Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

42ND LCA DISCUSSION FORUM: INTEGRATING BIODIVERSITY INTO LIFE CYCLE ASSESSMENT

Alpha-Palmiers Hotel, Lausanne, 19 Nov 2010



Organizers and mediators: Francesca Verones, Michael Curran and Laura de Baan[1]

Host: Quantis

[1]Institute of Environmental Engineering (IfU), Section Ecological Systems Design (ESD), ETH Zurich

Important anouncements

- Last minute changes to programme

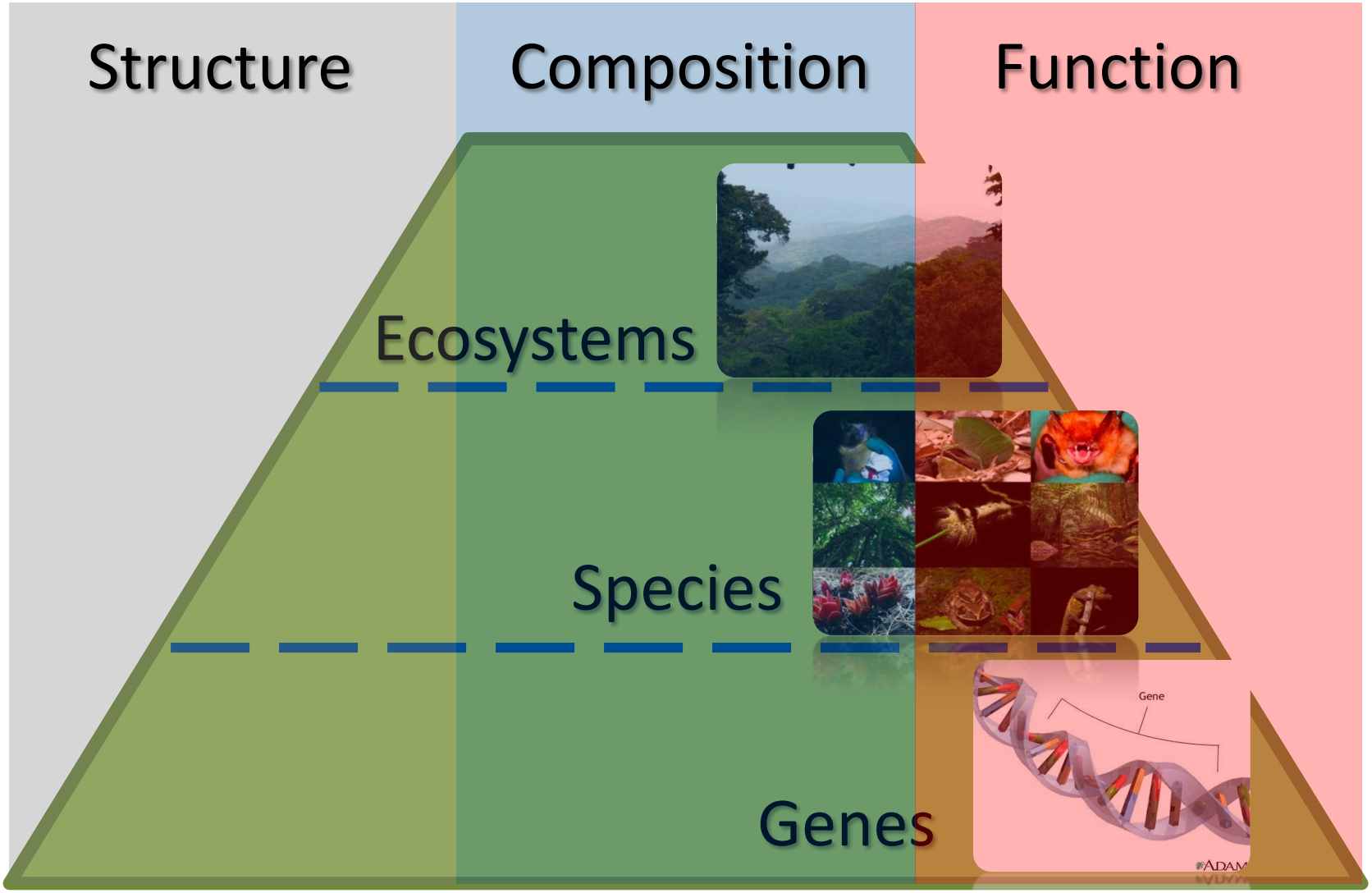
14.40	Assessing impacts to biodiversity: myth and reality	Pedro Rosabal, IUCN, Gland, Switerland

- Topics for discussion

www.getentrepreneurial.com

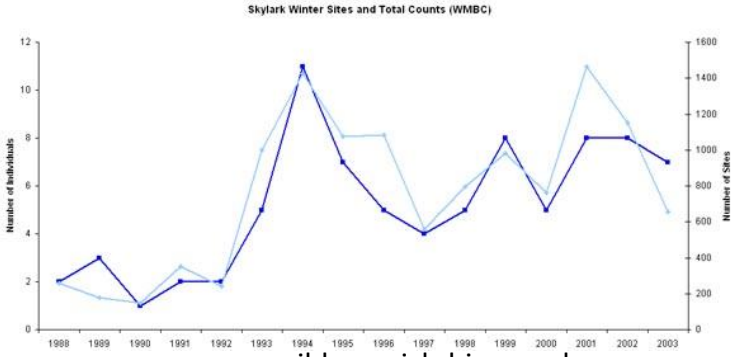
catalog.bestteachersupply.com

Biodiversity → biological complexity…

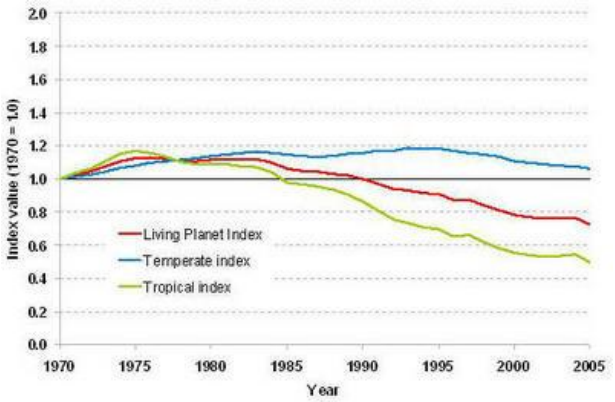


Biodiversity → patterns through time…

- Short-term perspective

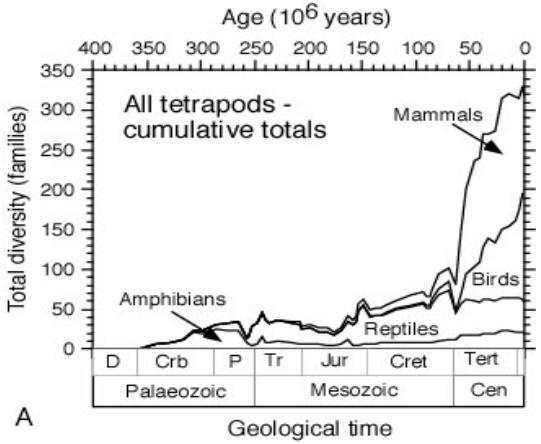


www.wildwarwickshire.co.uk

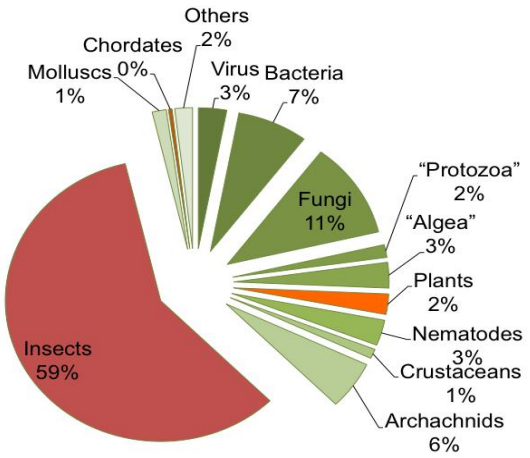


Loh et al. 2005

- Evolutionary perspective



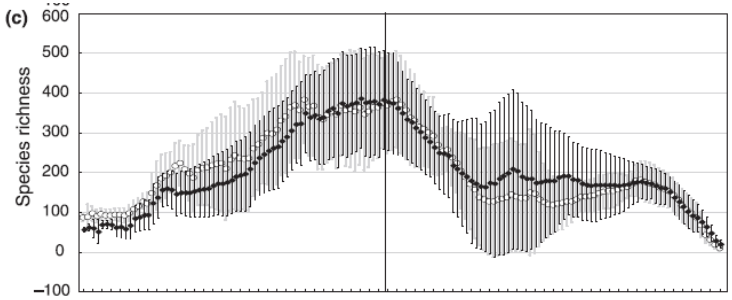
palaeo.gly.bris.ac.uk



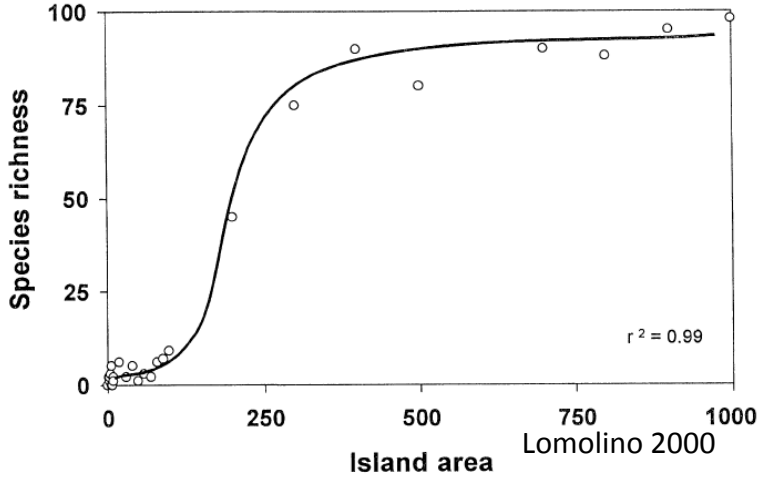
Haywood and Watson 1995

Biodiversity → patterns through space…

- Latitude and area

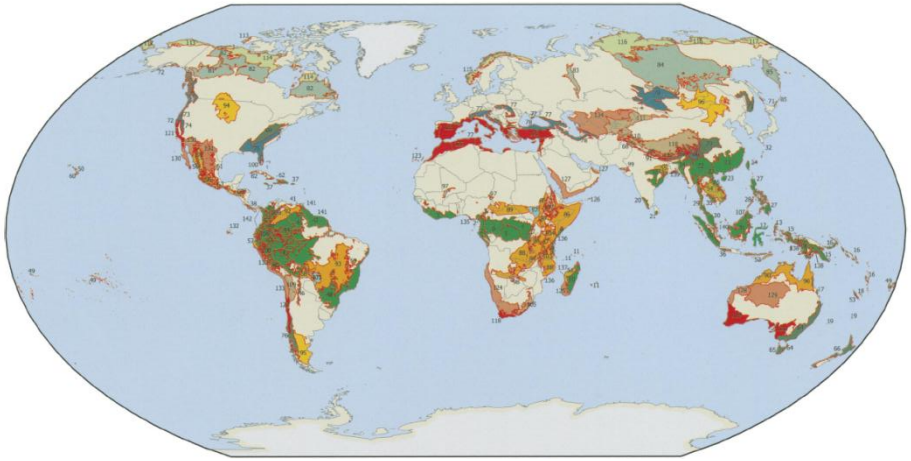


Storch et al. 2006

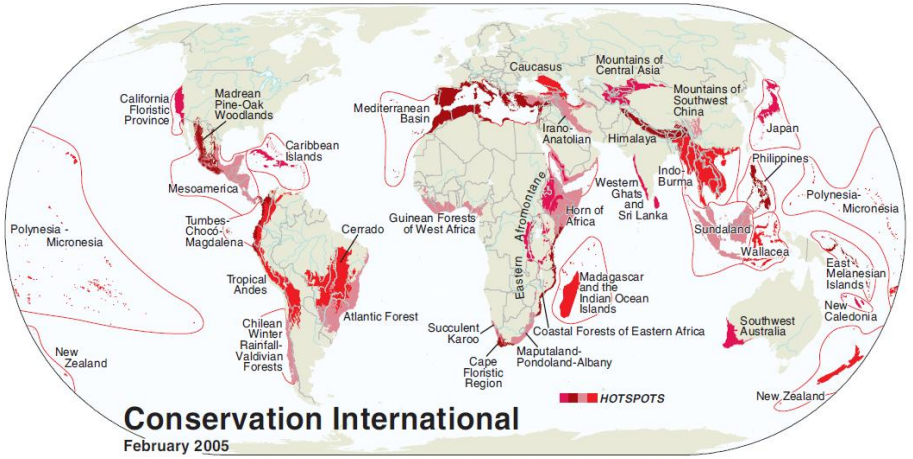


Lomolino 2000

- Global centres of diversity



Global 200 ecoregions; Oslen and Dinerstein 2002



Hotspots; Mitermier et al. 2005

Biodiversity *loss* → the "Big 5"

***Habitat change and fragmentation**: Deforestation in the Amazon (NASA Terra)*

***Invasive species**: Water lettuce in the US*

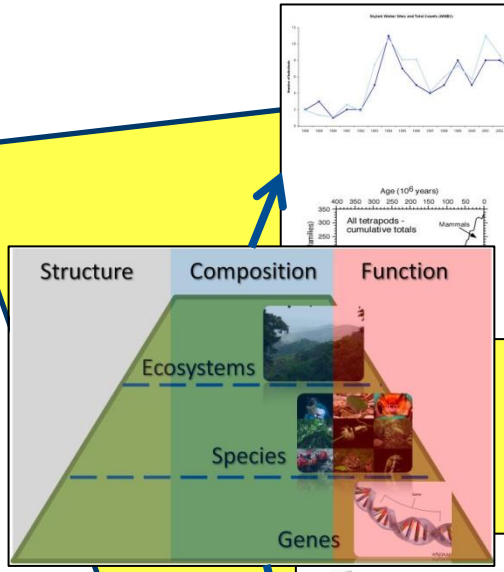
***Overexploitation**: Overfishing in Malta (www.Gozonews.com)*

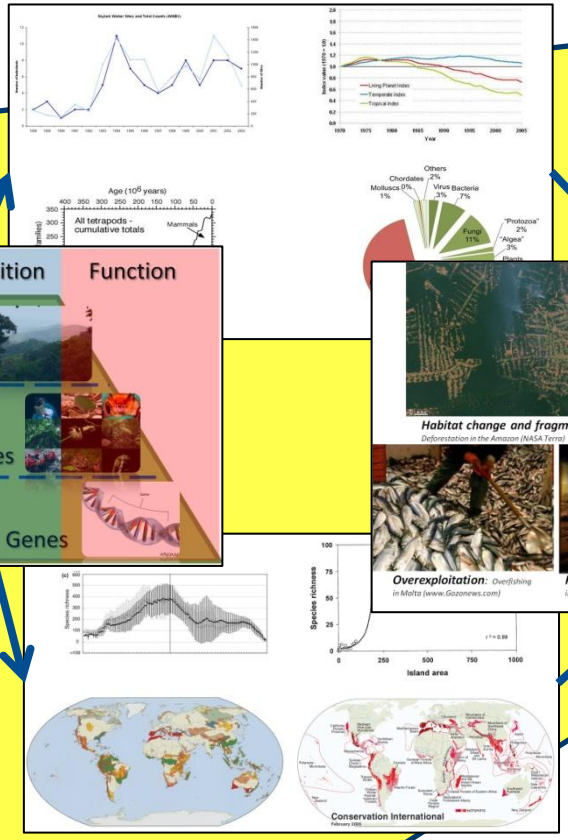
***Pollution**: Concept art of the industrial age*

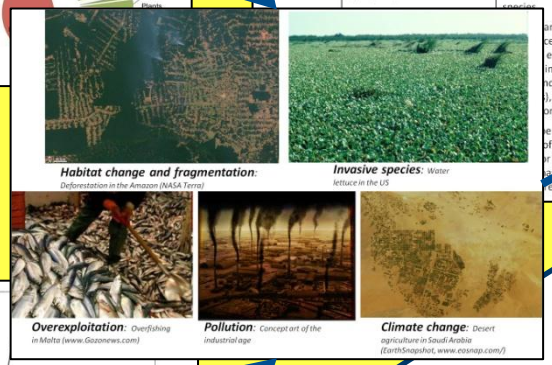
***Climate change**: Desert agriculture in Saudi Arabia (EarthSnapshot, www.eosnap.com/)*

Biodiversity loss → LCA

- Some simplification required…

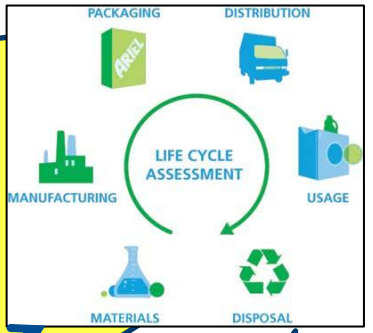






	Structure	Composition	Function
Gene (biotic)	Genetic structure, size of genome	Heterozygosity, allelic diversity, linkage, trends in gene diversity	Mutation, duplication, translocation, polyploidy
Species (biotic)	Size, morphology, species physiognomy, home range structure, distribution in space, dispersal distance	(Meta-)population structure, population size, number of populations, demographics, focal species, threatened	Genetic drift, bottle necks, inbreeding/outbreeding depression, growth, reproductive, feeding, nesting, dispersal rate
		…and relative …ce of species, species …endemism, alpha …indices (Shannon- …ndex, Fishers alpha, …), beta diversity …on, similarity)	Nutrient turnover and cascades, decomposition rates, trophic diversity, parasite-host interactions, predator-prey interactions, plant-disperser interactions, seed rain patterns, biomass production
		…e composition, …of ecosystems …r absolute area, area …at… vegetation in …e	Seasonal change, fire frequency, NPP, NDVI index, water drainage, corridors, stepping stones, river flow rate

LCA



RECENT METHODOLOGICAL DEVELOPMENTS IN LCA

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

BIODIVERSITY LOSS AND LIFE CYCLE ASSESSMENT

Michael Curran

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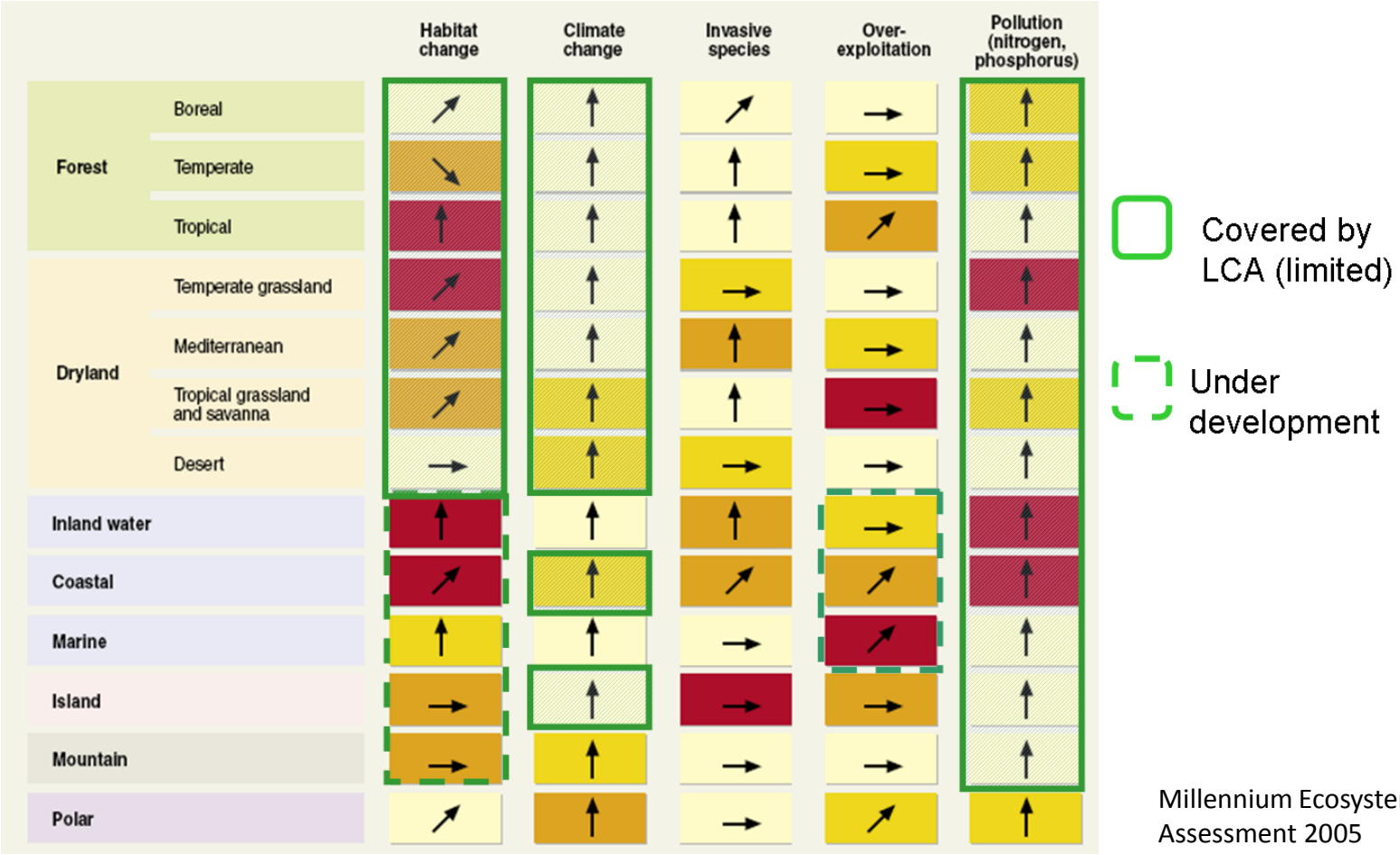
LCA Discussion Forum 42

Lausanne, 19/11/2010

Photos: www.edwardburtynsky.com (above)
M. Curran (below)

Biodiversity loss and LCA

- 5 major drivers of biodiversity loss (MA 2005)

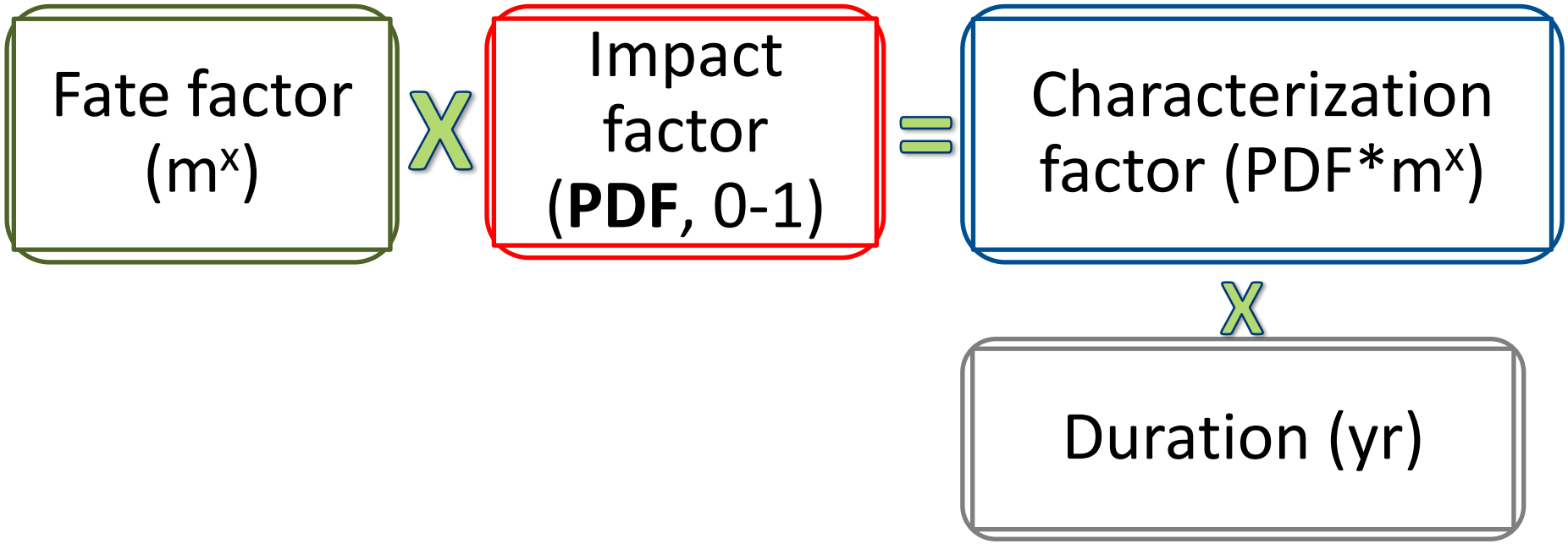


Millennium Ecosystem Assessment 2005

Impact assessment framework

Species loss as an endpoint

- From EcoIndicator99 to Recipe2008



Fate factor

- Fate of an **environmental intervention** (where it ends up, at what intensity)
- Var

All Impact Categories:
Impact*area/volume*year

ECO

CF

i

n, yr)

LAND USE:

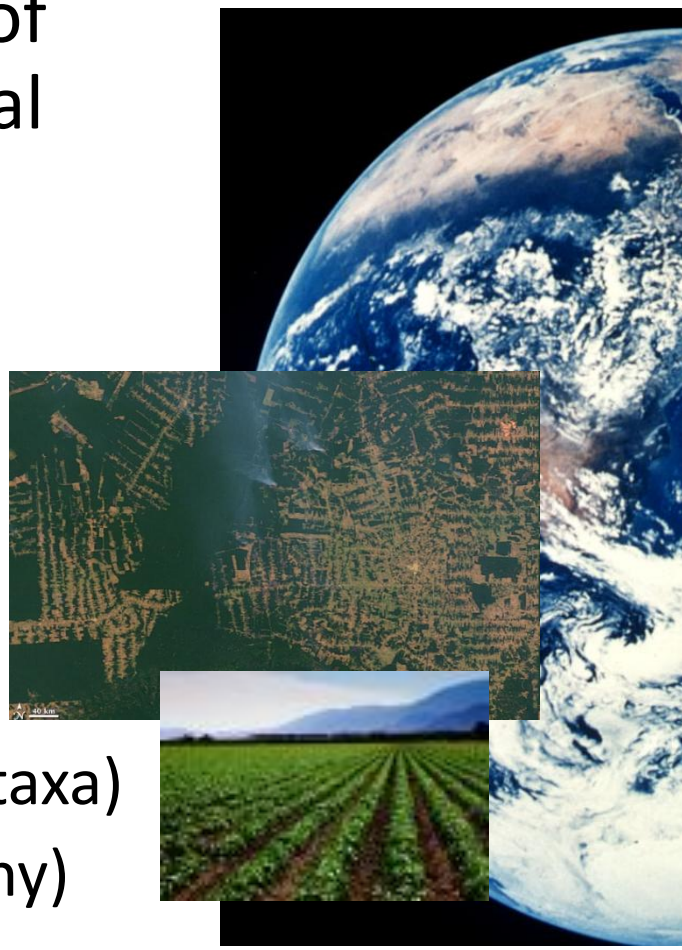
$$IS_{trans/rest} = CF_{trans/rest,i} \cdot A_i$$

(Area, m2, and duration, yr))

A. De Schryver, R. van Zelm, Pers Comm.

Impact factor

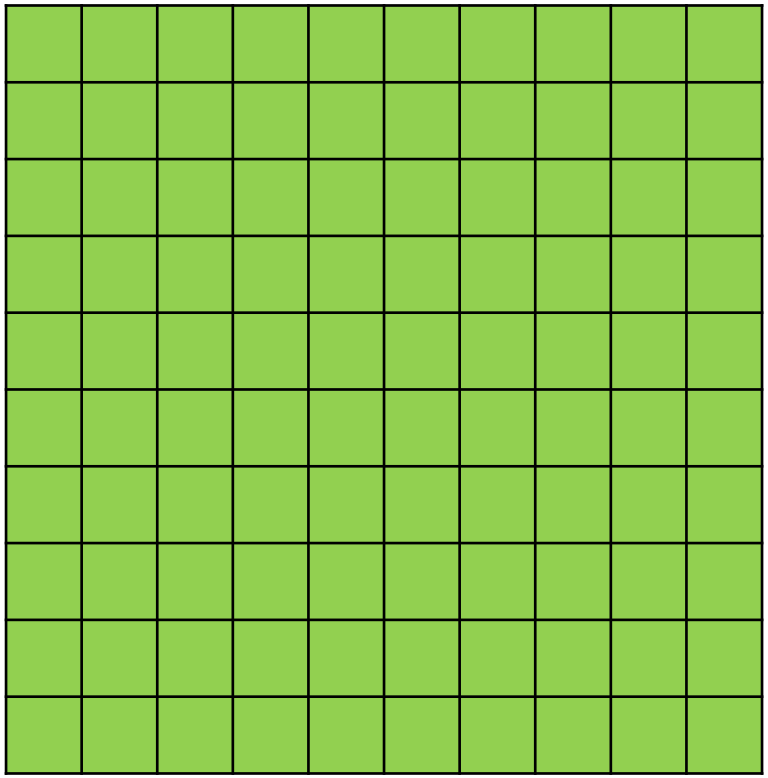
- Impact to biodiversity of one unit of intervention (0, no effect, to 1, total loss)
- **Potentially Disappeared Fraction (PDF)** of species… *from where???*
- *Conceptual* shortcomings
  - Scale – locality, region, planet?
- *Data* shortcomings
  - Knowledge on biological responses (taxa)
  - Incomplete regionalization (geography)



Curran et al. 2010

Characterization factor

- Common damage unit → **effective habitat loss**



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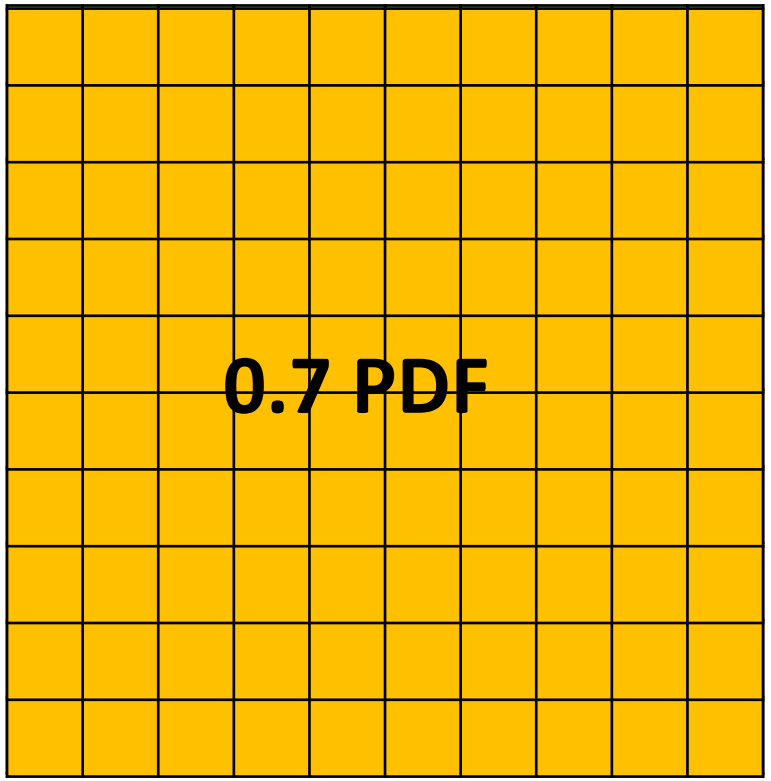

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Characterization factor

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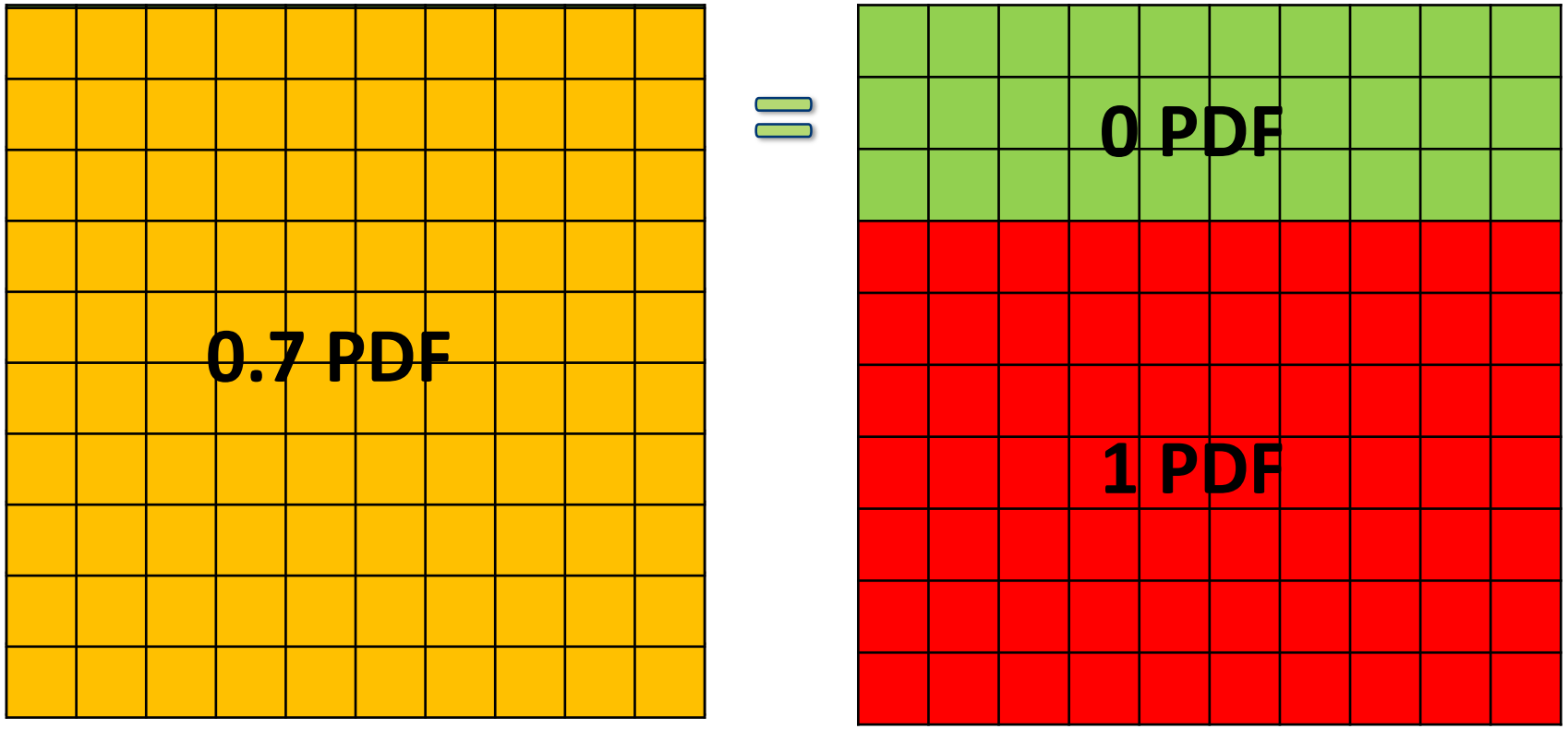
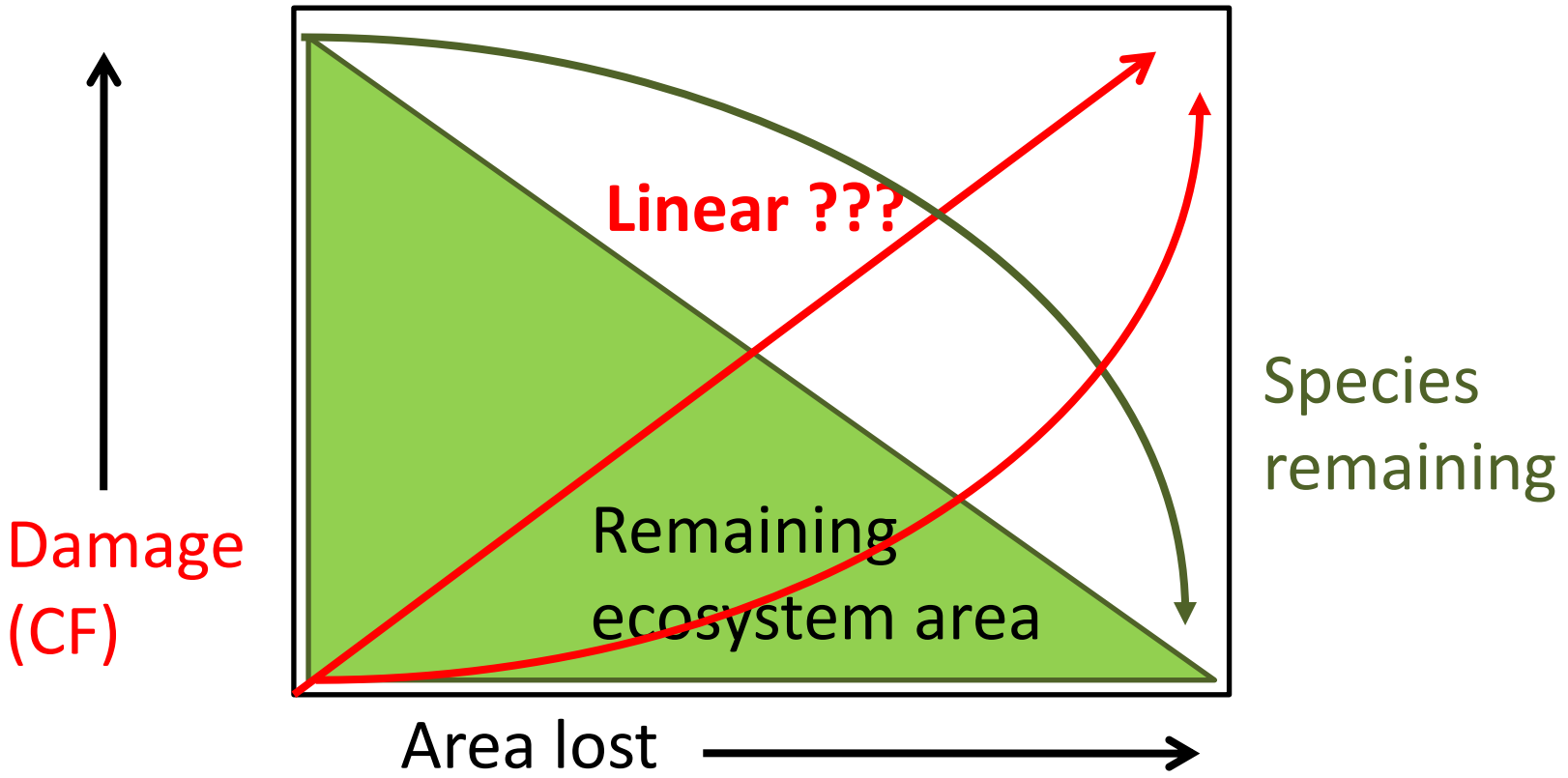
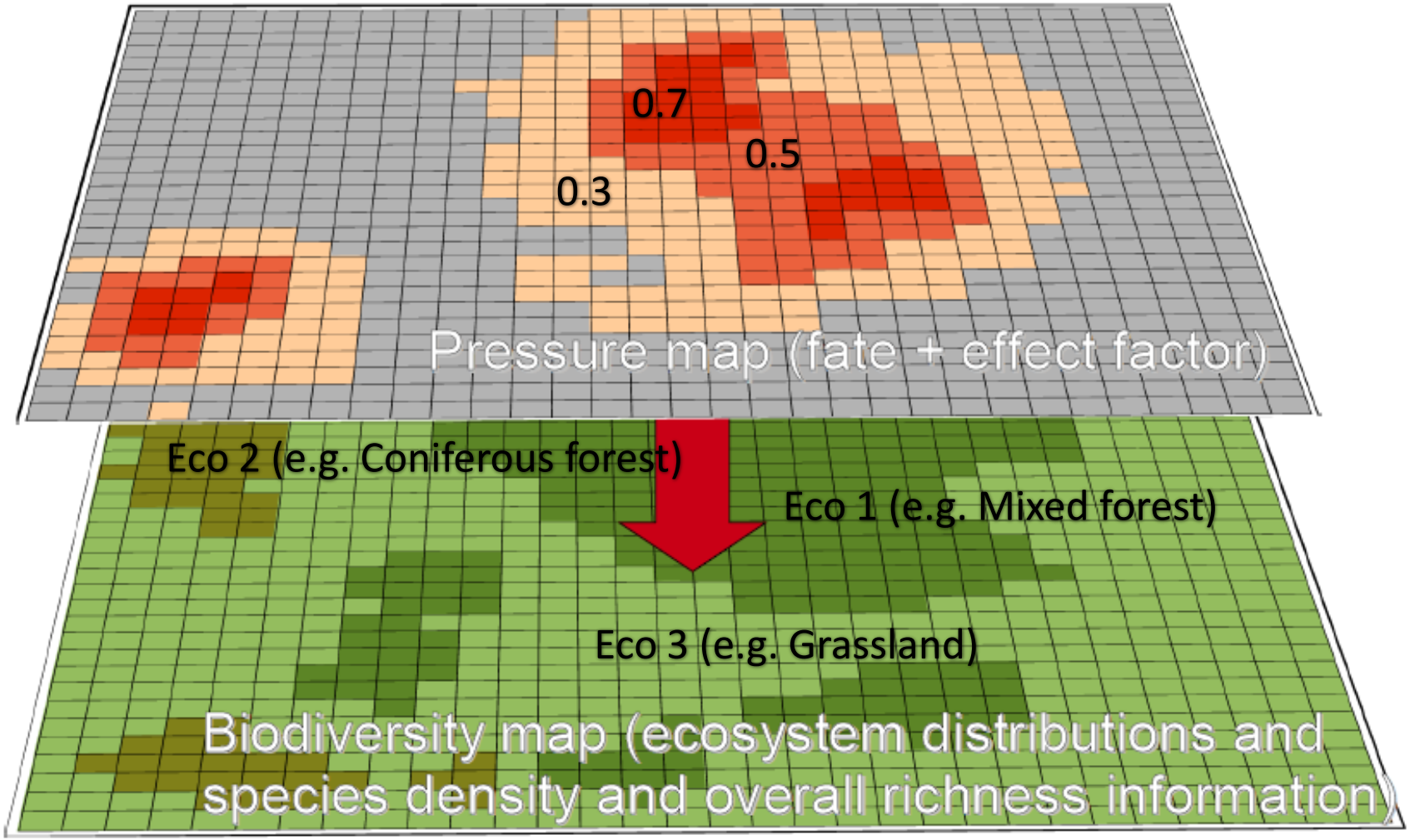


Characterization factor

- Common damage unit → **effective habitat loss**
- Increased area lost → **linear damage increase**



Integrating non-linearity via SAR

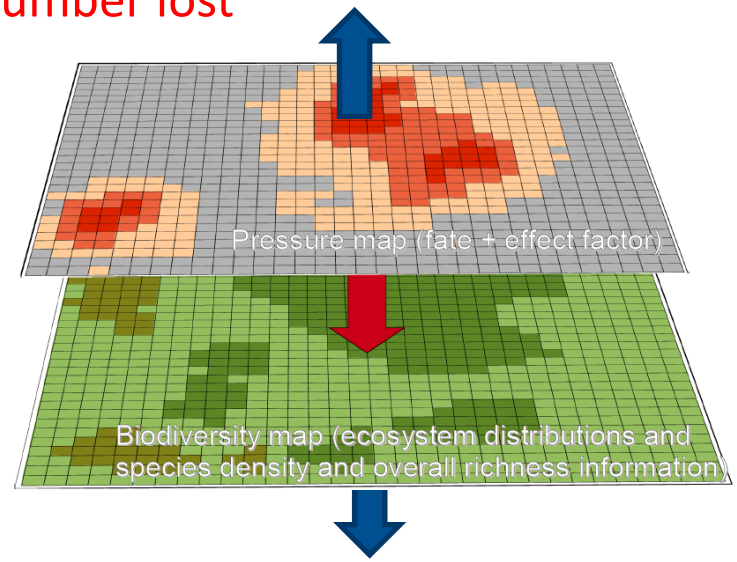


Integrating non-linearity via SAR

- Traditional LCA approach (ReCiPe 2008)
  - *How many species does the intervention affect (**in isolation**)?*
- Non-linear approach starts with the ecosystem and works backward
  - *How does the intervention reduce the **species pool of the ecosystem** (given prevailing conditions)?*

$$S_{impacted} = \sum_i I_i * (\Delta A_i) * SD_{meter^2}$$

Number lost



Precentage remaining

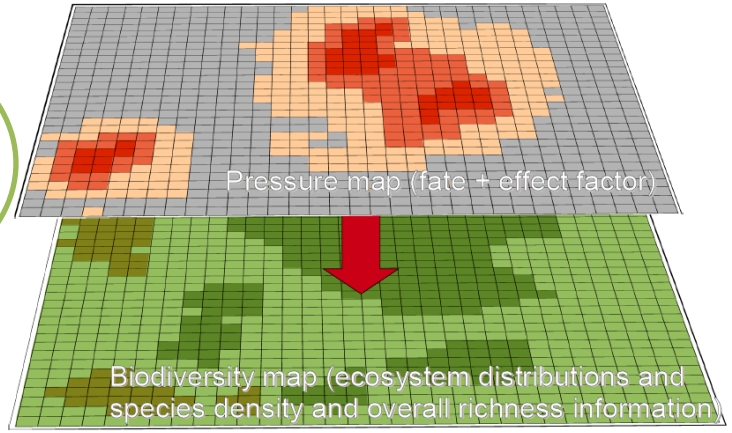
$$S_{remaining} = \left[\frac{\sum_i (1 - I_i) * A_i}{A_o} \right]^z$$

$$S_{impacted} = 1 - S_{remaining} * SD_{ecosystem}$$

Number lost

Integrating non-linearity via SAR

LCA (traditional)	ReCiPe 2008
PDF*Area (effective area loss)	130.40
Number of species lost (global SD)	**0.0000018**
Number of species lost (regional SD)	**1776.77**
LCA + SAR	Peira and Daily 2006
% Species remaining	96.09
% Species loss	3.91
Number of species lost (ecosystem SD)	**3.23**



Final remarks - purpose of LCA

1. Potential time- and space-independent impacts, strongly linked to a functional unit (rather than an entire process); **comparative**

Allocation

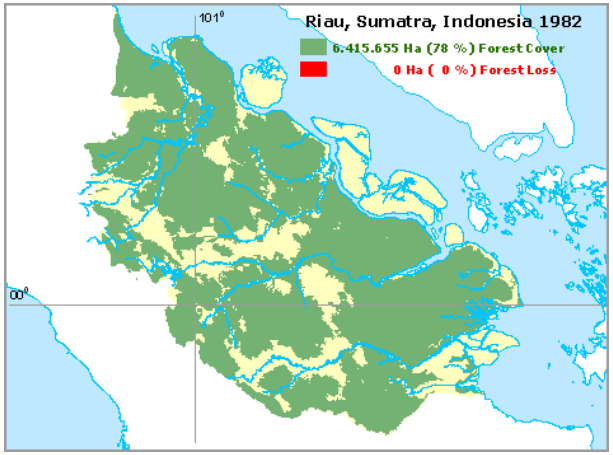
ReCiPe 2008

2. Potential real impacts from whole processes at a defined location and time period; **comparative or absolute** on regional scale

Scale

Thank you for your attention…

Michael.Curran@ifu.baug.ethz.ch



Forest loss due to palm-oil and logging expansion in the Riau Peninsula, Sumatra, Indonesia.

Source: Global Forest Watch, www.globalforestwatch.org

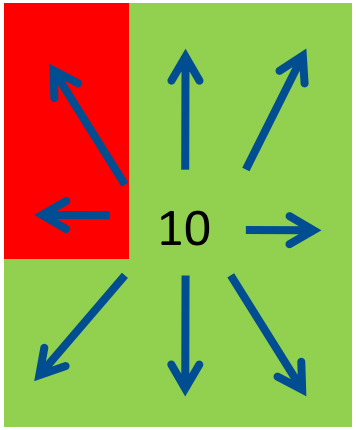
Extra Info

Species density (SD/m^2)

5	2	3
4	5	6
5	3	5
2	4	2
4	5	6
3	3	3
6	2	5

SP lost = 4*SD =
16 species

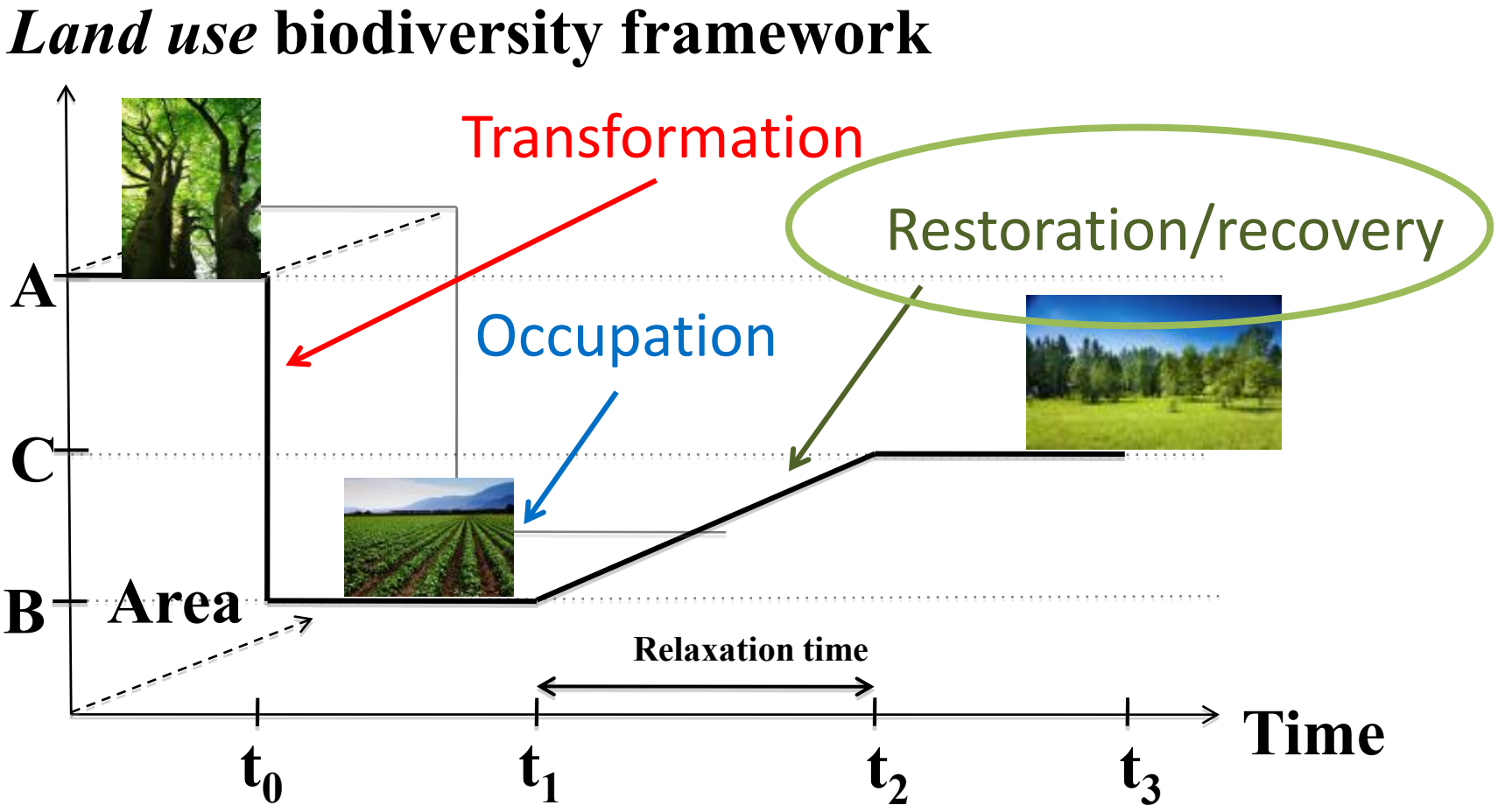
Total species



May be only 10 species in whole ecosystem (but repeatedly found in each m^2)

SAR = 15% area loss translates to <1 species

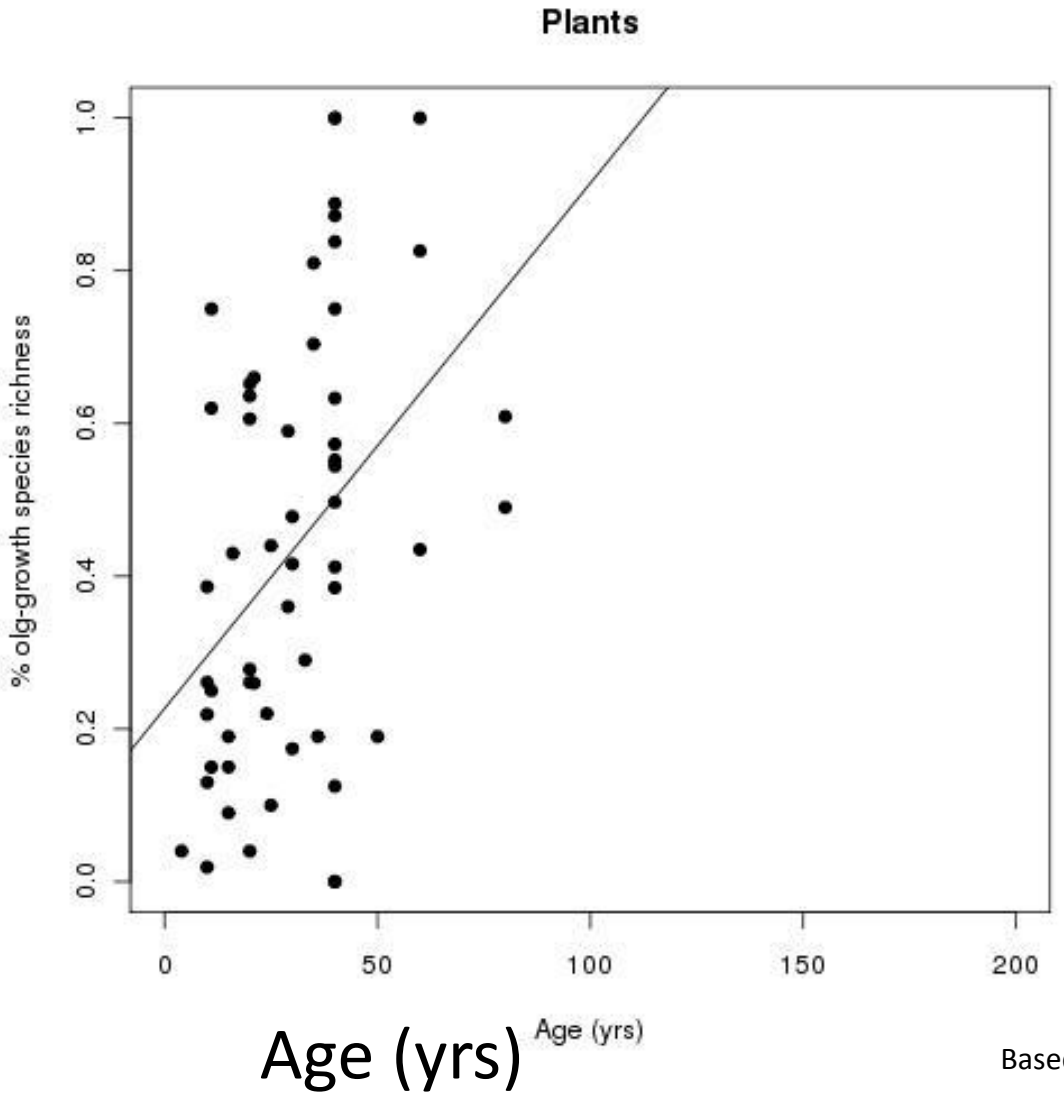
Duration



Adapted from Mila i Canals et al. 2007

Biodiversity recovery - Plants

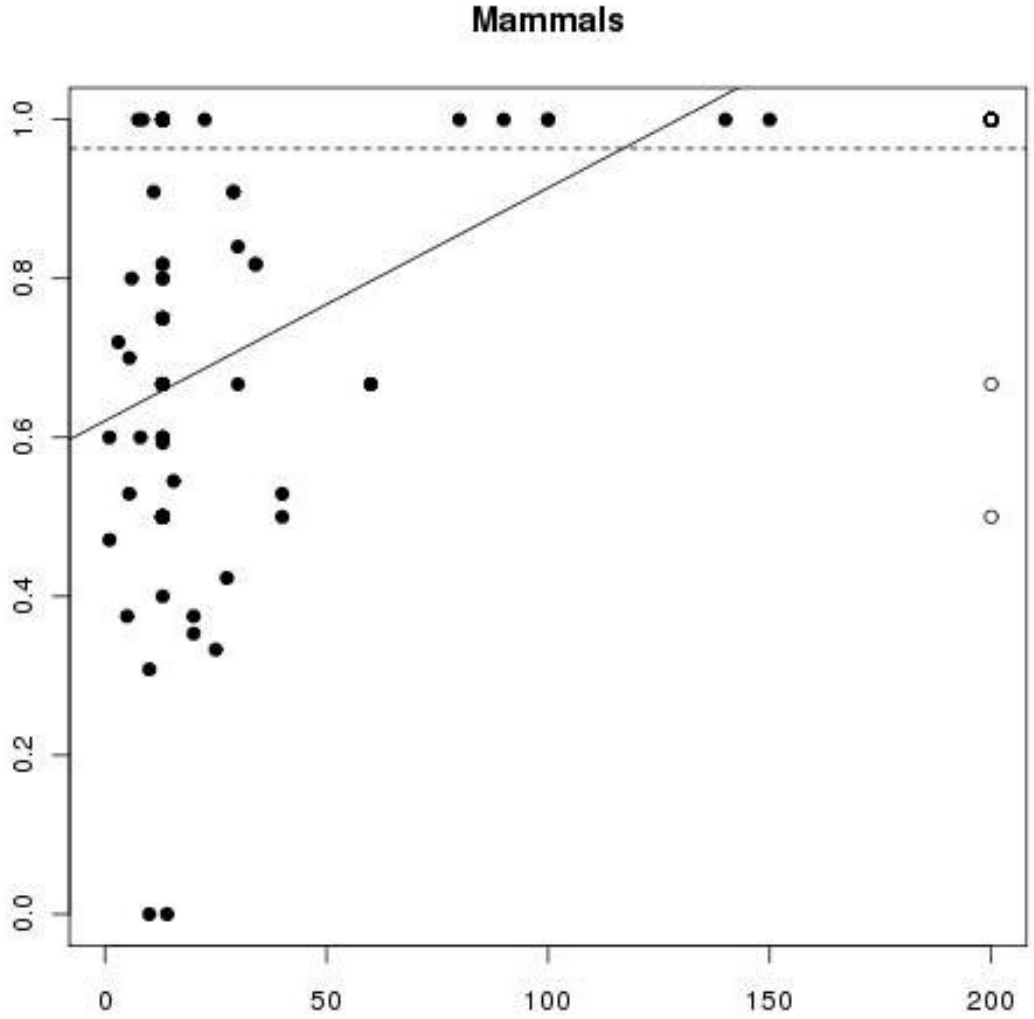
% Old-growth species richness



Age (yrs)

Based on Dent and Wright 2010

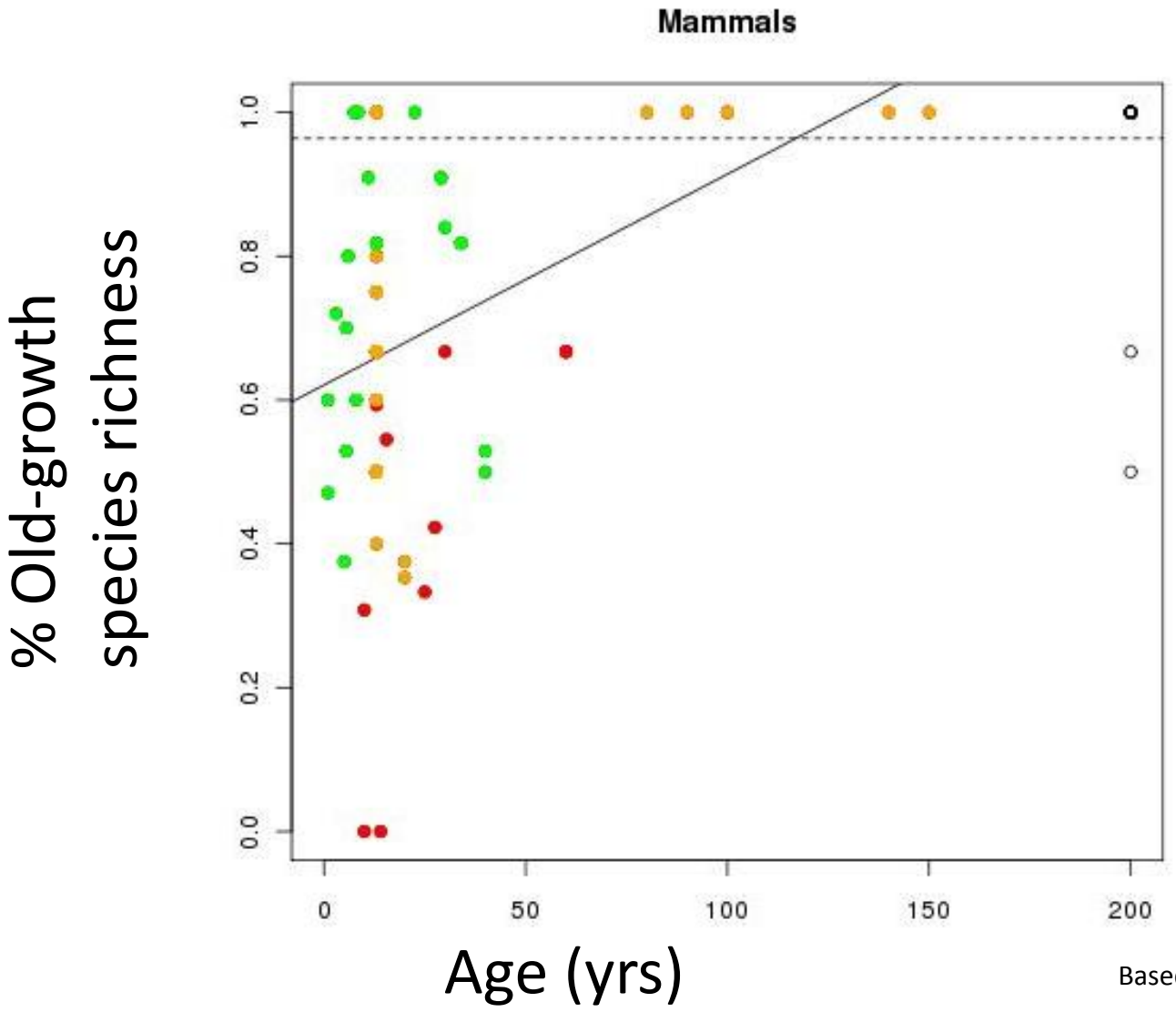
Biodiversity recovery - Mammals



Reference ecosystem

Based on Dent and Wright 2010

Biodiversity recovery - Mammals

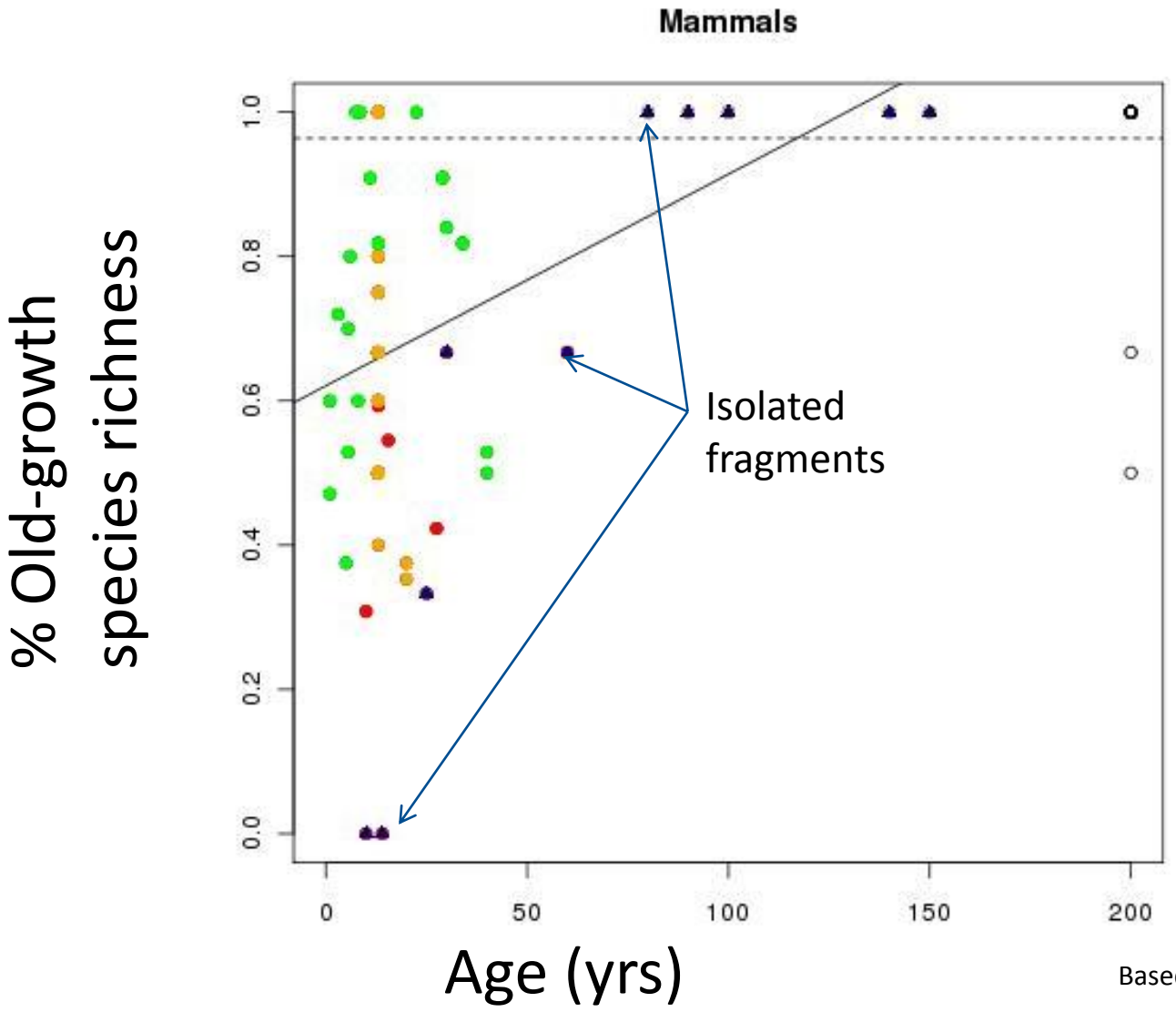


1. LU history intensity

- High
- Moderate
- Low

Based on Dent and Wright 2010

Biodiversity recovery - Mammals



1. LU history intensity

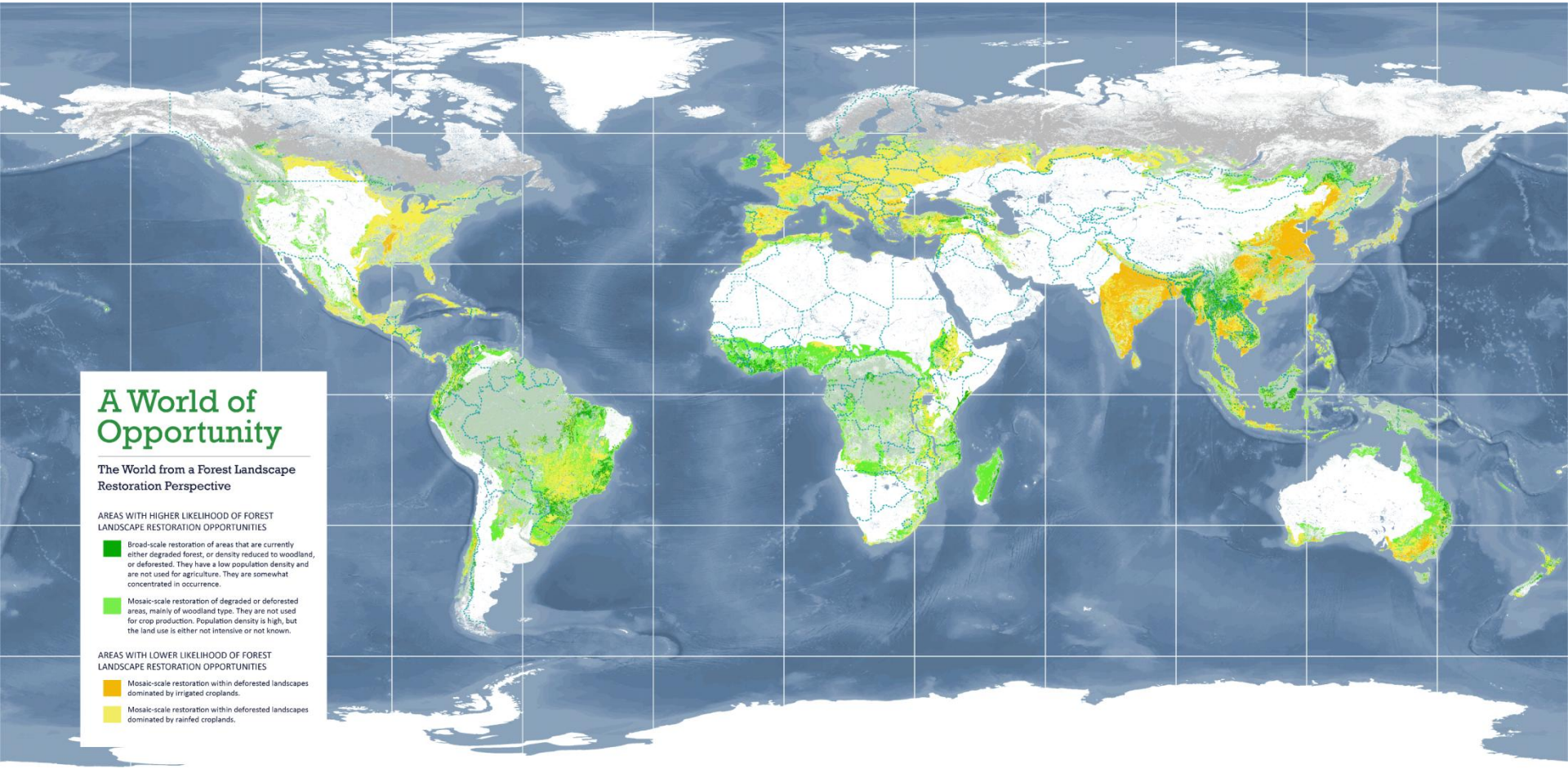
- High
- Moderate
- Low

2. Isolation of recovering fragment

Based on Dent and Wright 2010

Words of caution

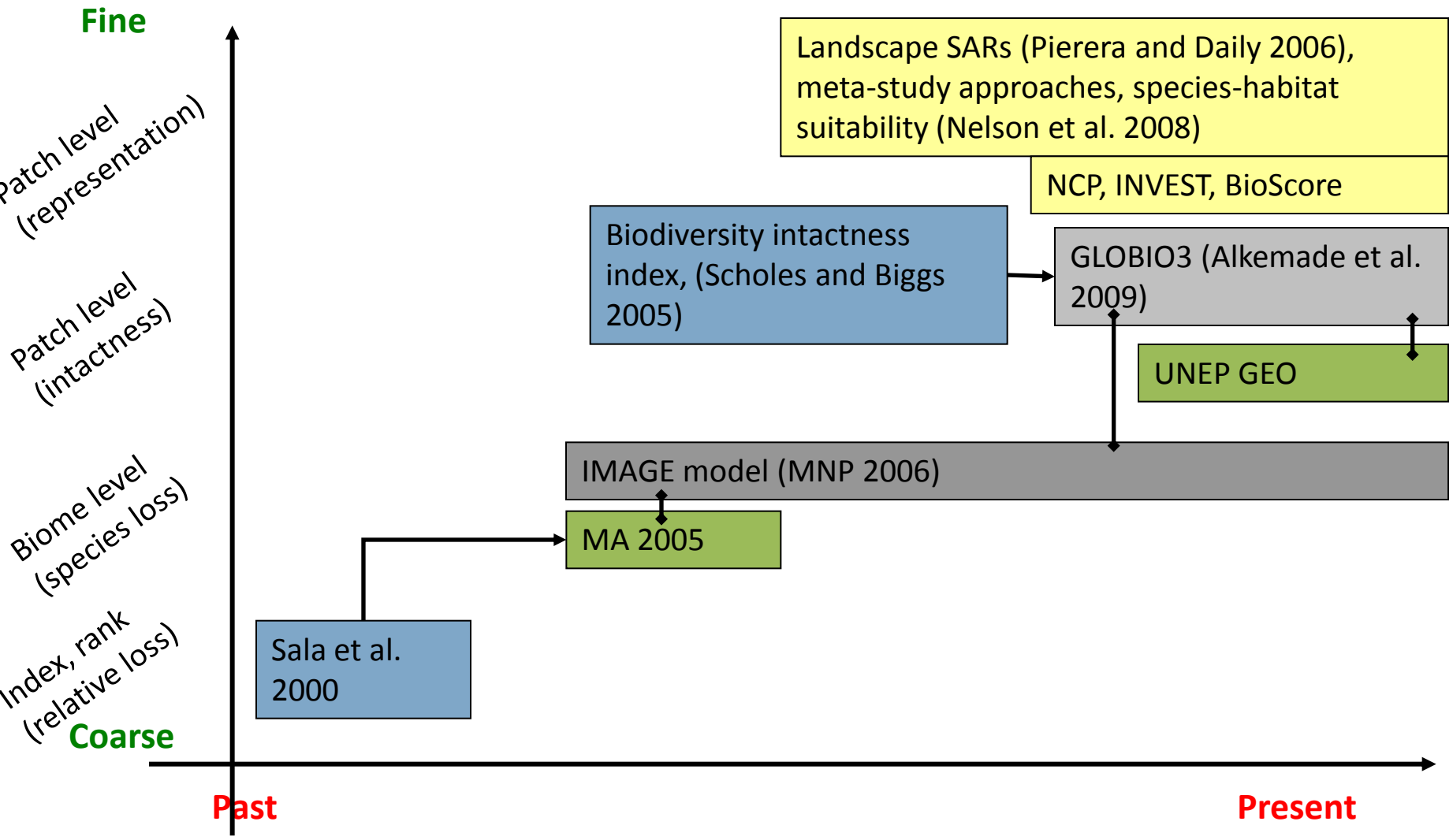
- Remaining source habitat? Irreversible damage?



Biodiversity → indicators…

	Structure	Composition	Function
Gene (biotic)	Genetic structure, size of genome	Heterozygosity, allelic diversity, linkage, trends in gene diversity	Mutation, duplication, translocation, polyploidy
Species (biotic)	Size, morphology, species physiognomy, home range structure, distribution in space, dispersal distance	(Meta-)population structure, population size, number of populations, demographics, focal species, threatened species	Genetic drift, bottle necks, inbreeding/outbreeding depression, growth, reproductive, feeding, nesting, dispersal rate
Community (abiotic and biotic)	Habitat structural complexity or physiognomy, habitat density, volume and surface area, coral reef rugosity index, community stratification in space	Number and relative abundance of species, species richness, endemism, alpha diversity indices (Shannon-Wiener index, Fishers alpha, evenness), beta diversity (ordination, similarity)	Nutrient turnover and cascades, decomposition rates, trophic diversity, parasite-host interactions, predator-prey interactions, plant-disperser interaction, seed rain patterns, biomass production
Ecosystem (abiotic)	Fragmentation, isolation, connectivity, topography, shoreline profile, river flow diversion / fragmentation	Landscape composition, number of ecosystems, relative or absolute area, area of semi-natural vegetation in agriculture	Seasonal change, fire frequency, NPP, NDVI index, water drainage, corridors, stepping stones, river flow rate

Terminology, models, and methods



Land use - alternatives

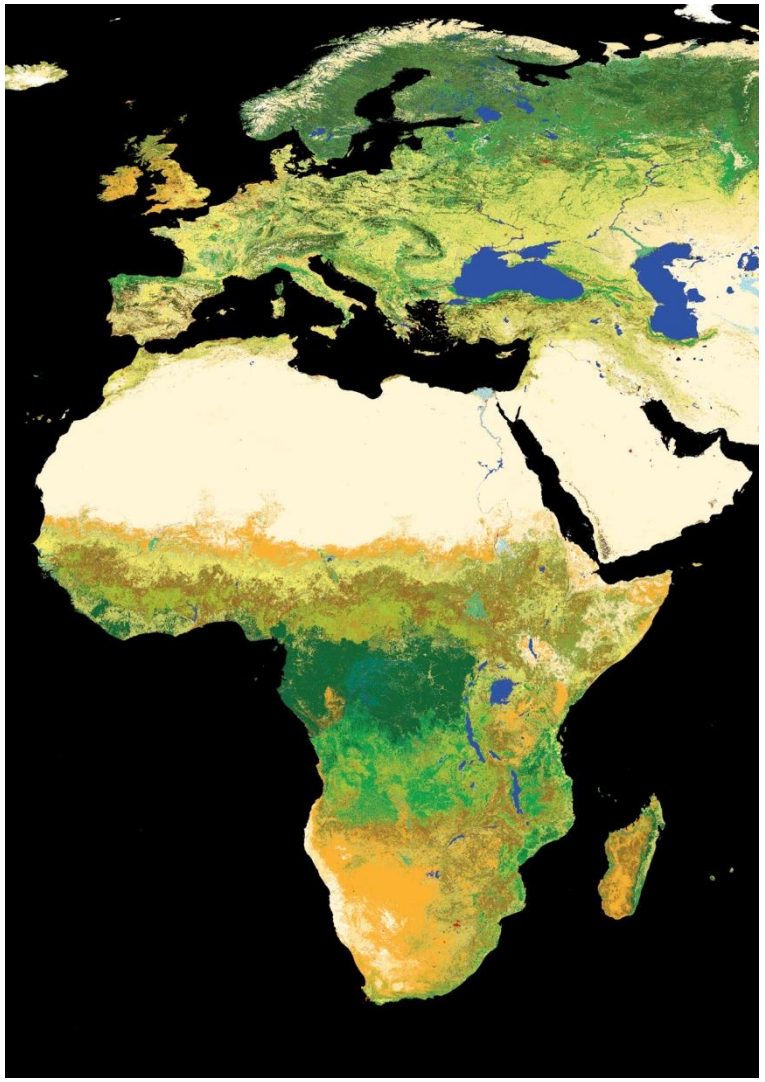
- MA used SARs and vascular plant species richness per biome
- Countryside SARs developed to attribute biodiversity value to human-dominated land use
- INVEST tool from Natural Capital Project
- Habitat-suitability matrices being incorporated by Linder et al., in press

$$S_i = c_i \times \left(\sum_j h_{ij} A_j \right)^z$$

Pierera and Daily 2006 (eq. 4)

$$\frac{S_1}{S_0} = \left(\frac{\sum_j \left(I_j^w \times A_j \right)}{A_0} \right)^z$$

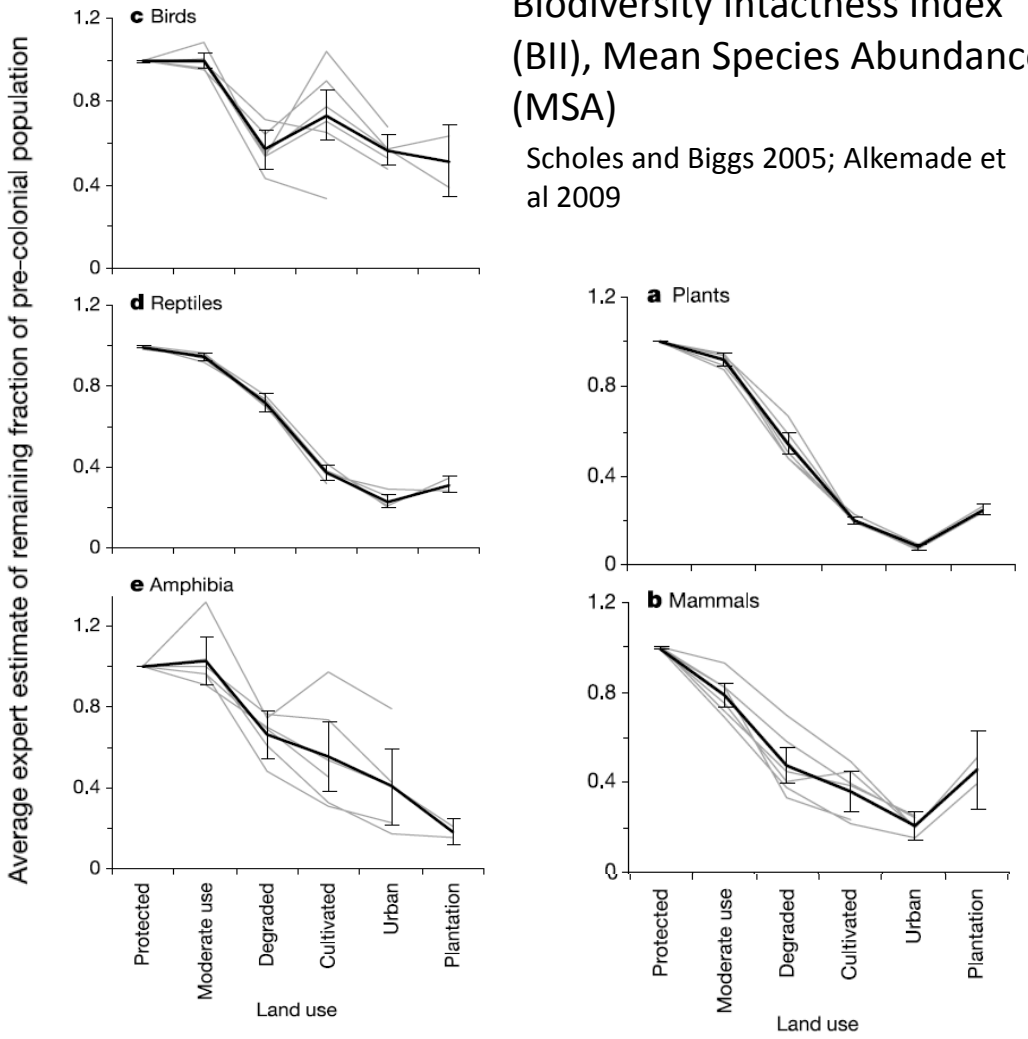
Faith et al. 2008 (eq 8)



ESA 2008

Land use - alternatives

- Intactness-based indicators
- No SAR necessary
- Trends in abundance of species
  - Species loss usually only the end product of the impact
- Criticised as focusing on *quantity, not diversity*

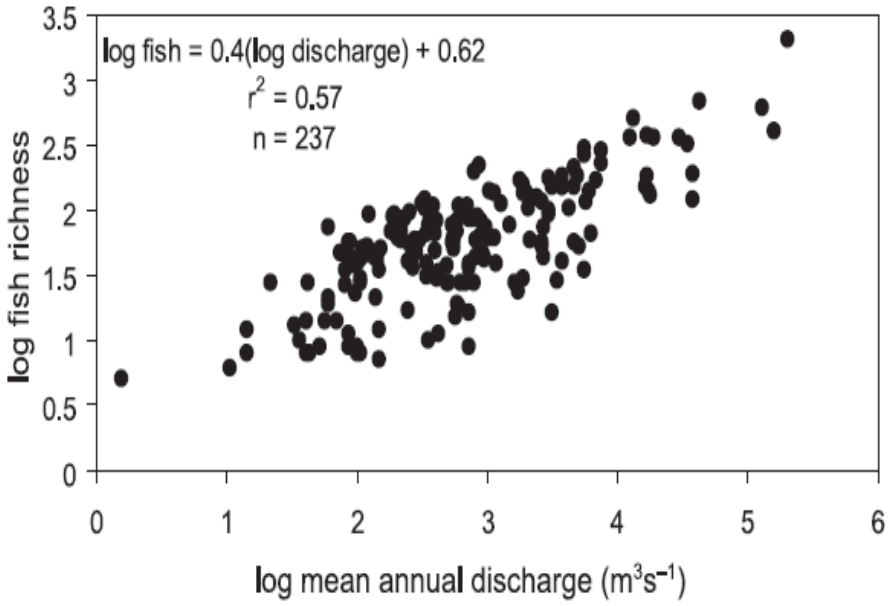


Biodiversity Intactness Index (BII), Mean Species Abundance (MSA)

Scholes and Biggs 2005; Alkemade et al 2009

Water use – alternatives

- Oberdorf et al. (1995) developed a model of global fish species richness per watershed
- River discharge rate related to fish species richness
- Behaves like the species area relationship (power law, $S=cD^z$)
- Further elaborated by Xenopoulus et al. 2005 for MA scenario calculations

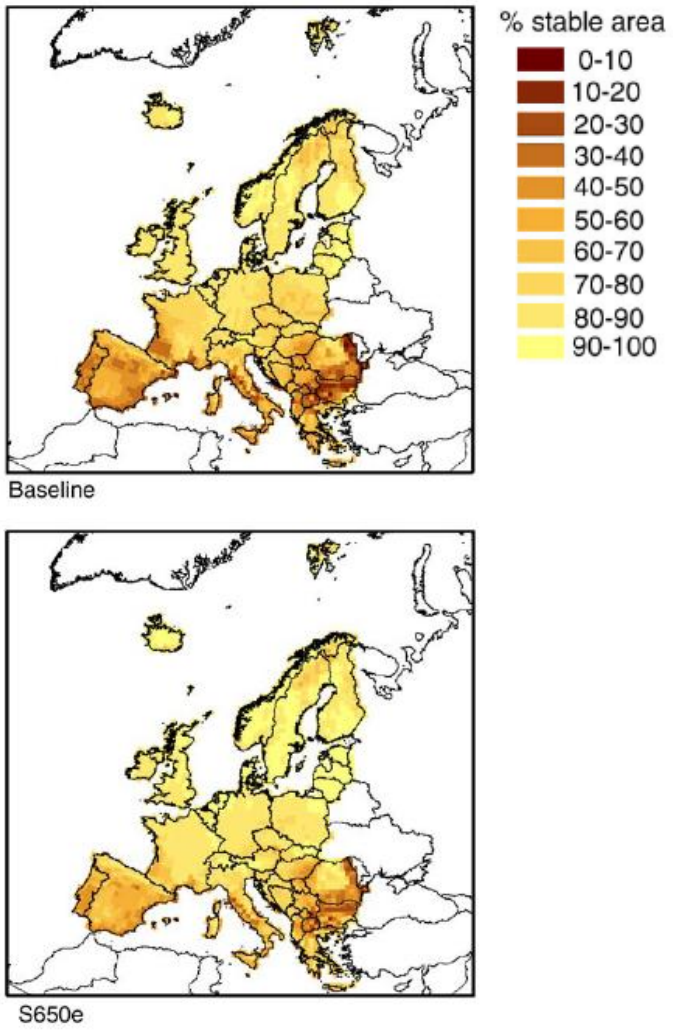


Xenopoulus et al. 2005

Climate change - alternatives

MA 2005, GLOBIO3

- Biome and vegetation community shifts (from IMAGE model)
- Predict shift in actual vegetation communities relative to potential new climate conditions
- Predicts less species loss than species-based
- Detailed indicator taxa vs. coarse vegetation communities

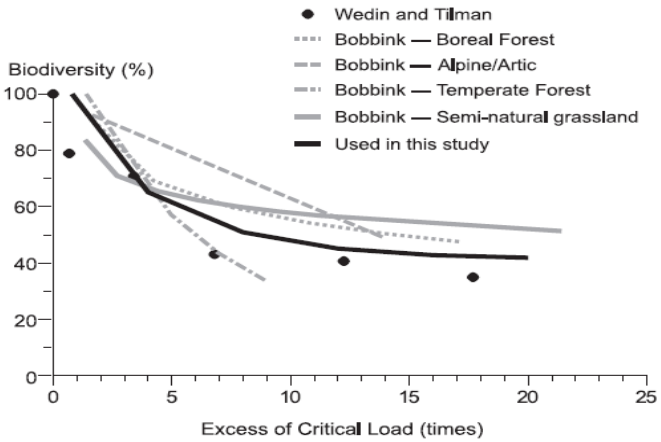


Bakkenes et al. 2006; Van Vuuren et al. 2006; Alkemade et al. 2009

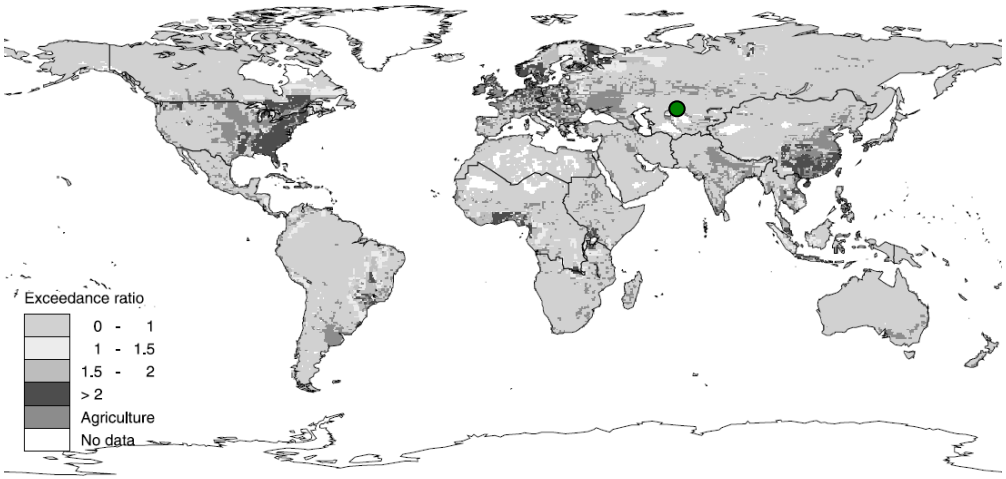
Acidification and Eutrophication – alt.

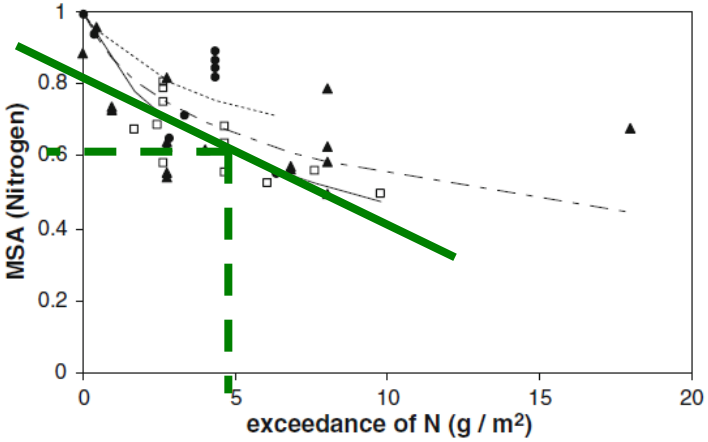
MA 2005, GLOBIO3

- Meta-analysis of empirical studies on plant species richness and critical load exceedance
- Representation of species in a community



MA 2005 (Chap 10)

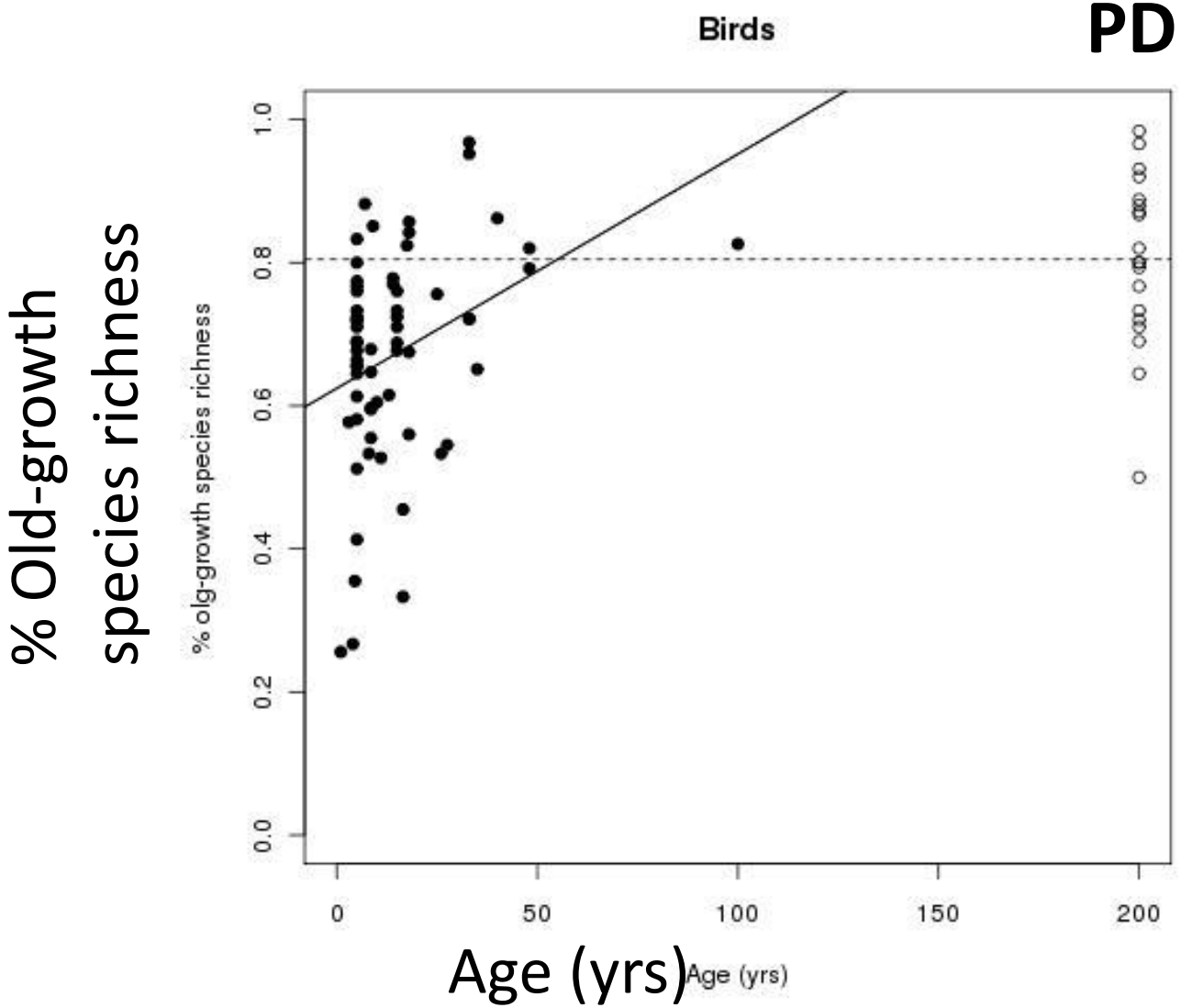




Bouwman et al. 2002; Alkamende et al. 2009

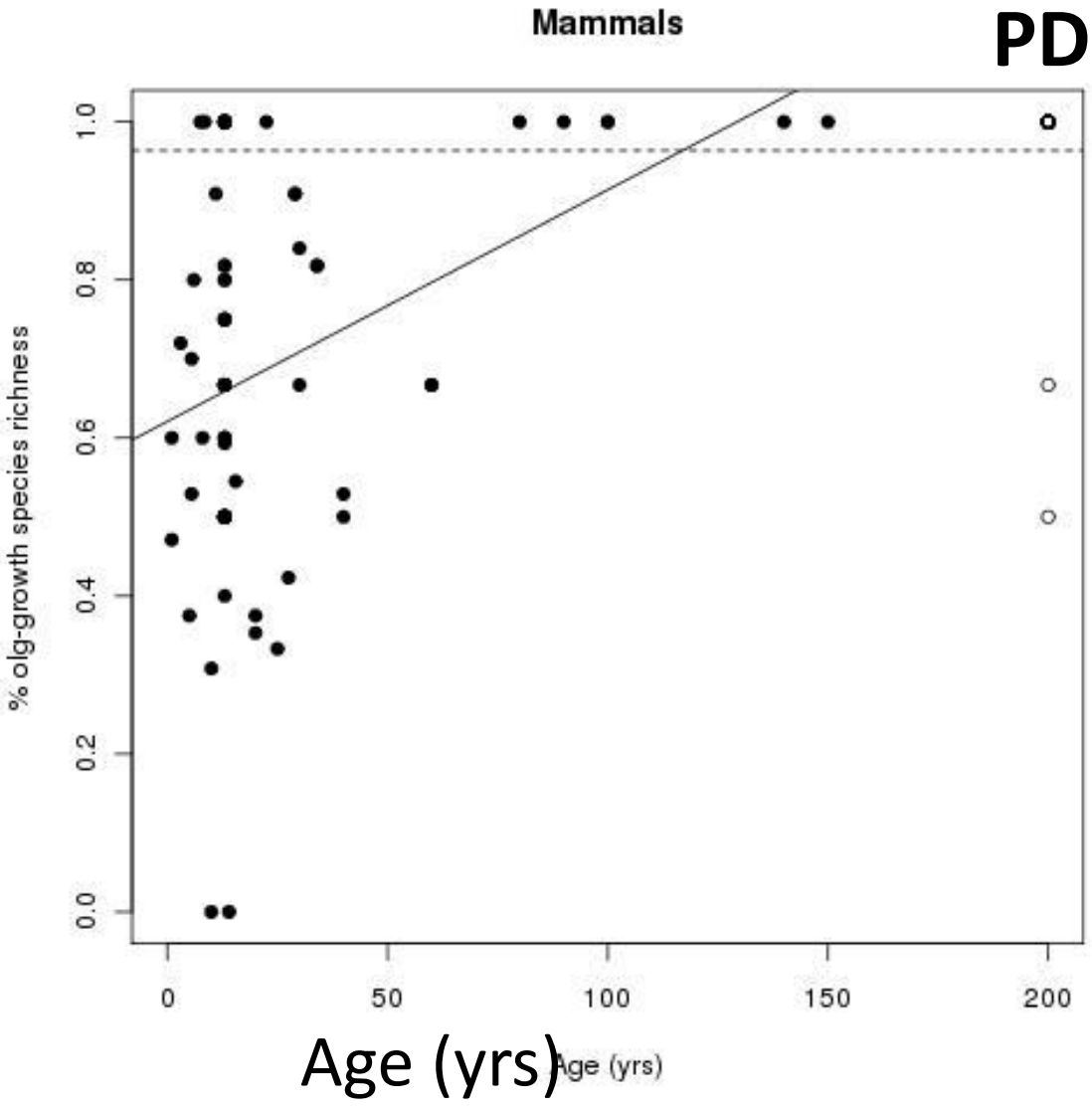
3. Biodiversity recovery - Birds

PDF*m^2*yr



3. Biodiversity recovery - Mammals

PDF*m^2*yr

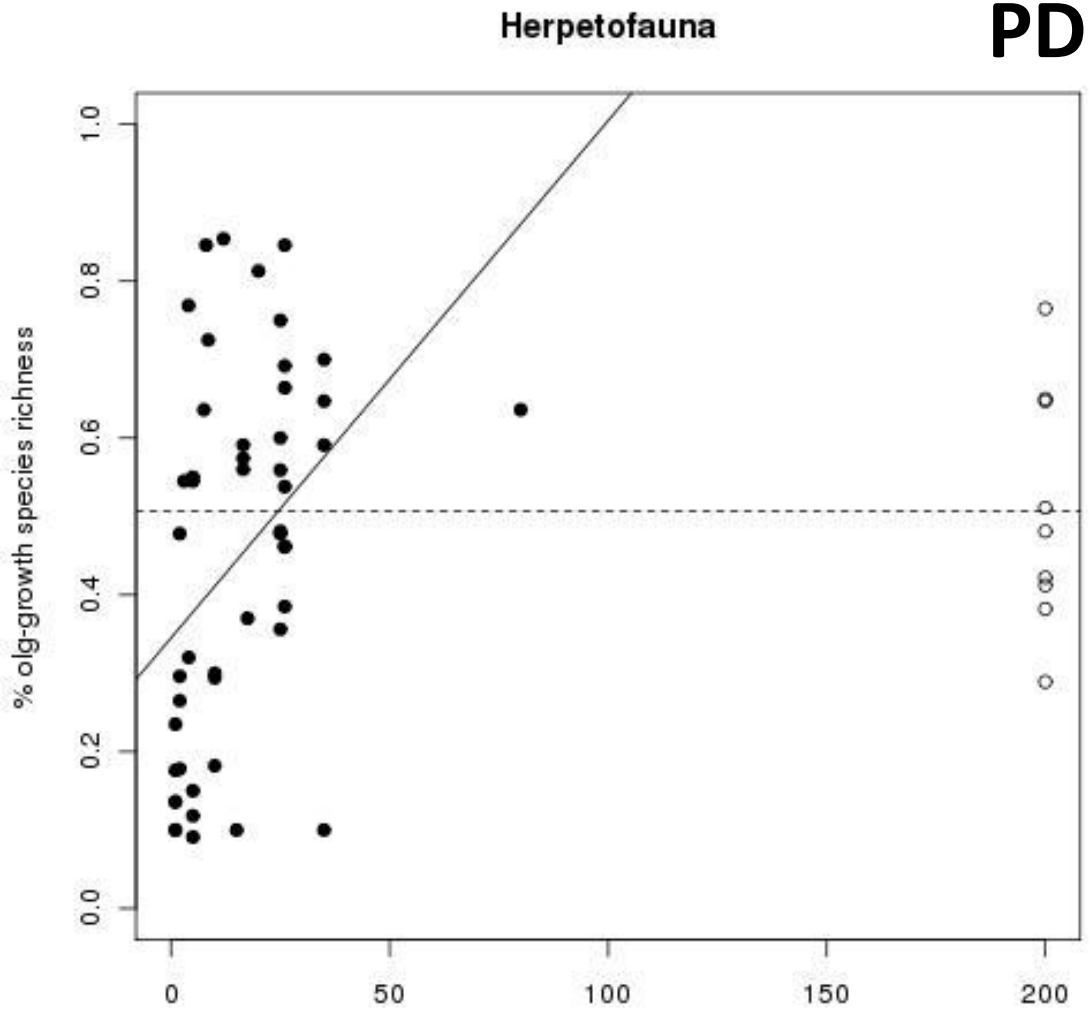


% Old-growth species richness

Age (yrs)

3. Biodiversity recovery - Herpetofauna

PDF*m^2*yr



% Old-growth species richness

3. Biodiversity recovery - Arthropods

PDF*m^2*yr