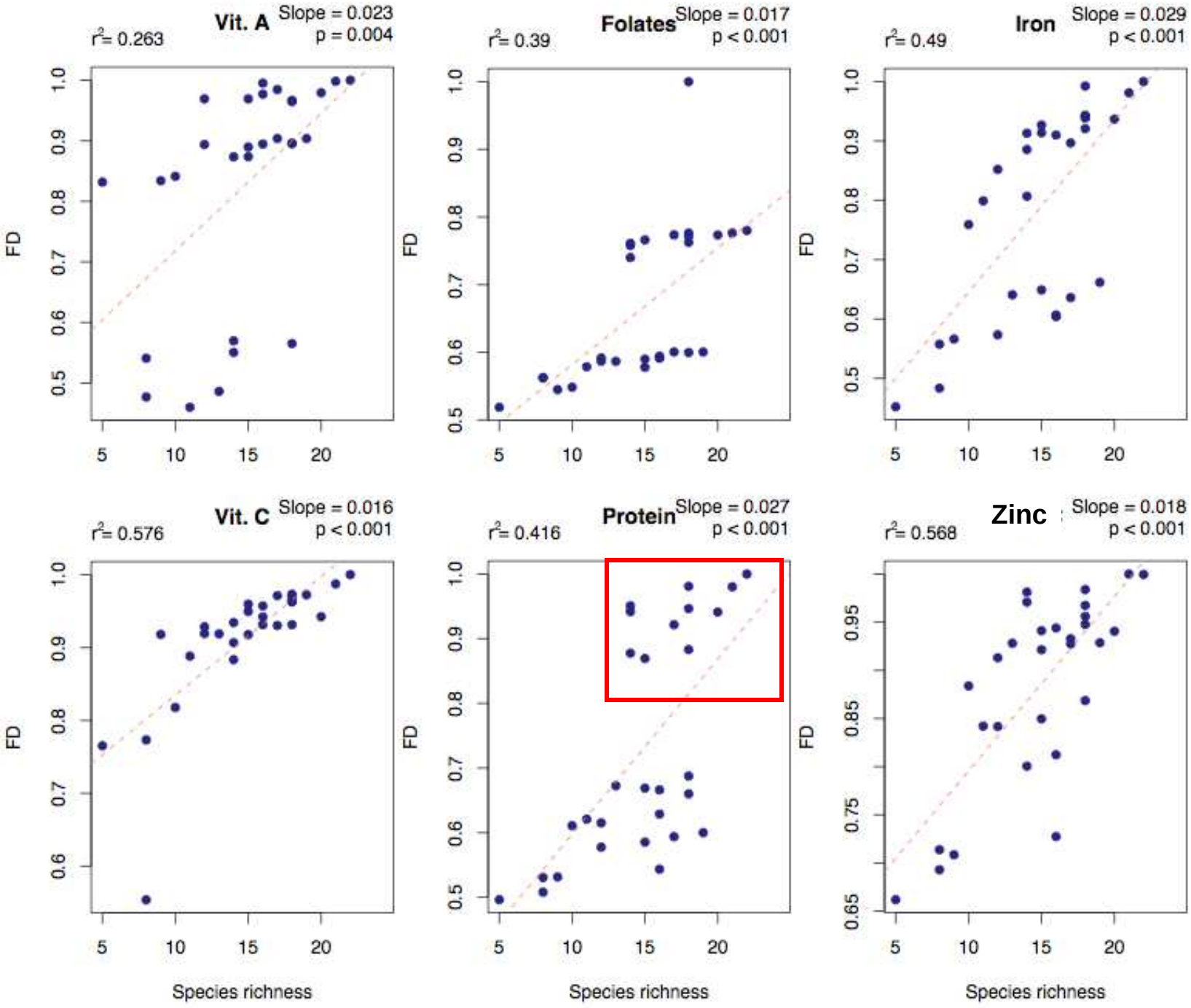


Farm 201201
Species Richness = 18
FD = 0.99

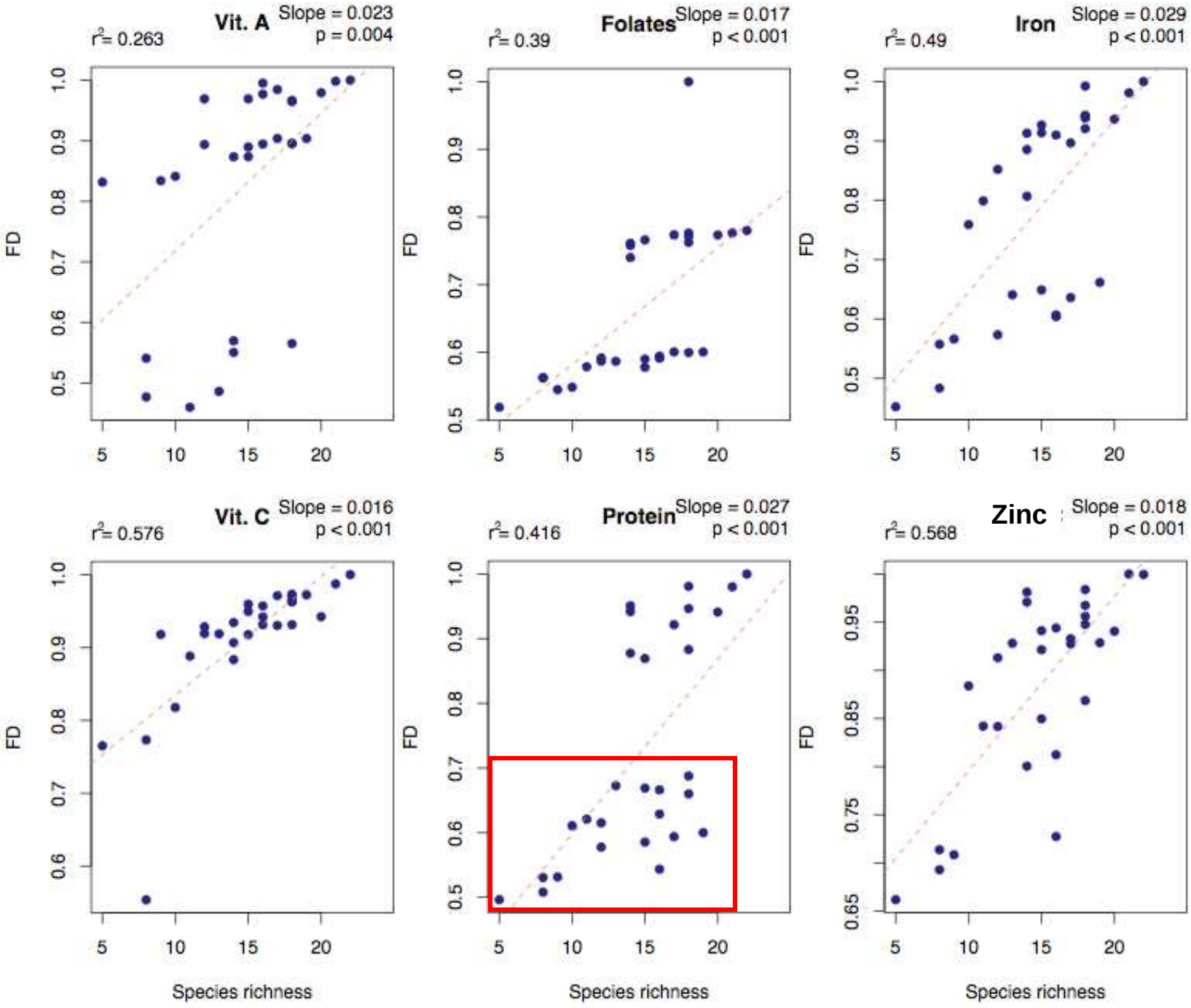


Farm 600102
Species Richness = 10
FD = 0.76

F. DeClerck


Vit. A
Slope = 0.023
p = 0.004
r²= 0.263
Folates
Slope = 0.017
p < 0.001
r²= 0.39
Iron
Slope = 0.029
p < 0.001
r²= 0.49
Vit. C
Slope = 0.016
p < 0.001
r²= 0.576
Protein
Slope = 0.027
p < 0.001
r²= 0.416
Zinc
Slope = 0.018
p < 0.001
r²= 0.568
FD
Species richness

F. DeClerck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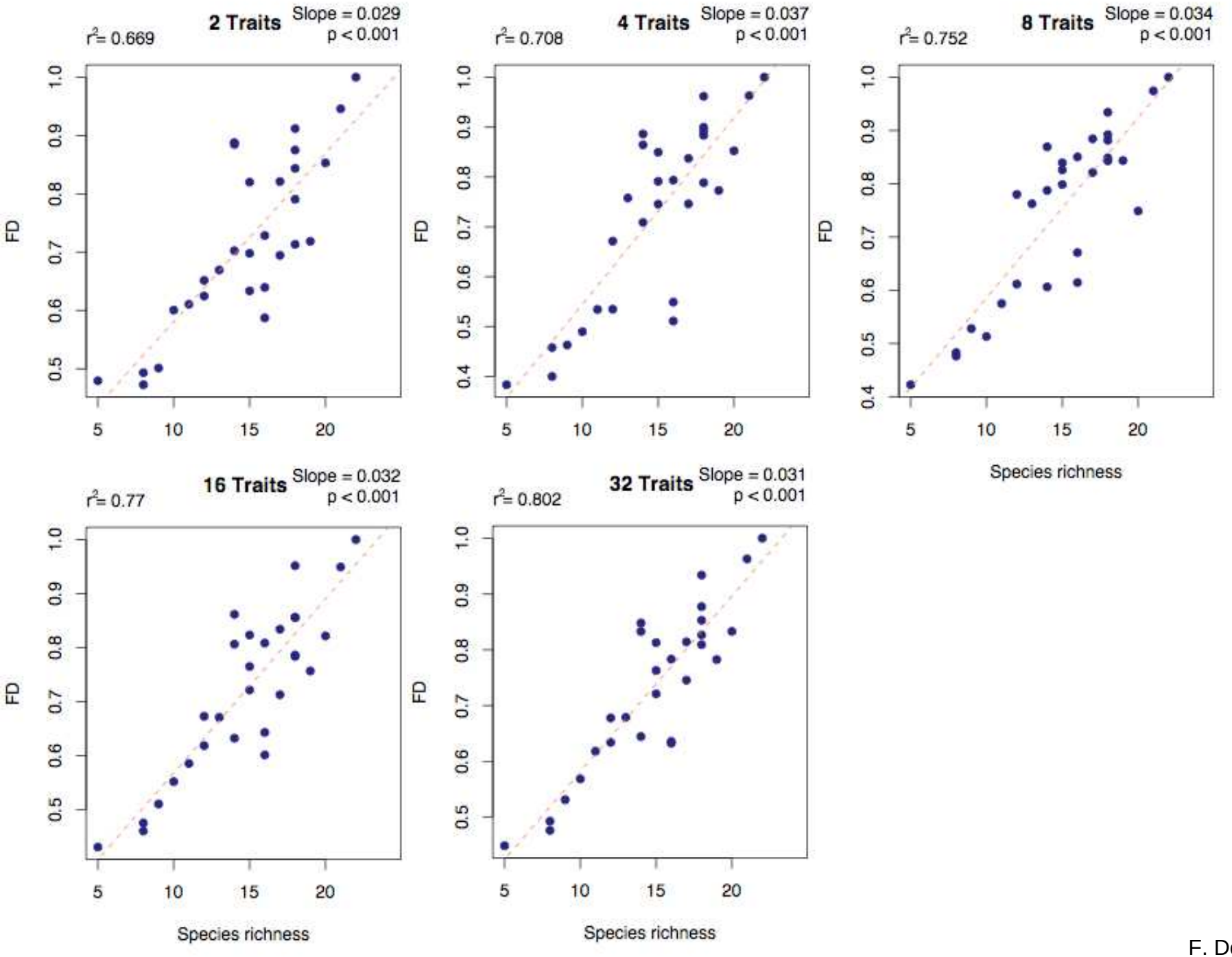
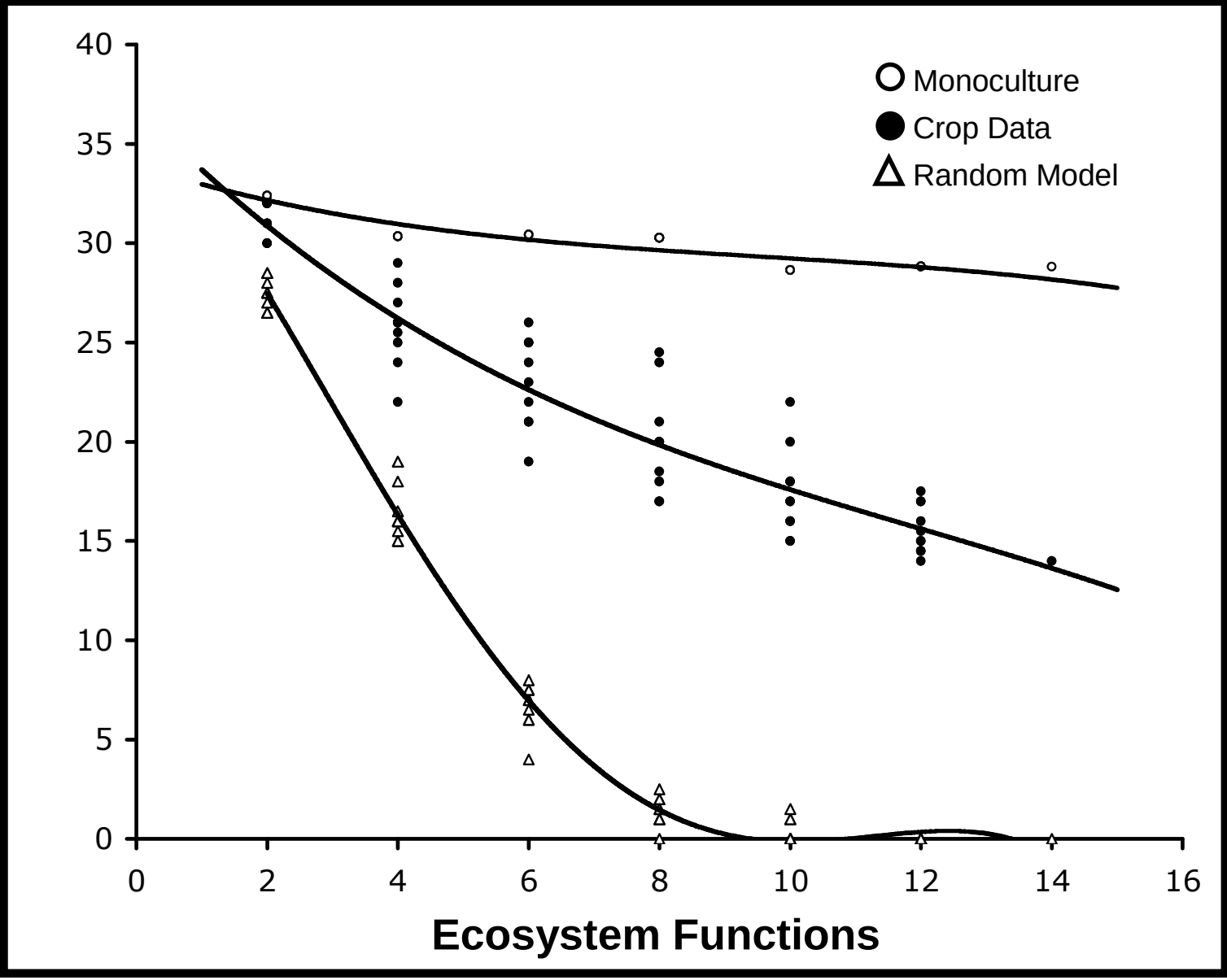

2 Traits
Slope = 0.029
p < 0.001
r2= 0.669
4 Traits
Slope = 0.037
p < 0.001
r2= 0.708
8 Traits
Slope = 0.034
p < 0.001
r2= 0.752
16 Traits
Slope = 0.032
p < 0.001
r2= 0.77
32 Traits
Slope = 0.031
p < 0.001
r2= 0.802
FD
Species richness

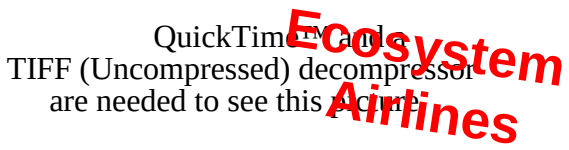
F. DeClerck

Redundancy decreases with the number of ecosystem functions of interest



F. DeClerck

A complex issue, but very simple warning…



Ehrlich 1994

The role of ecological theory and practice in poverty alleviation and environmental conservation

Fabrice DeClerk[1], Jane C Ingram[1], and Cristina M Rumbaitis del Rio[1,2]

The fight agains
Goals, which ai
poverty alleviati
millions of peop
dying from pre
ways in which e
tion programs.

Front Ecol Environ 2006

In September of 20
Millennium Develo
the new millennium w
eradication of extrem
centrations of extrem
tudes, coinciding wit
rates of environmen
loss. This overlap has
development goals wi
implementation will
tion. Others point ou
measures have result
by limiting people
(Brockington and Sch

Integrating environ

I

- Ecology offers many
reduce hunger, provid
energy, decrease disea

Leveraging ecological knowledge to end global poverty

Globally, 1.2 billion people live on less than US$1 per day. This population is highly dependent on natural resources for daily survival, whether they live in rural or urban areas. Often, the poorest people are the most vulnerable to the effects of degradation of natural resources, loss of ecosystem services, and natural disasters. Thus, the application of ecological knowledge is central to improving living conditions for the world's poor.

At the Ecological Society of America's 2005 Annual Meeting in Montreal, more than 50 ecologists gathered to identify specific ways in which ecology could be used in poverty alleviation. It was clear to the group that ecologists are needed to "paint the big picture". The tradition of elucidating complex systems and relationships while working across scales and disciplines equips ecologists with the tools necessary to tackle the similarly complex and multifaceted problems associated with poverty. Much of the ecological knowledge needed to address the challenges of poverty already exists and is well developed. Ecologists must now focus on using this knowledge in appropriate socioecological contexts as well as on identifying remaining knowledge gaps. Fundamental roles for ecologists in the development arena include directly applying ecological theory to problem solving, designing development projects, and conceptualizing the issues involved in poverty alleviation.

Many ecological theories can be directly and proactively applied to solve major development challenges. For instance, ecological theories have been used to inform interventions targeted at enhancing soil fertility, maintaining water quality and quantity, and managing malaria-carrying mosquito populations. Conservation biology and landscape ecology theories have been used to design woodlots that provide habitat corridors for avifauna and pollinators, as well as meeting community fuelwood needs.

The ecological appreciation of complexity provides an analytical foundation for designing large-scale devel-

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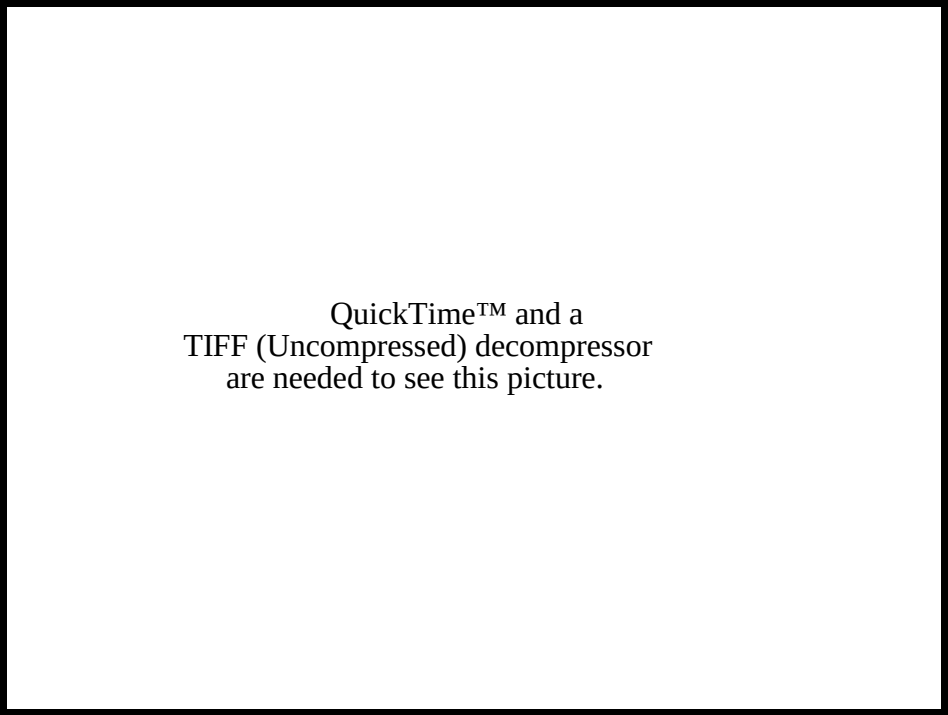

"There can be no peace without equitable development; and there can be no development without sustainable management of the environment in a democratic and peaceful space. This shift is an idea whose time has come."

Wangari Maathi, Nobel Peace Prize Recipient 2004