Biodiversity and ecosystem services: re-considering the policy links

Some novel perspectives on Phylogenetic diversity, functional trait diversity and extinction probabilities

Daniel P Faith
The Australian Museum

VIII Symposium & VIII Evaluation Meeting

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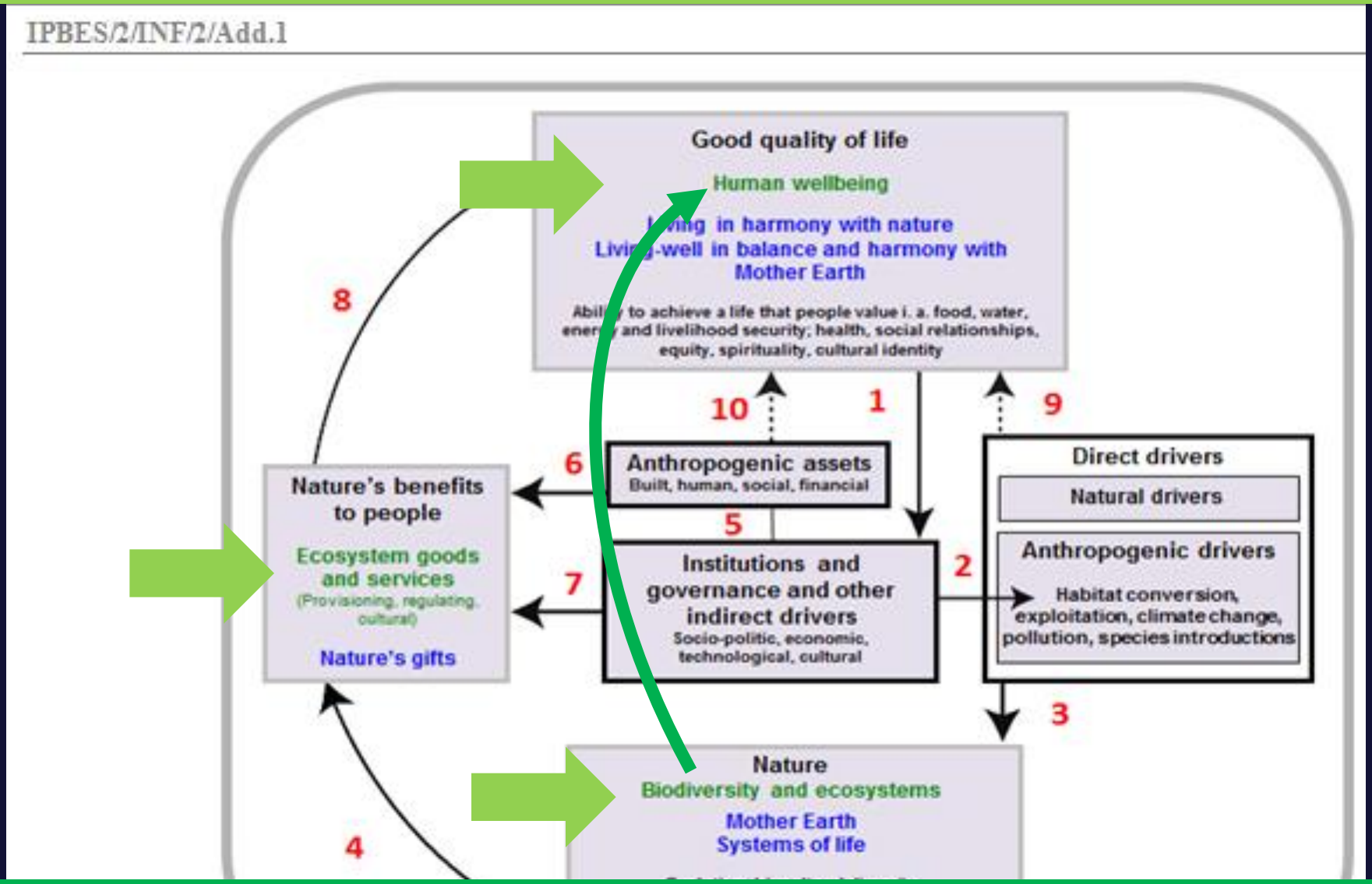
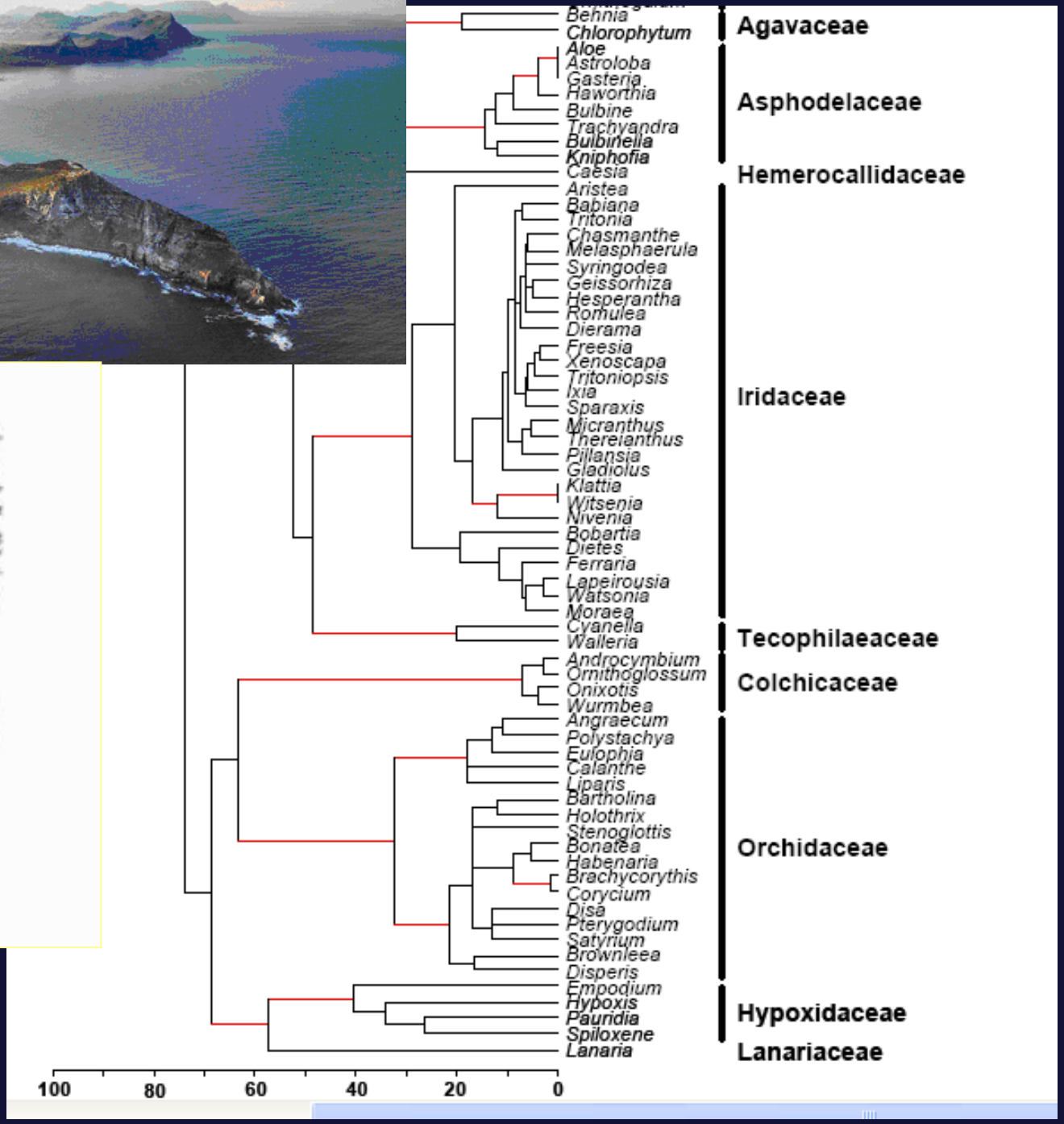
bioGENESIS
a core project of DIVERSITAS

IPBES conceptual framework.



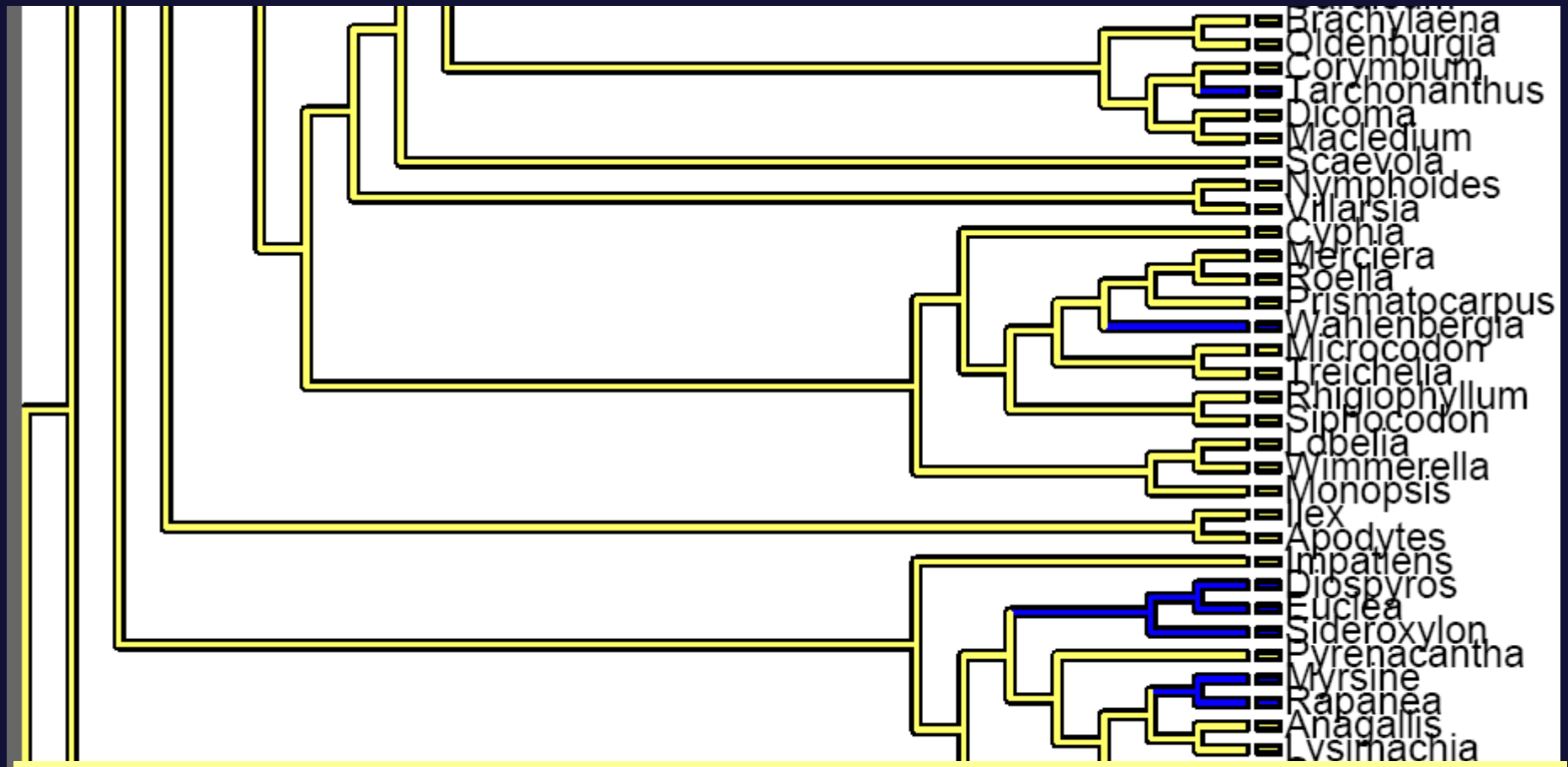
"option value" - the benefit in maintaining ***variation*** in the absence of knowledge about its future benefits.



Forest et al. (2007) *Nature*

blue = genera in the Cape having species of medicinal or economic importance

(as recorded in Survey of Economic Plants for Arid and Semi-Arid Lands)



maximise PD (phylogenetic diversity) to preserve options

Perspectives

Functional trait diversity: PD as feature diversity is a natural measure of option value but not the only way feature diversity links to option value

“expected diversity” calculations link lots of measures, but want to move beyond threats focus and talk about phylogenetic bright spots

Global option values are neglected in over focus on ecosystem services and local win-wins
- can produce a sustainability tipping point

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PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Phylogenetic Pattern and the Quantification of Organismal Biodiversity

Daniel P. Faith

Phil. Trans. R. Soc. Lond. B 1994 **345**, 45-58
doi: 10.1098/rstb.1994.0085

PD and phylogenetic ecology – any species-level index re-expressed as a PD-based measure

Richness = total PD
PD-Complementarity (gains & losses)
PD-Endemism
PD-Dissimilarity between communities

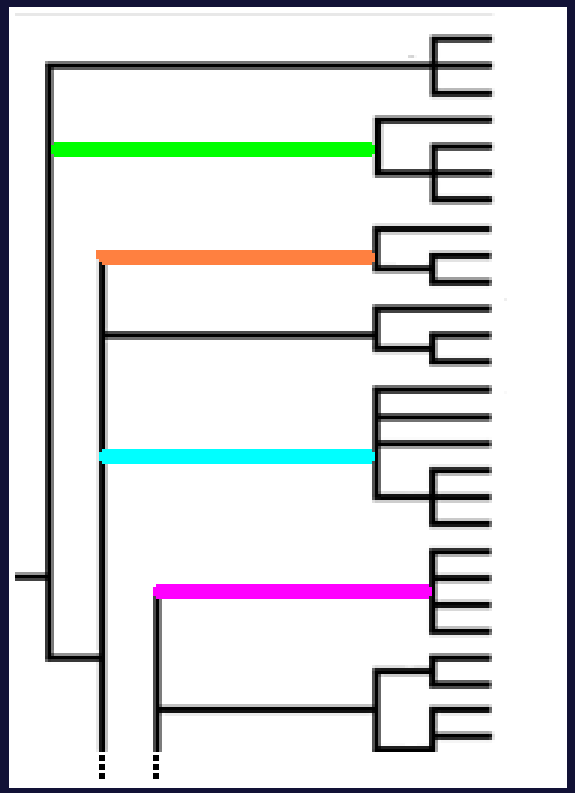
Expected diversity = expected PD

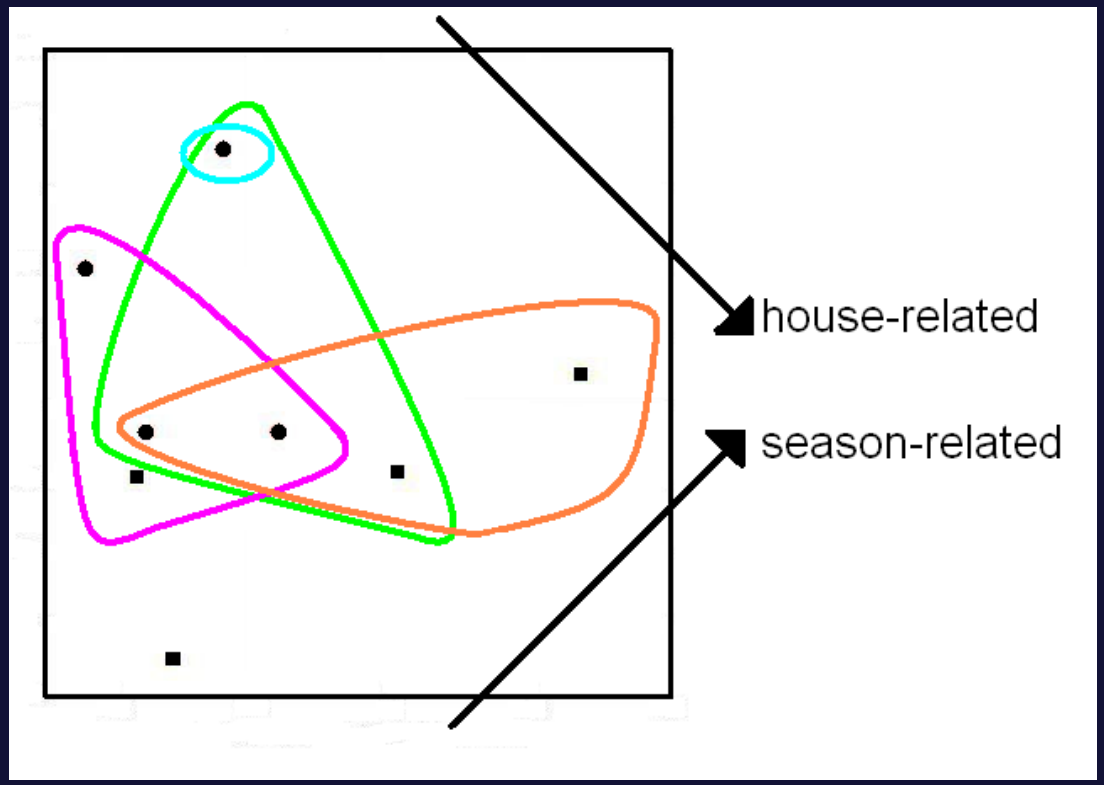
a general framework for biodiversity:

pattern/process model for objects allows inferences about diversity at level of underlying units

objects	pattern		biodiversity units
species	phylogeny	PD	features
populations	network	PDn	genes
places/samples	environmental ordination	ED	species, genes phylogenetic branches
species	habitat ordination	EDf	functional traits

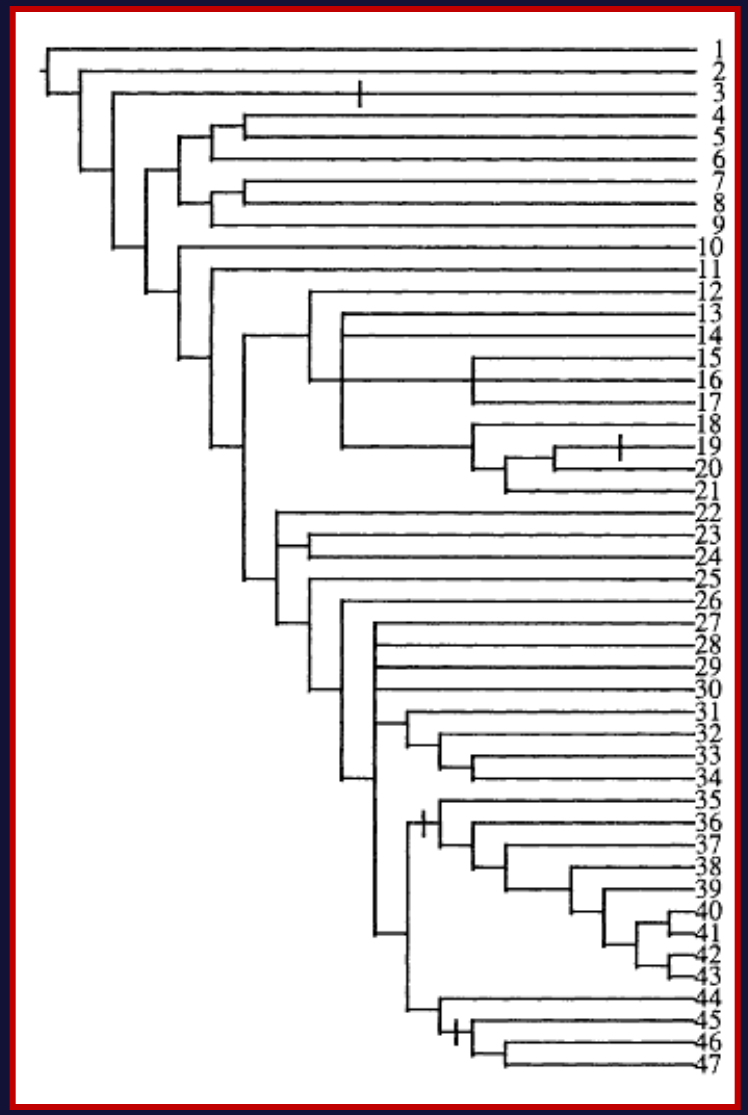
species/branches have unimodal response to gradients
e.g. microbial PD of house dust
An alternative to shared ancestry=shared features is
shared environment=shared features





Faith, D. P., C. A. Lozupone, D. Nipperess, R. Knight (2009)

Phylogeny and functional trait diversity



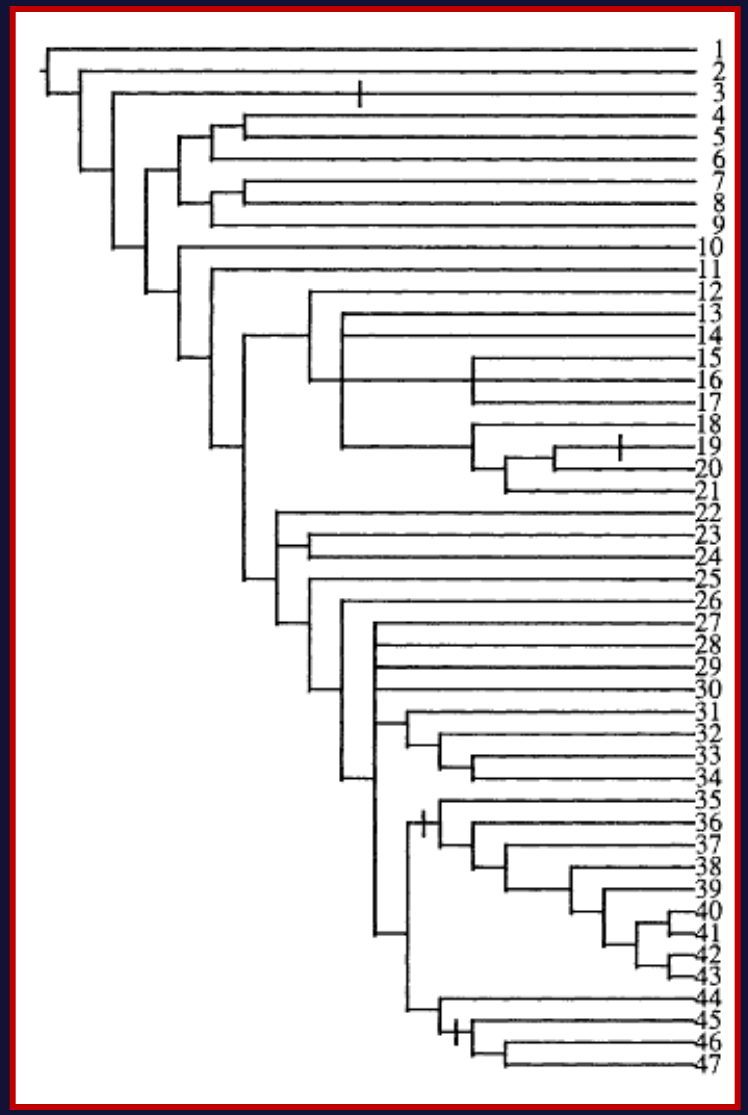
Anseriformes species

lots of convergent evolution

Faith 1996 *Con Bio*;

Faith *Plant ecology, Proc Royal Soc B* in press

Phylogeny and functional trait diversity



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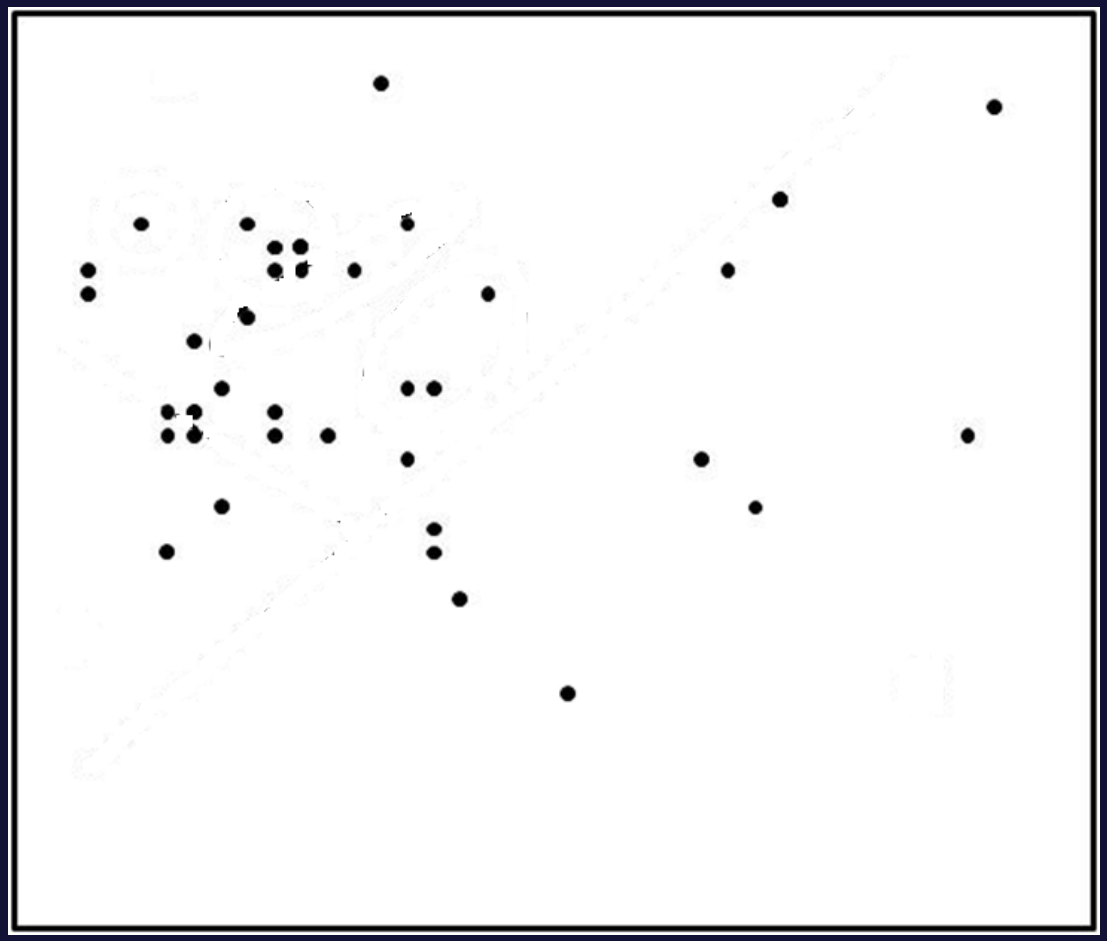

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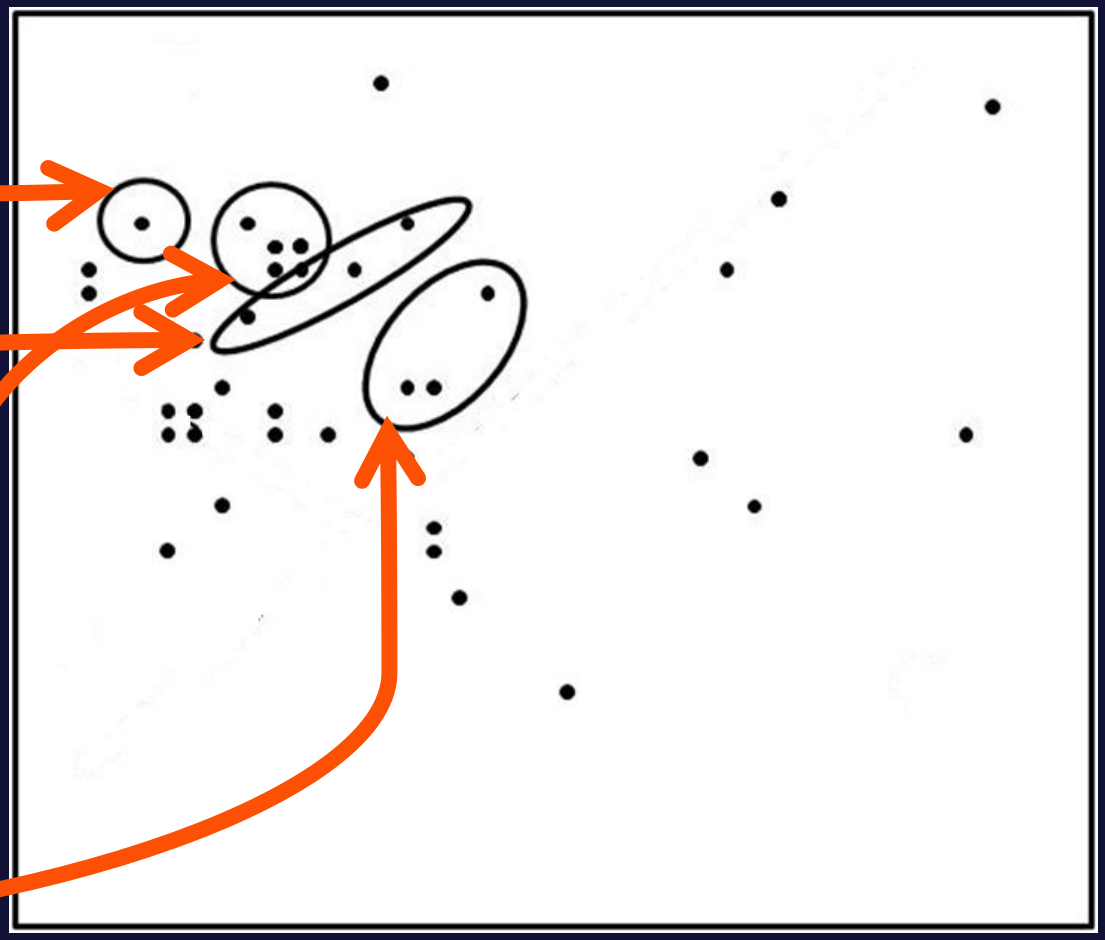
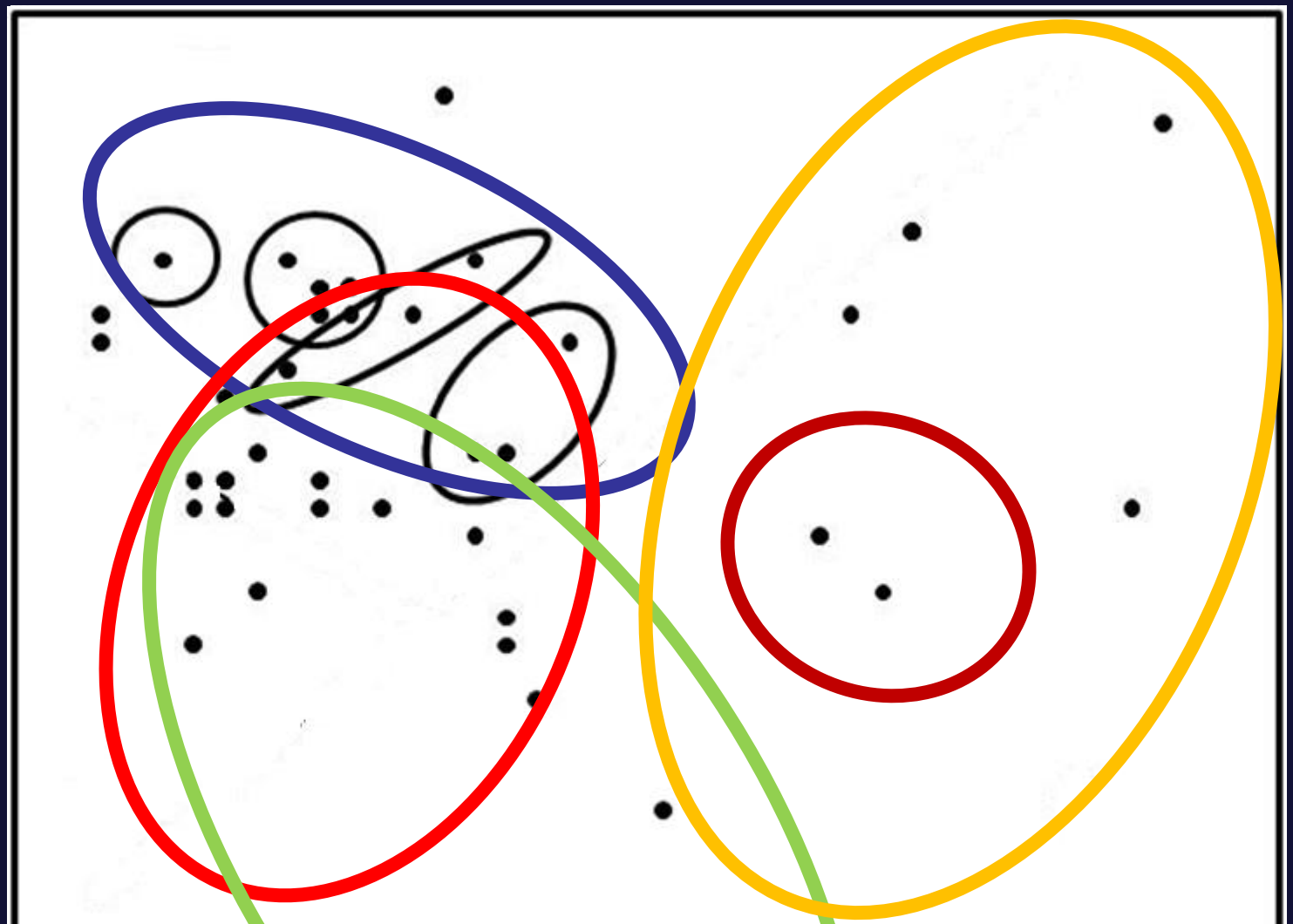


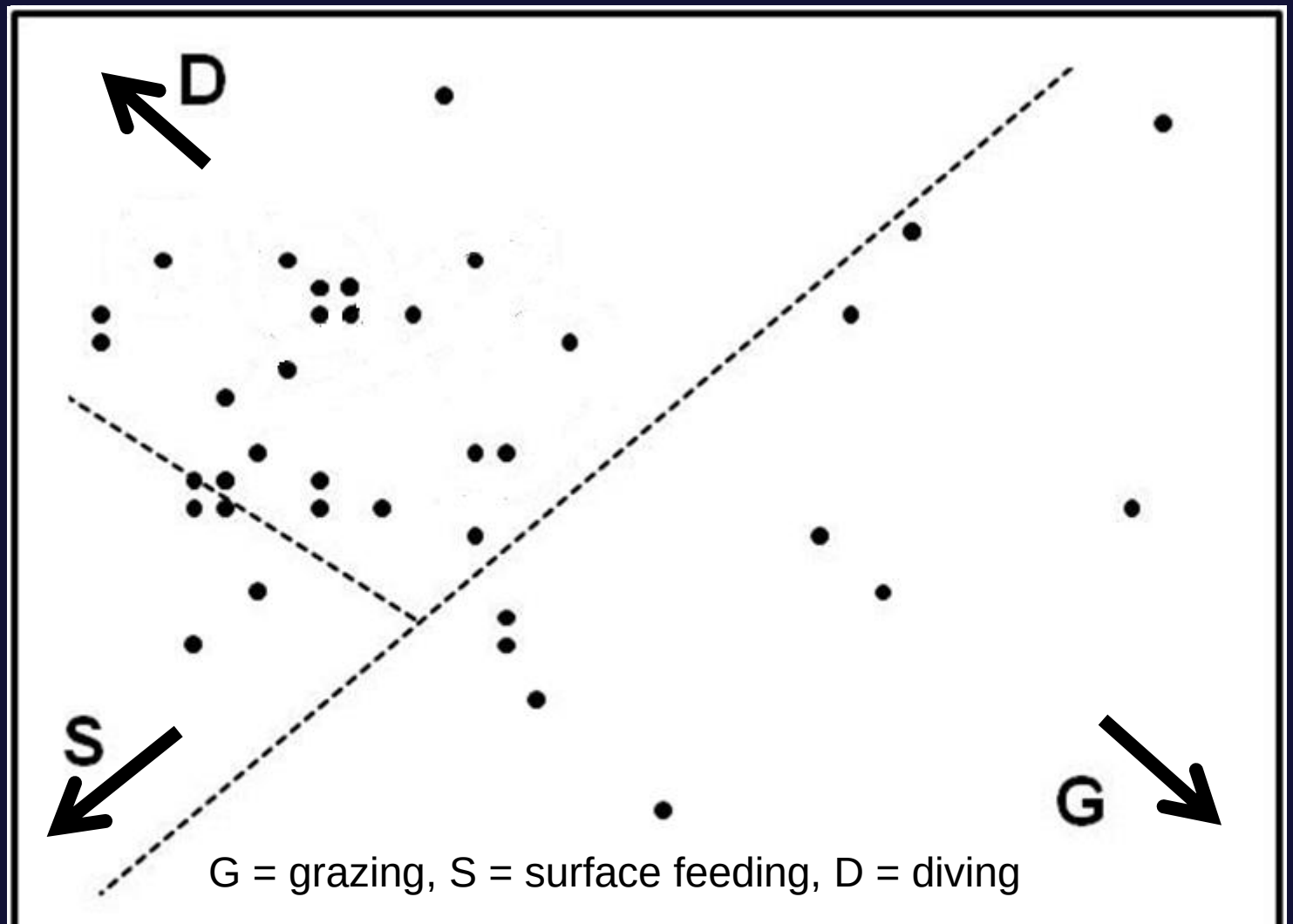
Convergent evolution for a femur trait

The EDf functional space arranges the species so that all such shared traits form unimodal response in the space



The EDf functional space reveals functions or habitat factors/gradients

(Faith 1987 *Cladistics)*



G = grazing, S = surface feeding, D = diving

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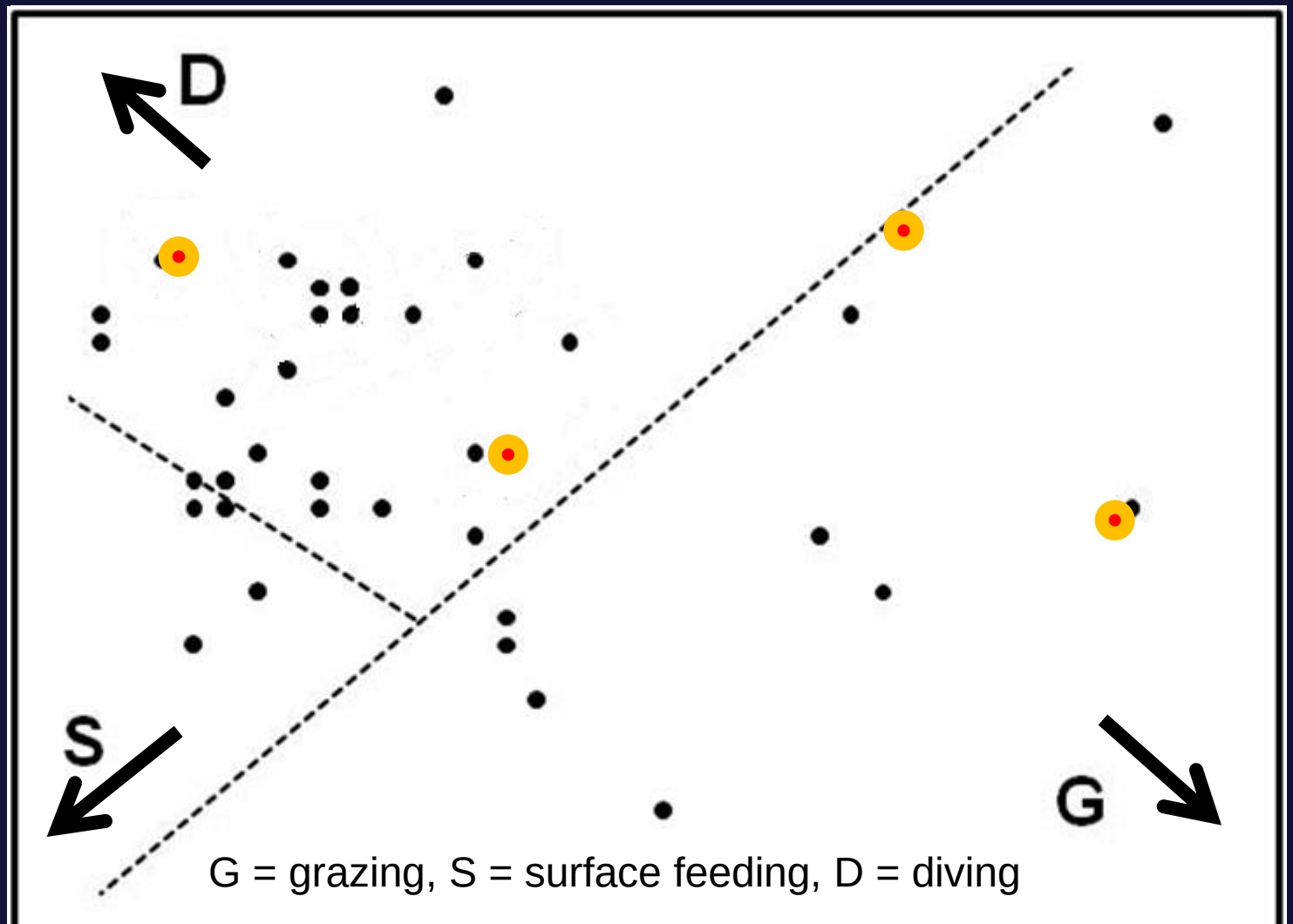
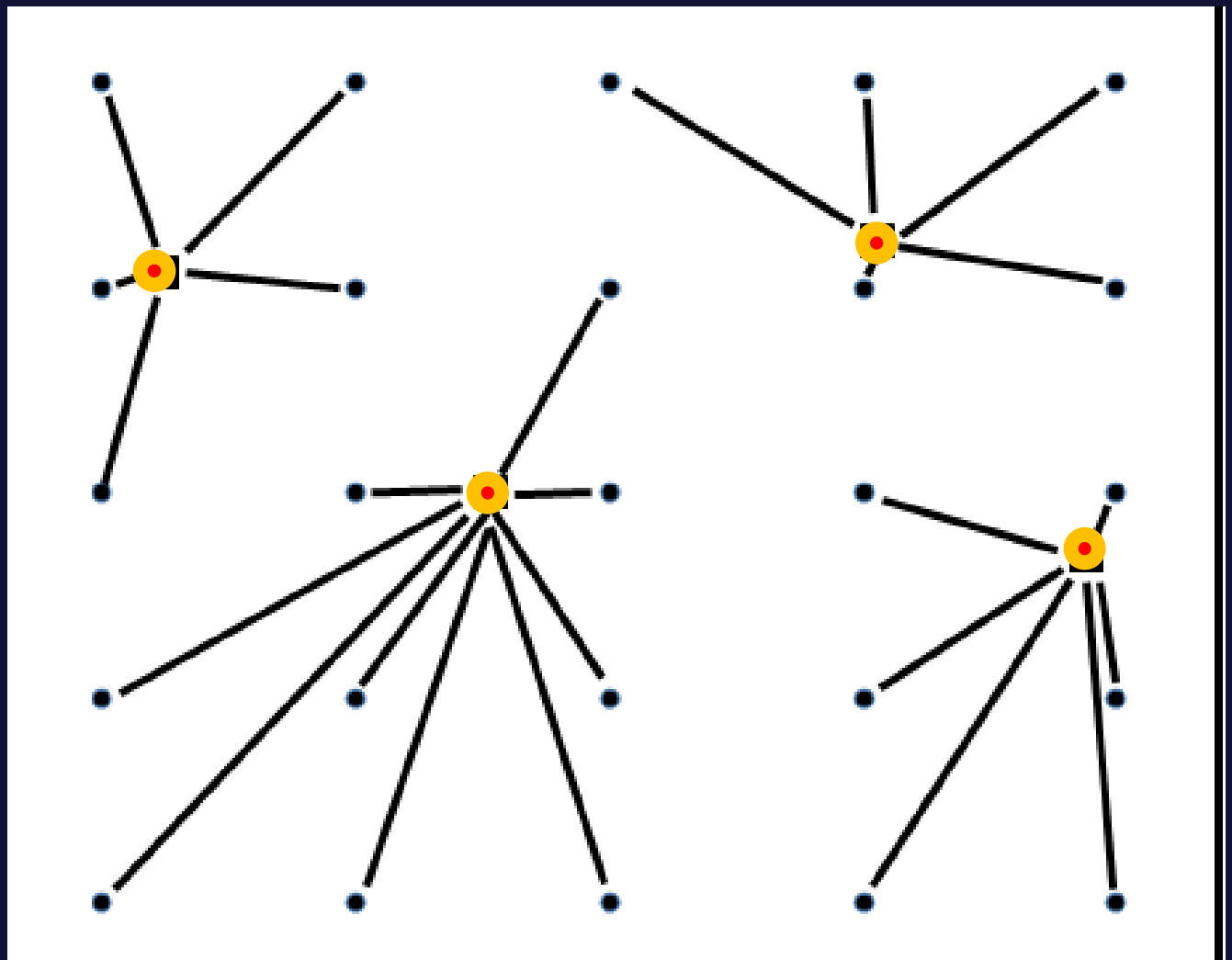


G = grazing, S = surface feeding, D = diving

EDf uses p-median type calculations to assess the relative number of features or traits represented by a set of species



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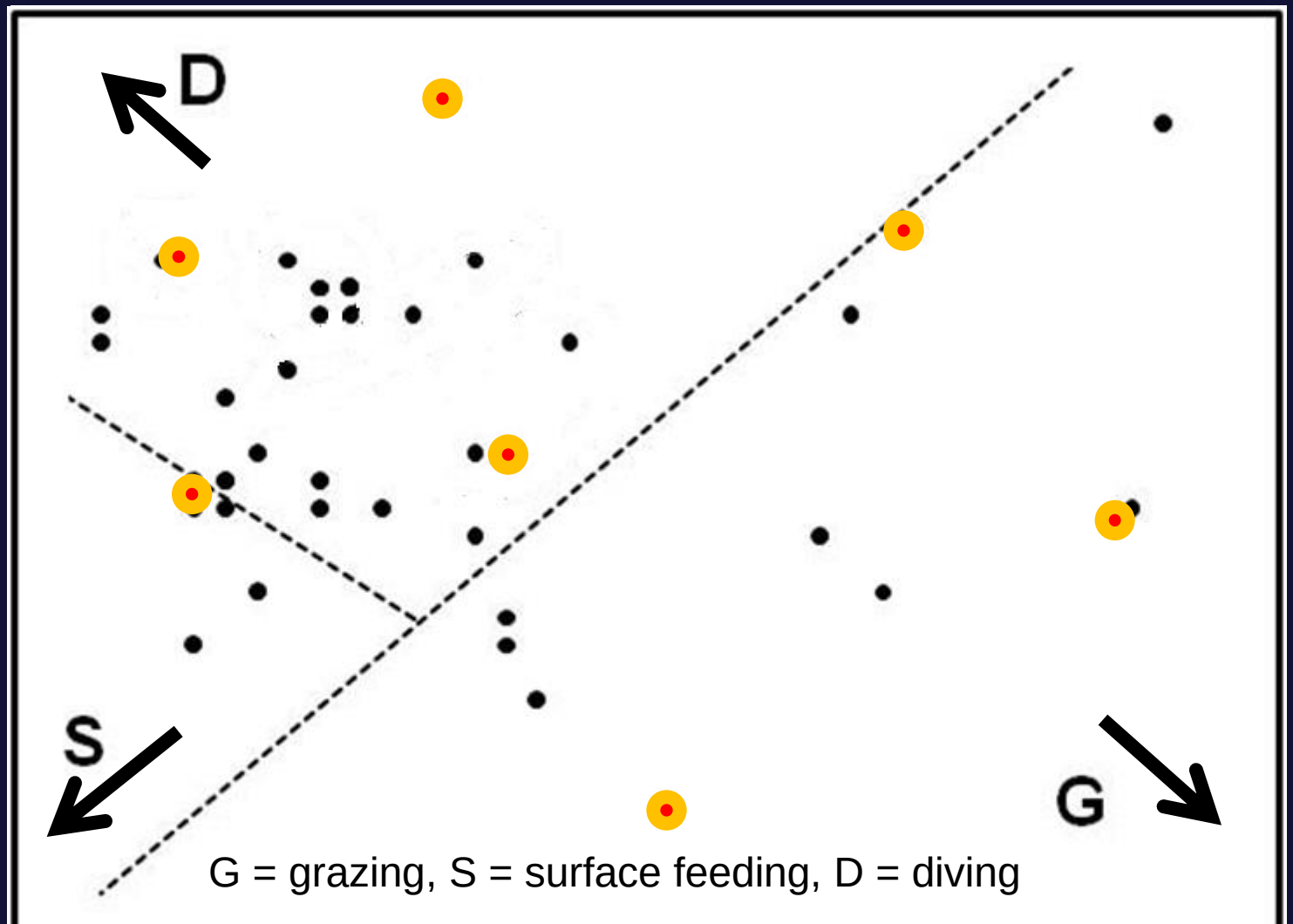

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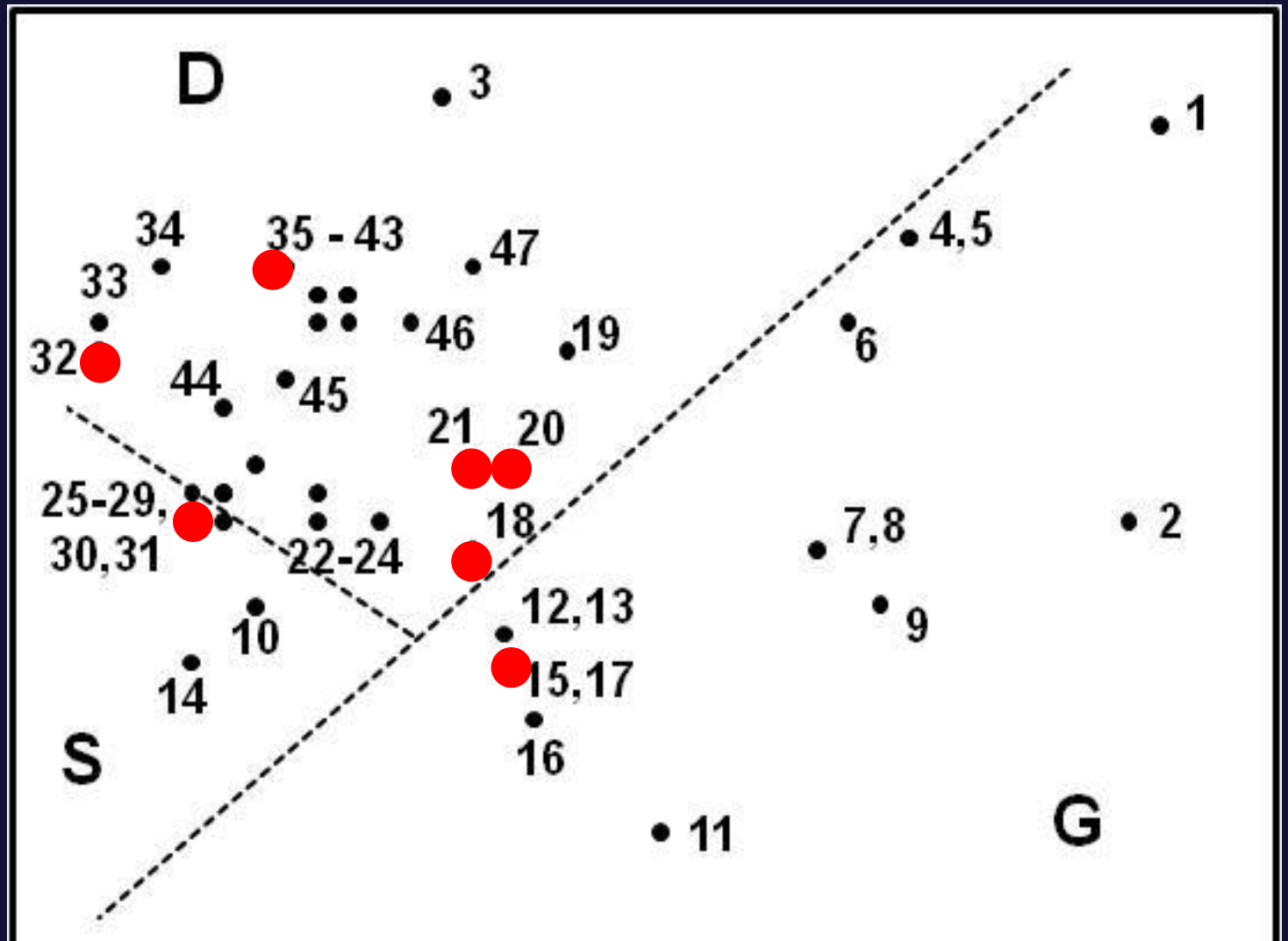
Current red list species use probabilities of extinction to estimate expected functional trait diversity loss



Weitzman (1992) “expected diversity” method

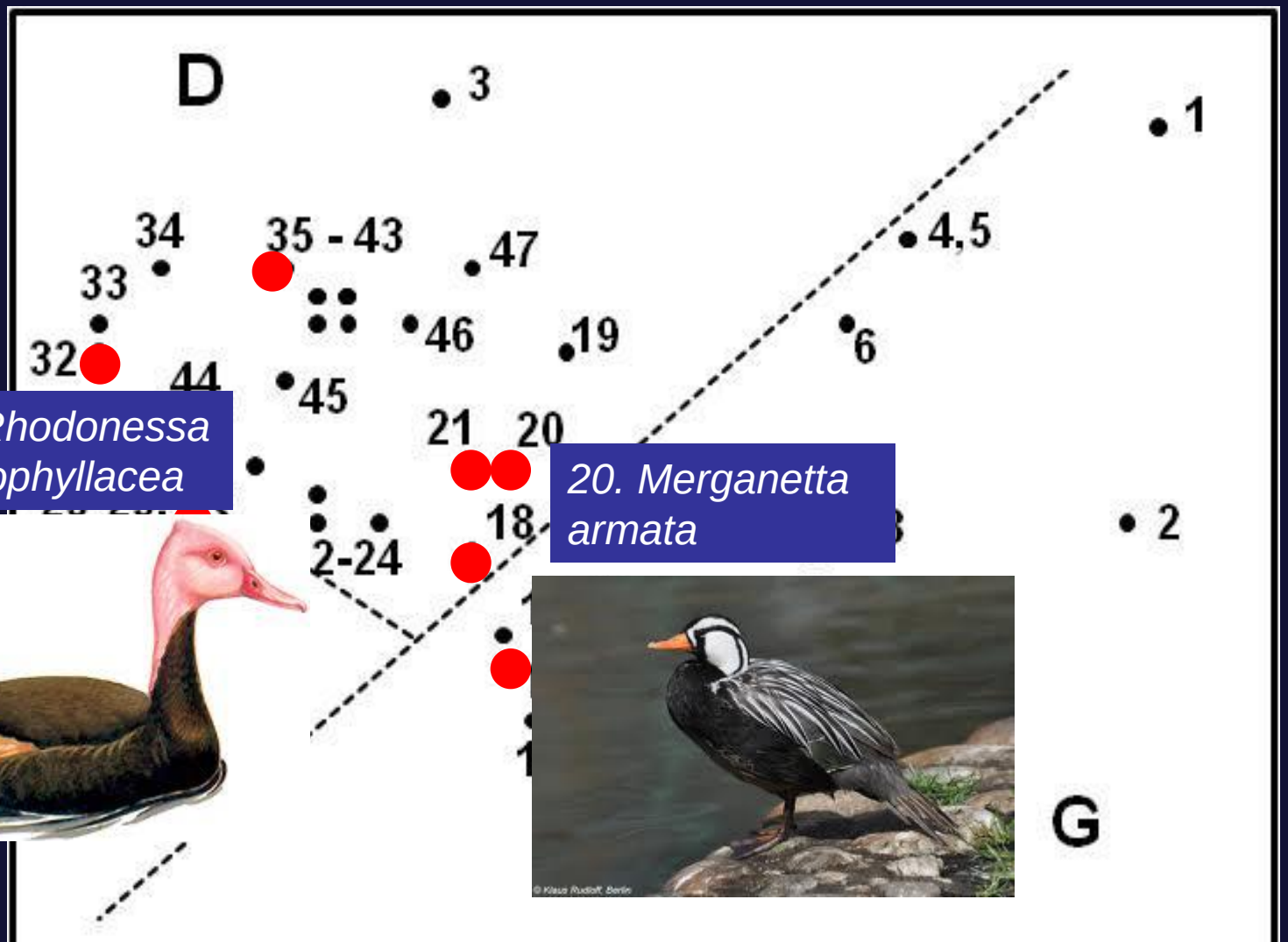
For each possible outcome or combination, c, of species (or other objects)
We have a diversity value, D(c).

with an estimated probability, q(c), that it will not be lost.

The expected diversity retained is the sum,
over all possible combinations, of $q(c)*D(c)$

$$\sum q(c)*D(c) \text{ or } \sum q(c)*EDf(c) \text{ or } \sum q(c)*PD(c)$$

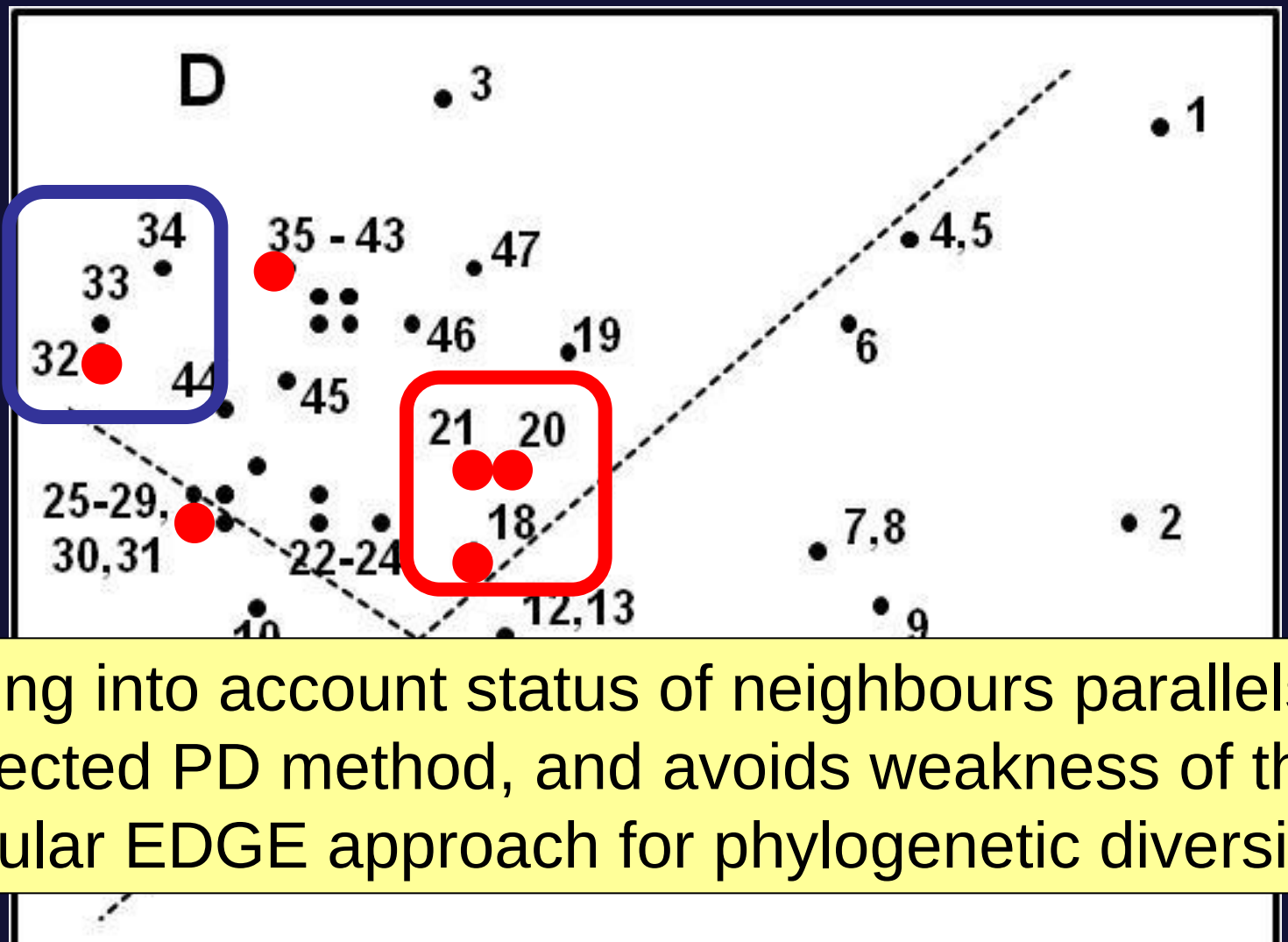
Current red list species use probabilities of extinction to estimate expected functional trait diversity gain



32. Rhodonessa caryophyllacea

20. Merganetta armata

The functional space neighbors of *Merganetta armata* (20) also are threatened, so protecting this species best increases expected functional trait diversity



Taking into account status of neighbours parallels expected PD method, and avoids weakness of the popular EDGE approach for phylogenetic diversity.

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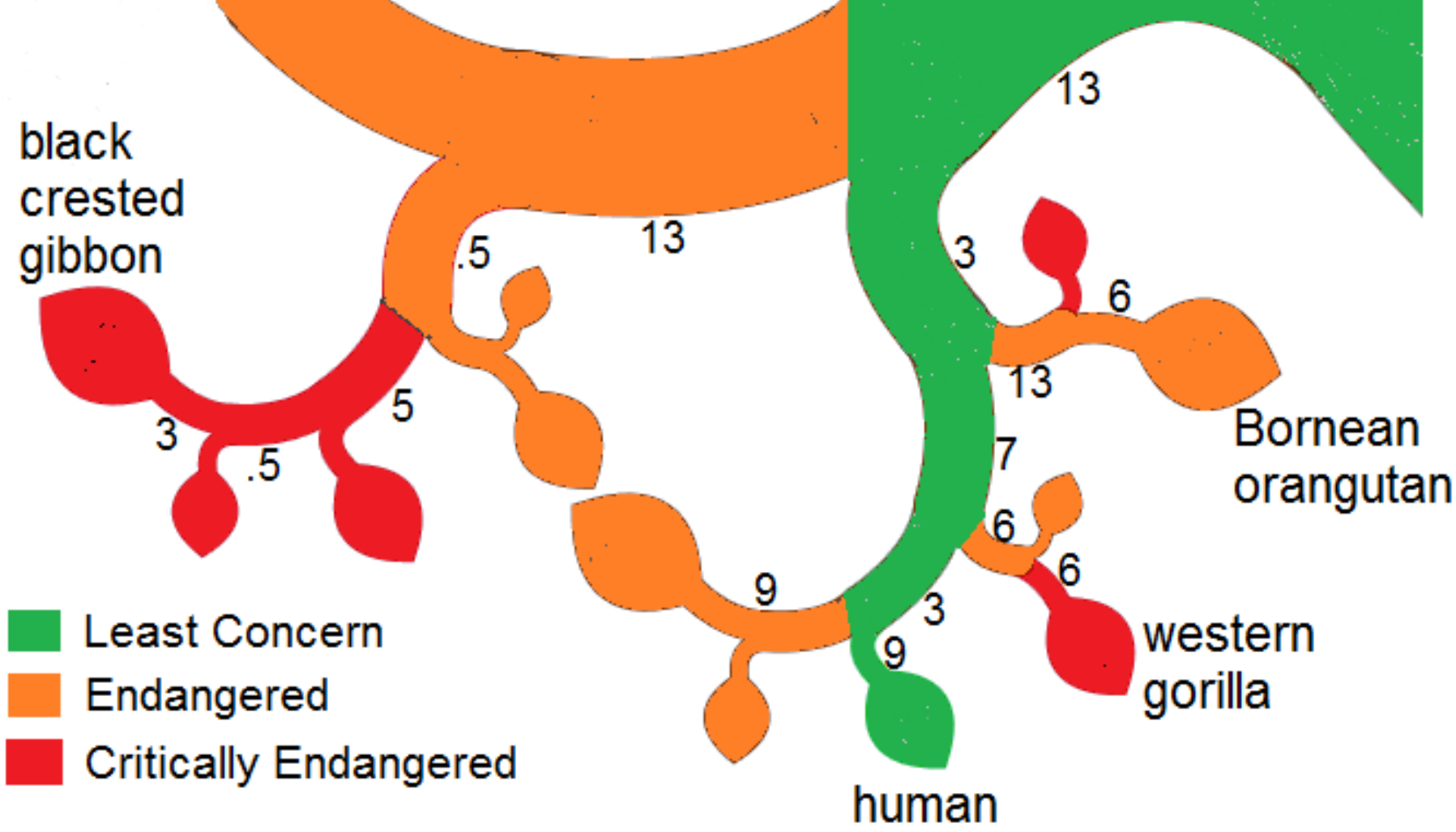
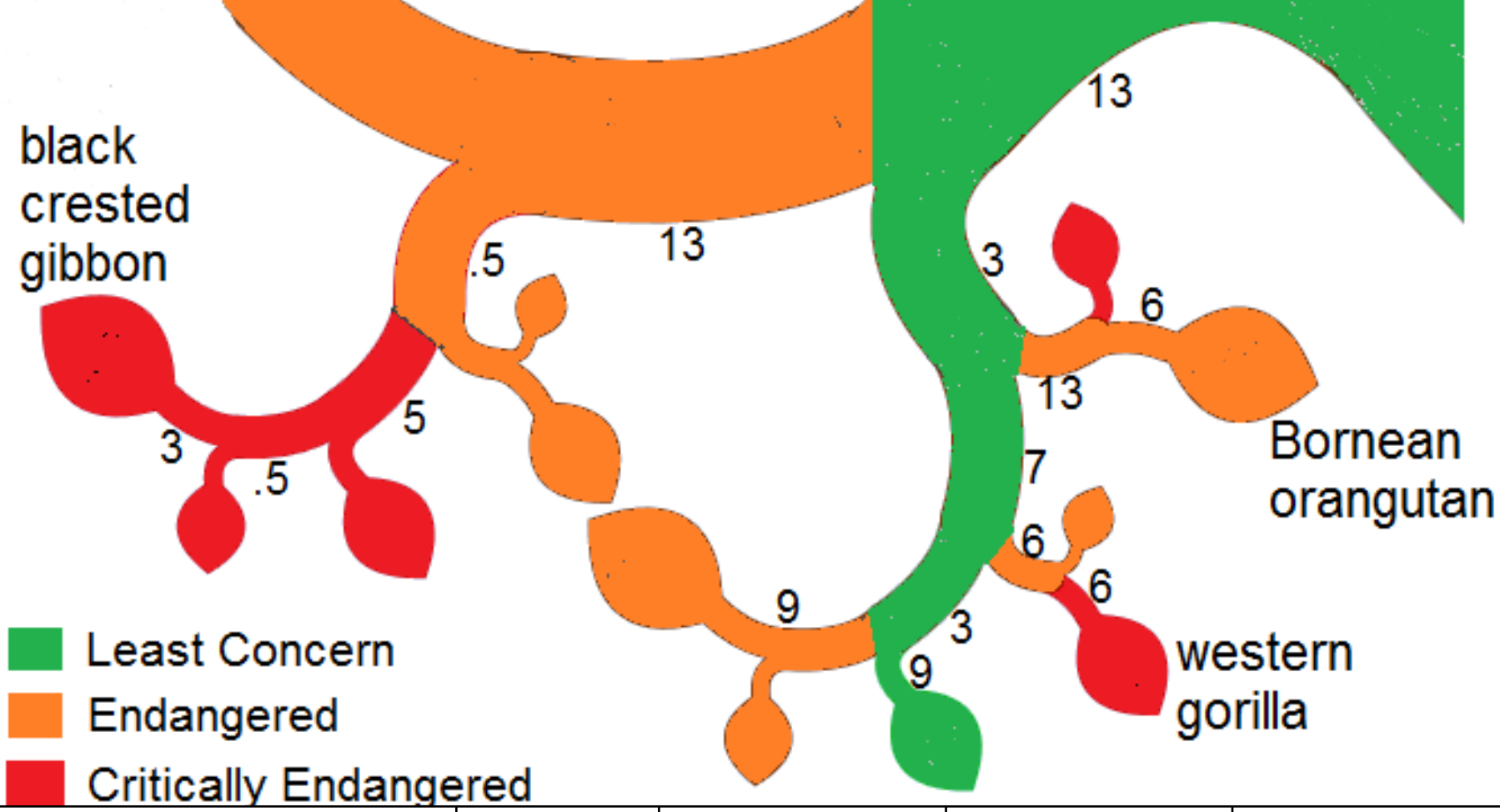


From Forest et al 2015. Phil Trans Royal Soc B

fig.redrawn from ONEZOOM.ORG



	Human	Western gorilla	Bornean orang-utan	Black crested gibbon
ED evol distinctness	12.5	11.5	13.6	6.7
Unique PD	9.0	6.0	6.0	3.0
PD complementarity given humans secure	0	12	19	22

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We have a diversity value, D(c).

with an estimated probability, q(c), that it will not be lost.

The expected diversity retained is the sum,
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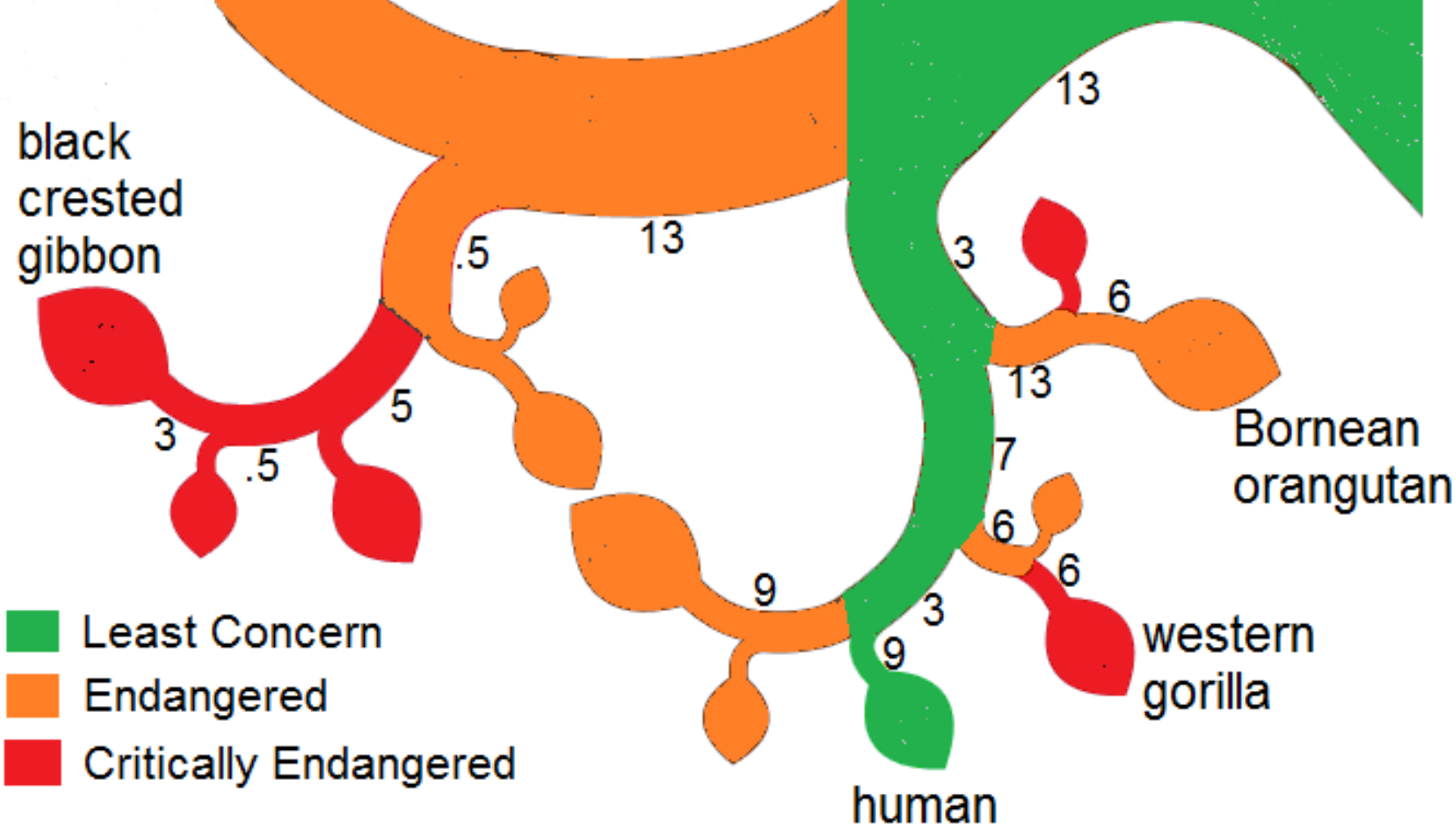
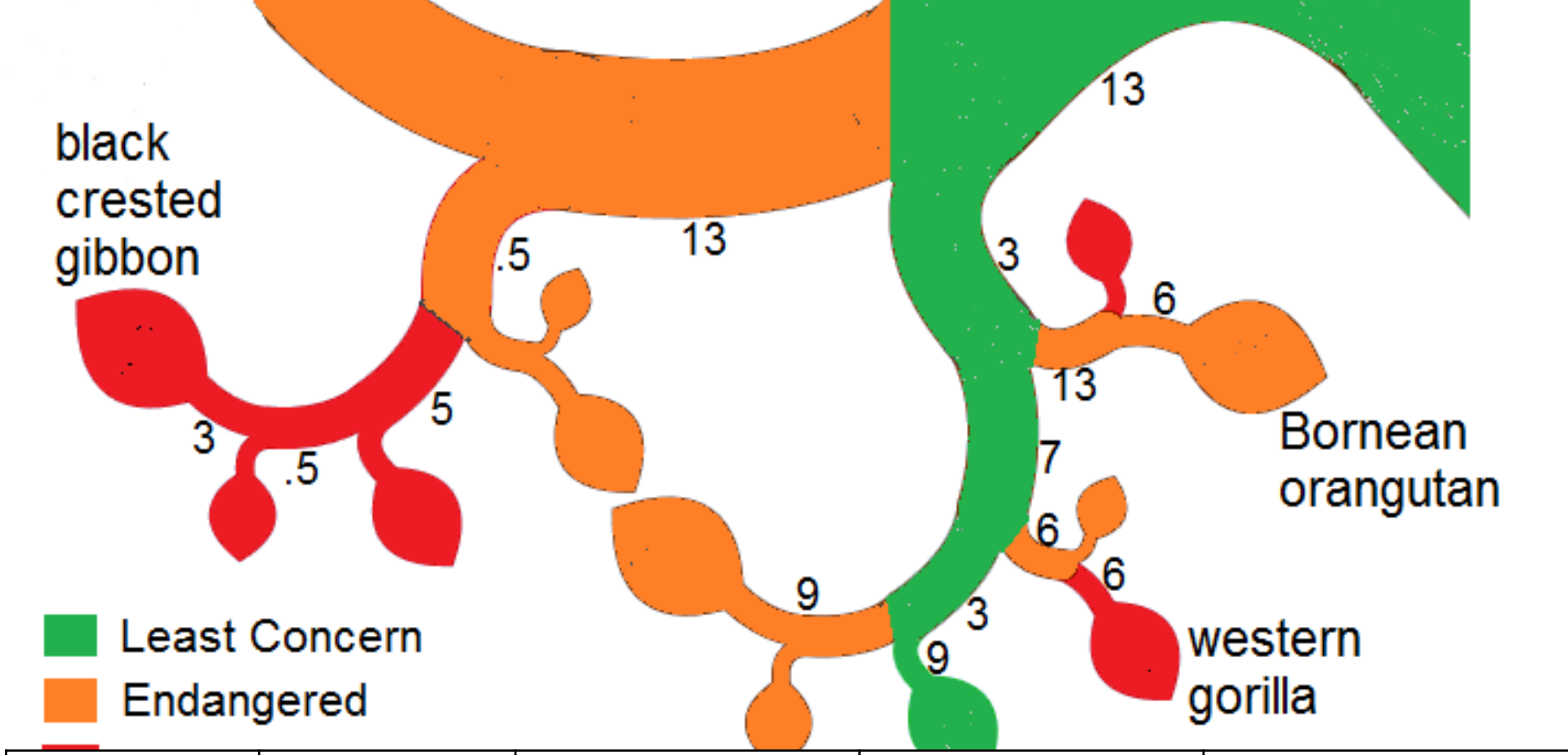
$$\sum q(c) * D(c) \text{ or } \sum q(c) * EDf(c) \text{ or } \sum q(c) * PD(c)$$



	Great ape clade	Apes & human clade
Total PD	155my	79my
Current expected PD loss	120my	70my



Expected PD indices	Human	Western gorilla	Bornean orangutan	Black crested gibbon
EDGE	0.31	4.6	2.7	2.7
HEDGE	0	12	19	22
ADEPD*	N/A	4.5	7.0	4.3
LEDGE	35	0	0	0

*Nunes et al in press

LEDGE species: PD bright spots

‘Loss-significant Evolutionarily Distinctive Globally Enduring’ (LEDGE) species.

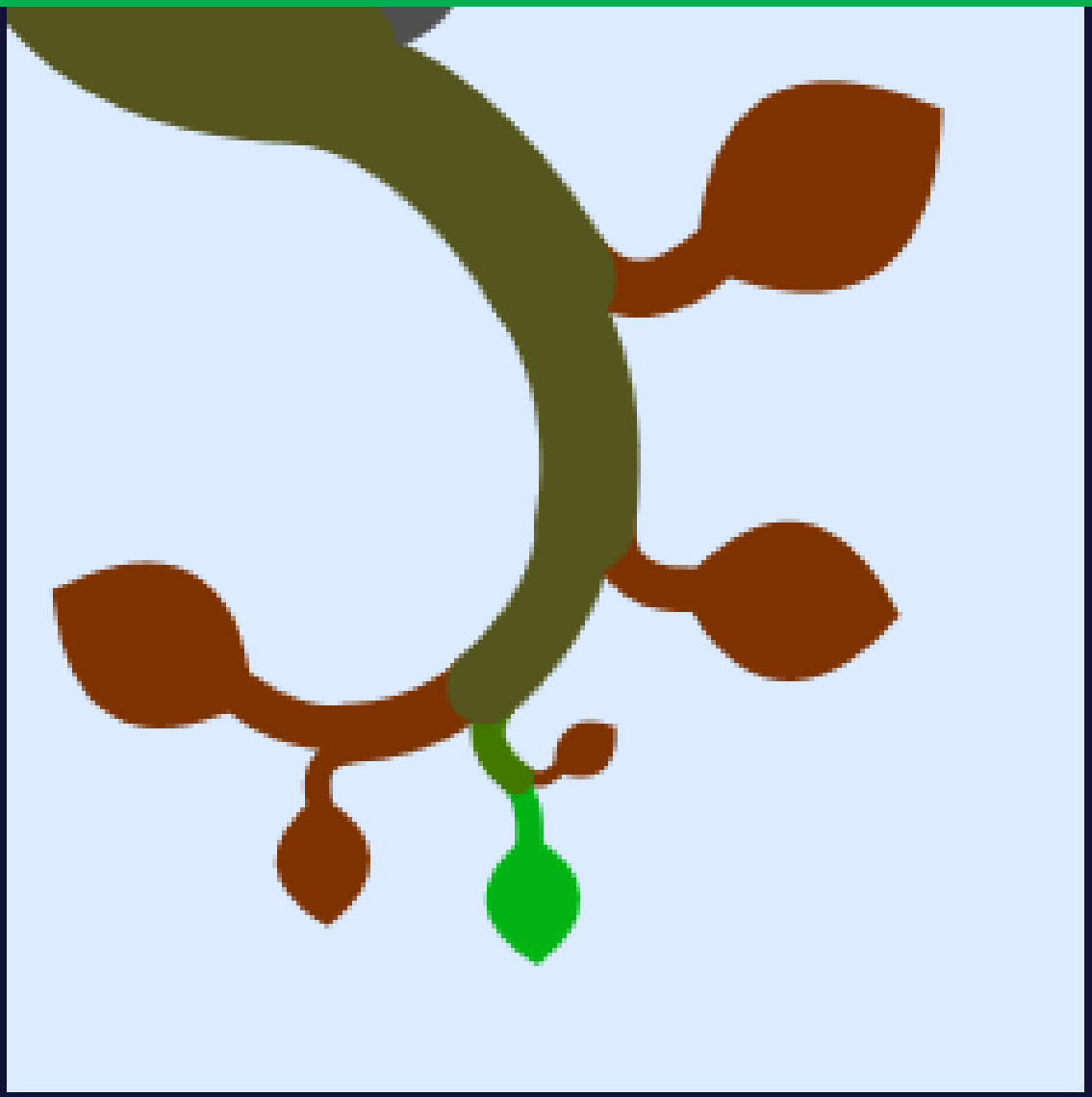
secure, distinctive, species whose loss would mean a big loss in expected PD.

example - the aardvark
rated as Least Concern
uniquely representing nearly 90 Myr of evolutionary heritage (it is the only living species of the order Tubulidentata).

If the aardvark were to go extinct, the change in expected PD, corresponding to its LEDGE score, would be about 90 Myr.

A LEDGE species:
the shrub frog *Pseudophilautus hoipolloi*

re-drawn from Onezoom (www.onezoom.org).



Hoi polloi' means 'the majority' (the working class, the commoners)

Conventional focus is on threatened species (and evolutionarily distinctive)

Pseudophilautus hoipolloi suggests that the common secure species sometimes are under-appreciated.

Species whose loss would imply a very large loss in expected PD deserve acknowledgement as key PD species

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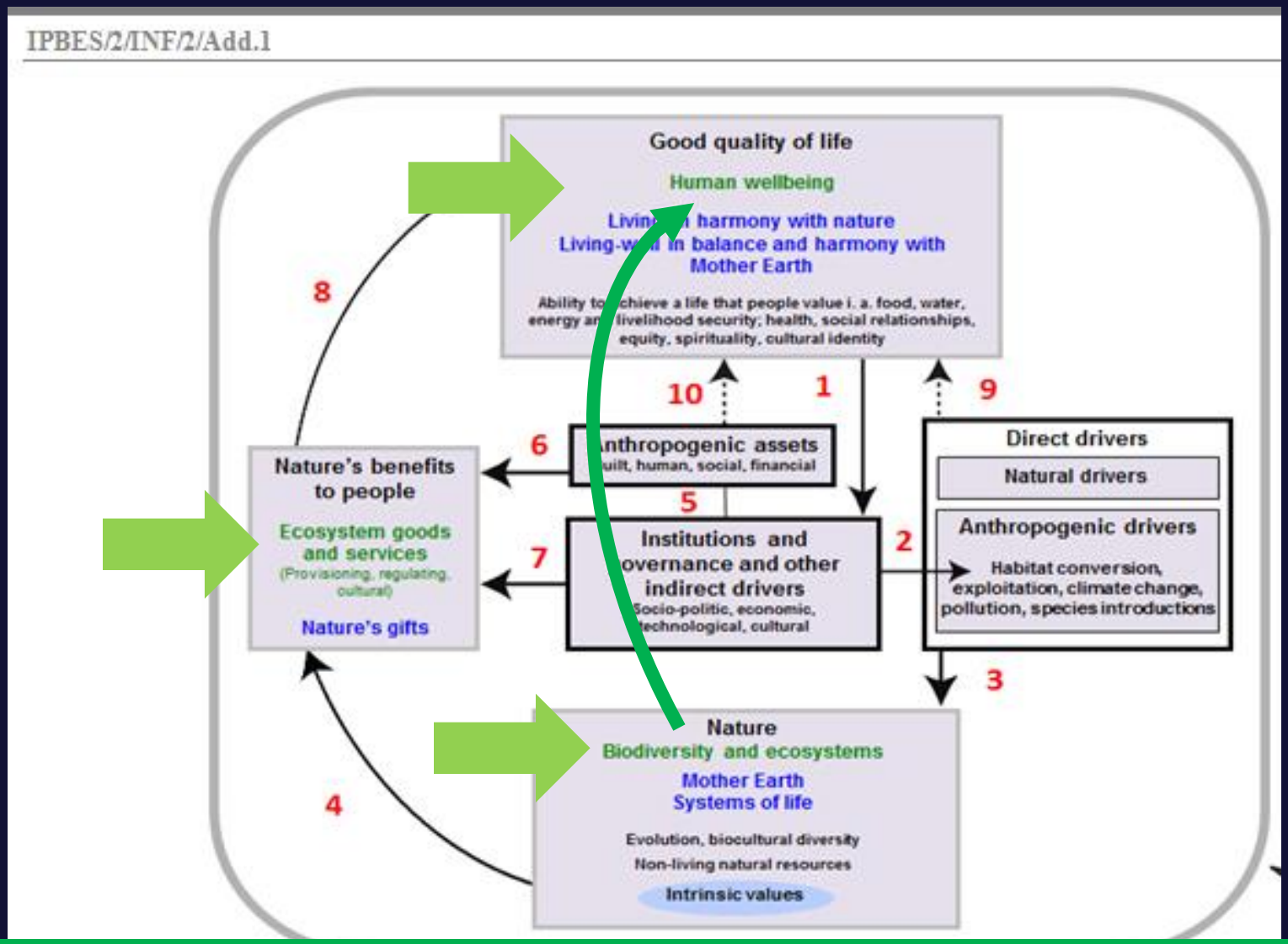
IPBES conceptual framework.



"option value" - the benefit in maintaining something in the absence of knowledge about its future benefits.

Sustainability tipping points

Ecosystem services seen as the pathway for biodiversity conservation

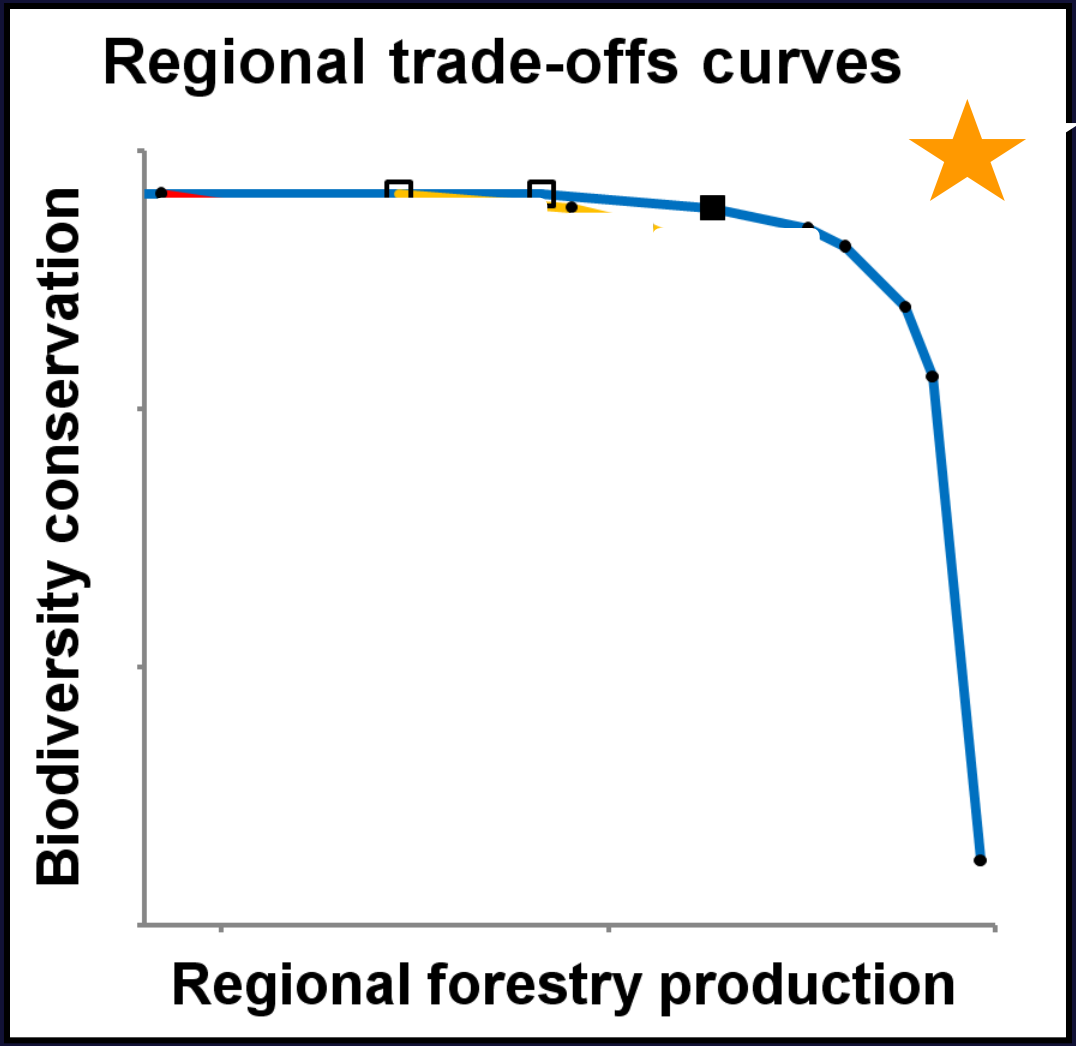
Assume win-wins: where-ever ecosystem services values beat forestry production values we also protect 100% of local biodiversity

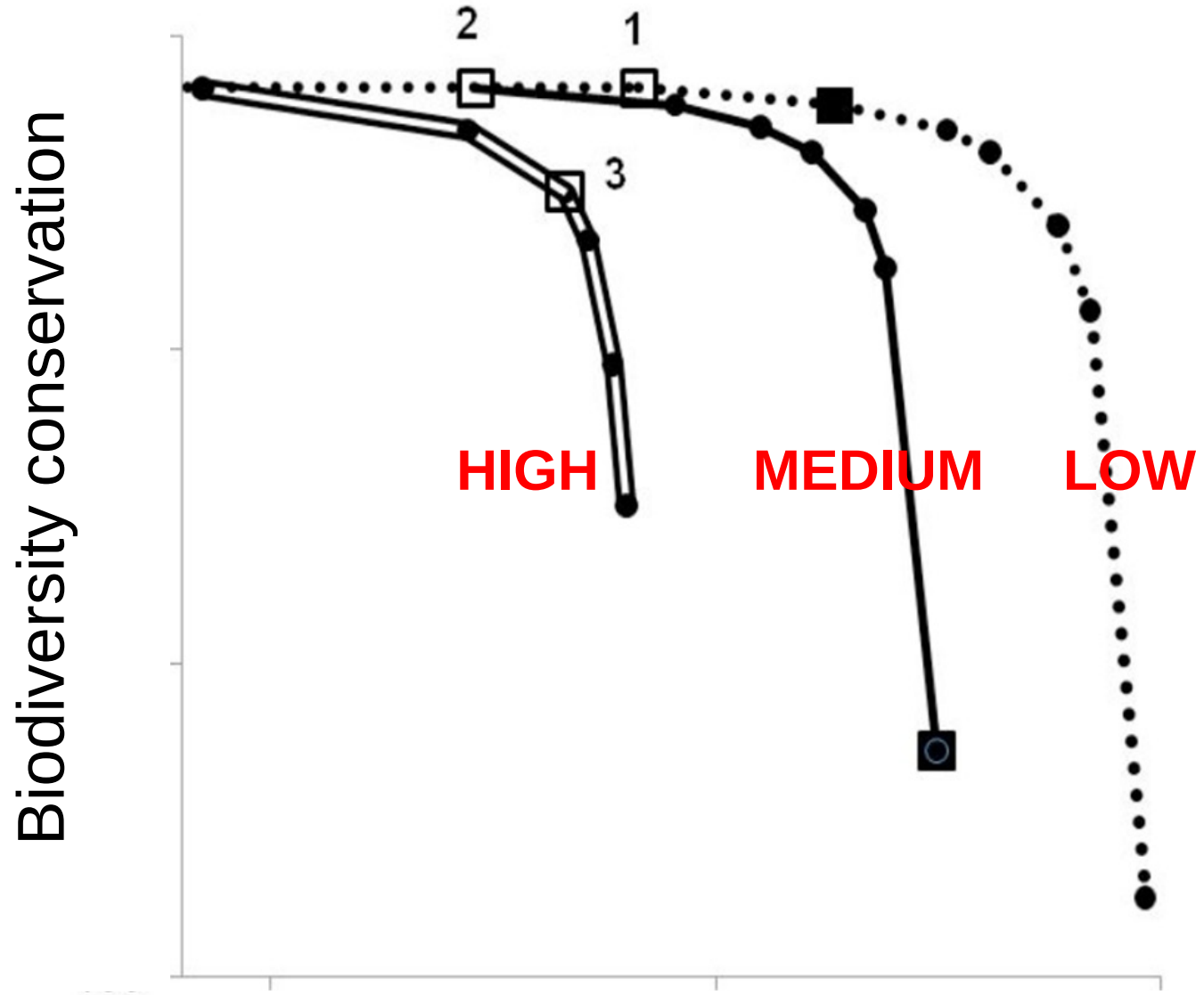
Faith DP (2014) Ecosystem services can promote conservation over conversion and protect local biodiversity, but these local win-wins can be a regional disaster. *Australian Zoologist*

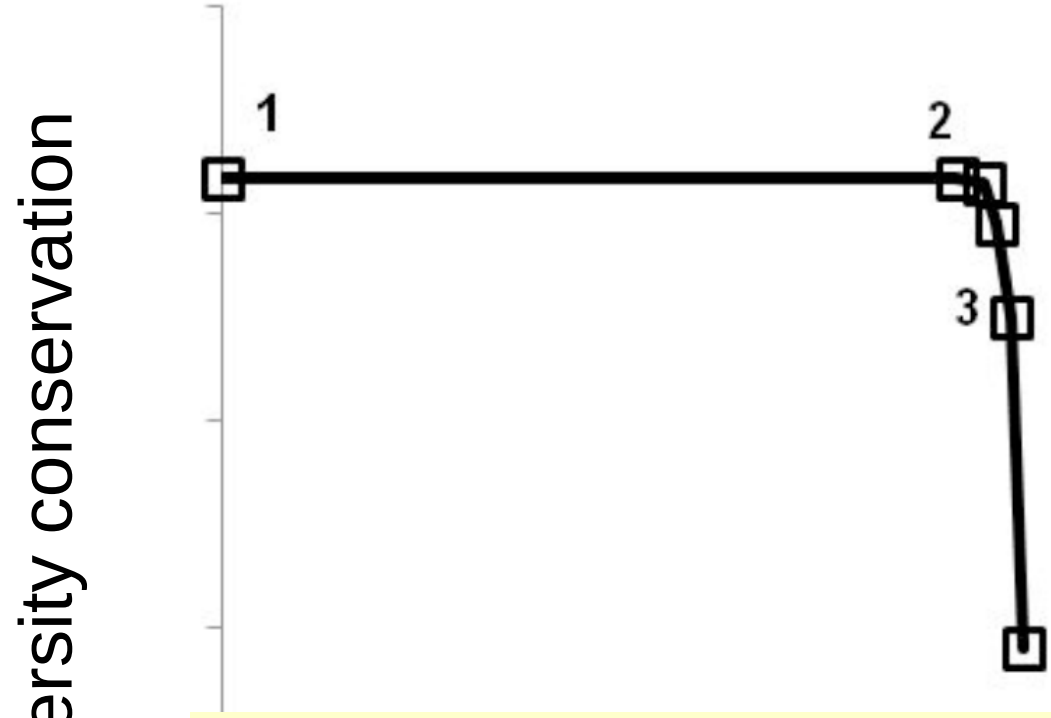
Systematic conservation planning (SCP) estimates efficiency-frontier (trade-offs) curves, reflecting biodiversity conservation level (ordinate) and opportunity costs e.g. logging (abscissa).

We would like to find land allocations /uses in that upper right hand corner ★

But conflict or lack of synergies limits us to an efficiency frontier




2
1
3
HIGH
MEDIUM
LOW
Biodiversity conservation
Forestry production achieved



Biodiversity conservation

Sustainability tipping point:
The high ecosystem services areas are largely redundant in biodiversity contributions. Systematic conservation planning can choose additional areas, but this flexibility disappears for high magnitude of ecosystem services

Magnitude of ecosystem services

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