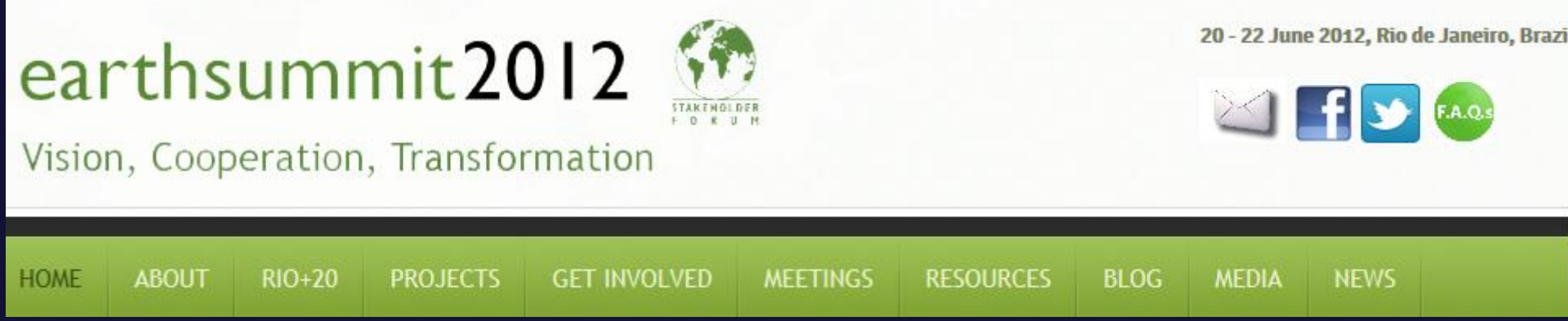
"Ecology, Evolution and Sustainable Use of Tropical Biodiversity"

Phylogeny and the sustainable use of biodiversity

Daniel P. Faith
The Australian Museum

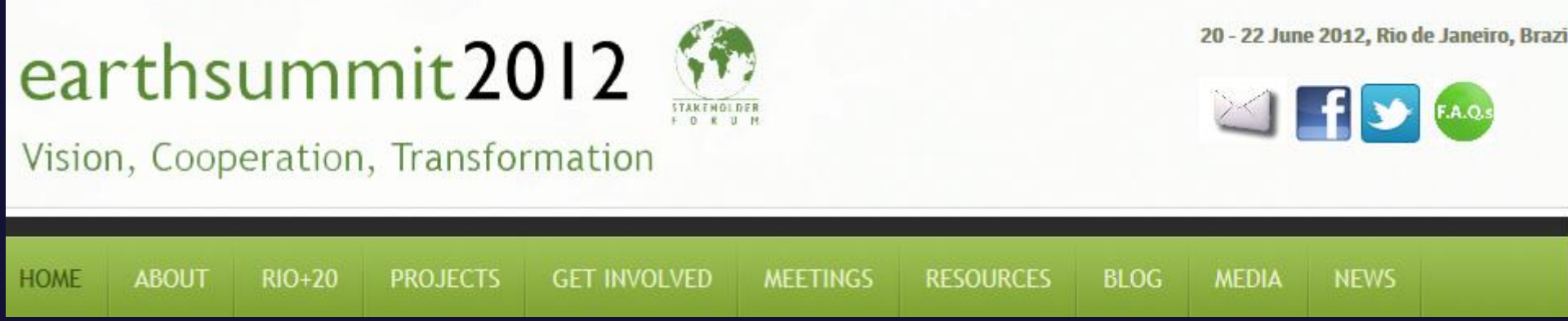


THE FUTURE WE WANT

I. Our Common Vision

1. We, the heads of State and Government and high level representatives, having met at Rio de Janeiro, Brazil, from 20-22 June 2012, with full participation of civil society, renew our commitment to sustainable development, and to ensure the promotion of economically, socially and environmentally sustainable future for our planet and for present and future generations…..

http://www.earthsummit2012.org/



THE FUTURE WE WANT

I. Our Common Vision

…We reaffirm the intrinsic value of biological diversity, as well as the ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values of biological diversity and its critical role in maintaining ecosystems….

http://www.earthsummit2012.org/

Biodiversity value as primarily about intrinsic/biocentric values
Ecosystem services as capturing the anthropocentric values

But early justifications for biodiversity conservation included human use, anthropocentric values

World Strategy for Conservation (IUCN 1980), strongly promoted conservation to ensure benefits for future-generations. It called for conservation of diversity "for present and future use".

McNeely (1988) highlighted the need for a "safety net of diversity" and linked to "option values" – the value of biodiversity in providing uses, often unanticipated, for future generations

Reyers et al (2012) Finding Common Ground for Biodiversity and Ecosystem Services. *Bioscience*

Faith DP (accepted) Biodiversity and ecosystem services: similar, but different. *Bioscience*.

Biodiversity value as primarily about intrinsic/biocentric values
Ecosystem services as capturing the anthropocentric values

Early justifications for biodiversity conservation included human use, anthropocentric, values

World Strategy for Conservation (IUCN 1980), strongly promoted conservation to ensure benefits for future-generations. It called for conservation of diversity "for present and future use".

McNeely (1988) highlighted the need for a "safety net of diversity" and linked to "option values" – the value of biodiversity in providing uses, often unanticipated, for future generations

Reyers et al (2012) Finding Common Ground for Biodiversity and Ecosystem Services. *Bioscience*

Faith DP (accepted) Biodiversity and ecosystem services: similar, but different. *Bioscience*.

Biodiversity value as primarily about intrinsic/biocentric values
Ecosystem services as capturing the anthropocentric values

Early justifications for biodiversity conservation included human use, anthropocentric, values

World Strategy for Conservation (IUCN 1980), highlighted benefits for future-generations, and called for conservation of diversity “for present and future use”.

McNeely (1988) highlighted the need for a “safety net of diversity” and linked to “option values” – the value of biodiversity in providing uses, often unanticipated, for future generations

Reyers et al (2012) Finding Common Ground for Biodiversity and Ecosystem Services. *Bioscience*

Faith DP (accepted) Biodiversity and ecosystem services: similar, but different. *Bioscience*.

Biodiversity value as primarily about intrinsic/biocentric values
Ecosystem services as capturing the anthropocentric values

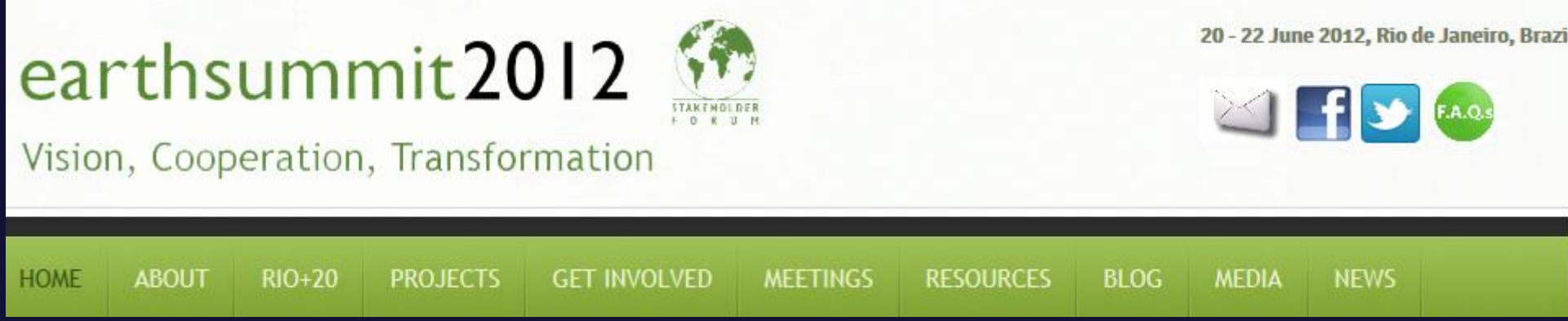
Early justifications for biodiversity conservation included human use, anthropocentric, values

World Strategy for Conservation (IUCN 1980), highlighted benefits for future-generations, and called for conservation of diversity “for present and future use”.

McNeely (1988) referred to a “safety net of diversity” , linked to “option values” – the value of biodiversity in providing uses, often unanticipated, for future generations

Reyers et al (2012) Finding Common Ground for Biodiversity and Ecosystem Services. *Bioscience*

Faith DP (accepted) Biodiversity and ecosystem services: similar, but different. *Bioscience*.



THE FUTURE WE WANT

Lots of references to

“sustainable use of biodiversity”

but nearly all are in the general phrase

“the conservation and sustainable use of biodiversity”

http://www.earthsummit2012.org/

What is “sustainable use”?

CBD definition: “the use of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations”

But the new CBD targets provide a mixed message about the importance of future generations….

Convention on Biological Diversity (CBD) Strategic Plan

20 headline targets

e.g –

- reducing the rate of loss of all natural habitats
- eliminating incentives harmful to biodiversity,
- conserving target percentages of terrestrial and marine areas
- preserving genetic diversity of crop species and their relatives
- maintaining ecosystems that provide essential services

Mission of the Strategic Plan —

- "to take effective and urgent action to halt the loss of biodiversity in order to ensure that by 2020 ecosystems are resilient and continue to provide essential services"

Perrings et al. recently argued that 20 targets
“should address the 20 highest-priority threats to critical ecosystem services.” because
”what and how much biodiversity should be targeted for conservation depends on what services are important”

But we want to preserve those services and benefits that are unknown to us, but will be apparent to our children’s children.

Perrings, et al. (2010) Ecosystem services for 2020. *Science*, 330, 323-324

Faith DP (2011) *Diversity* 3, 1-7.

How do we maintain those unknown benefits and uses for future generations?

“The benefits of bioprospecting have emerged from such a wide range of organisms and environments worldwide that it is not possible to predict what species or habitats will be critical to society, or industry, in the future.”

Beattie et al (2011) Ecology and bioprospecting. *Austral Ecology*

Sustainable use of biodiversity

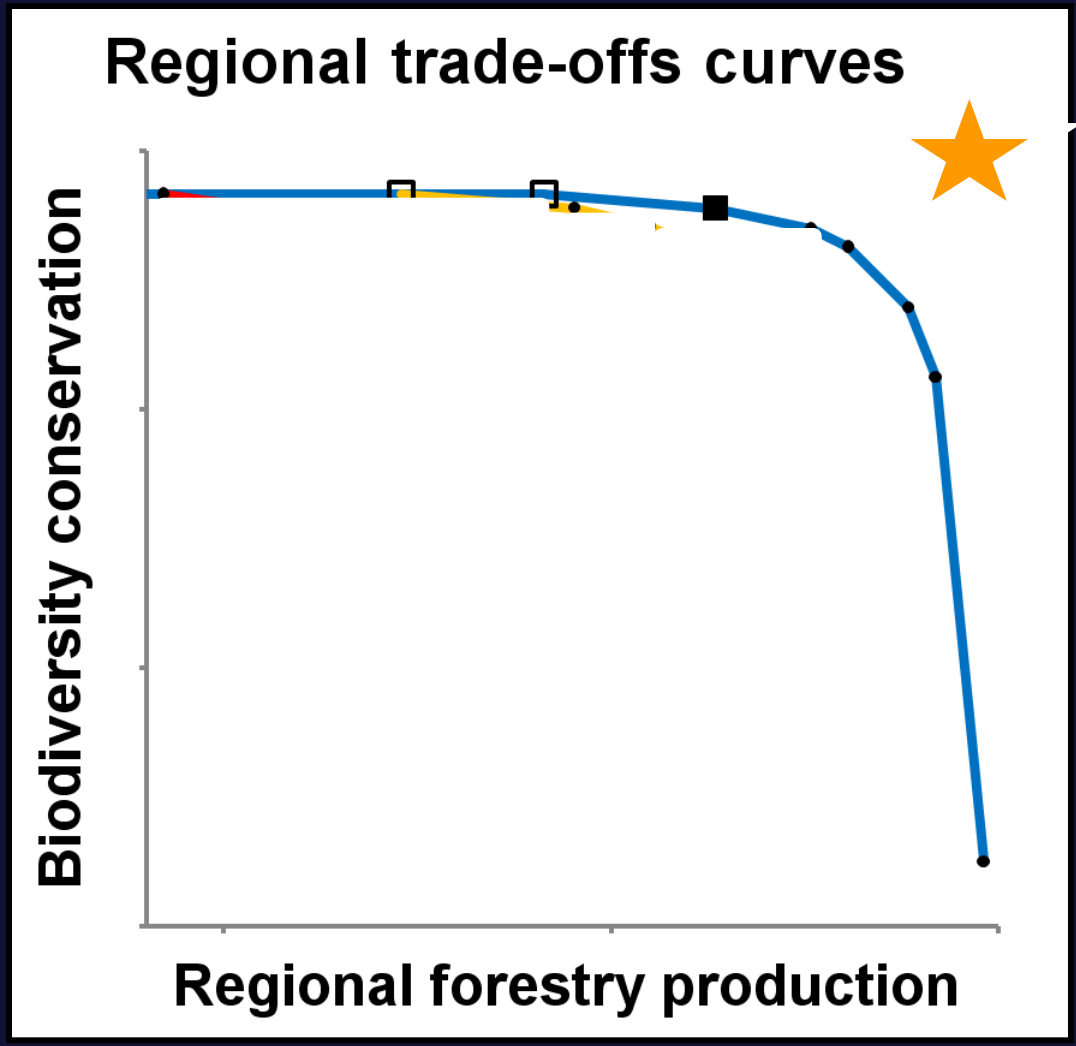
- One possibility – known ecosystem services often presented as pathway to preserve biodiversity

- Biodiversity loss is linked to provisioning services
- International trade in commodities is the underlying cause of 30% of threatened animal species extinctions
  - Lenzen, M. et al. *Nature* 486, 109–112 (2012).
- When current services value of an area leads to conservation this seems to be a good outcome – but perhaps not…

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

A key approach to regional sustainability may to avoid changes in land condition etc that shift the curve to the lower left

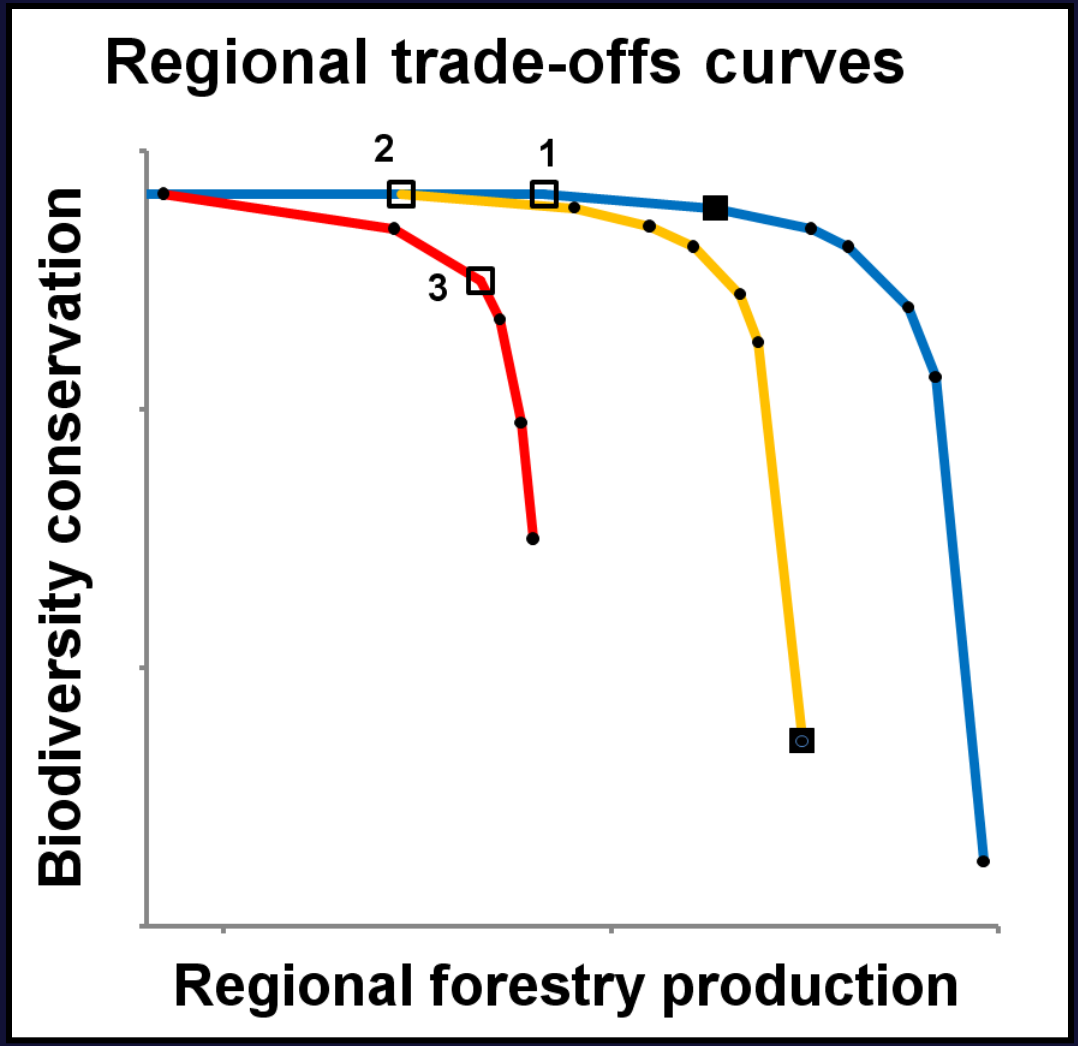


Systematic conservation planning (SCP) estimates efficiency-frontier (trade-offs) curves, reflecting biodiversity conservation level (ordinate) and opportunity costs e.g. logging (abscissa)

Curves shift to the left as increased water, recreation and other ecosystem services values imply that more areas are conserved for these services.

Blue curve ignores such ecosystem services, orange and red curves integrate the ecosystem services values (red = largest magnitude of ecosystem services values).

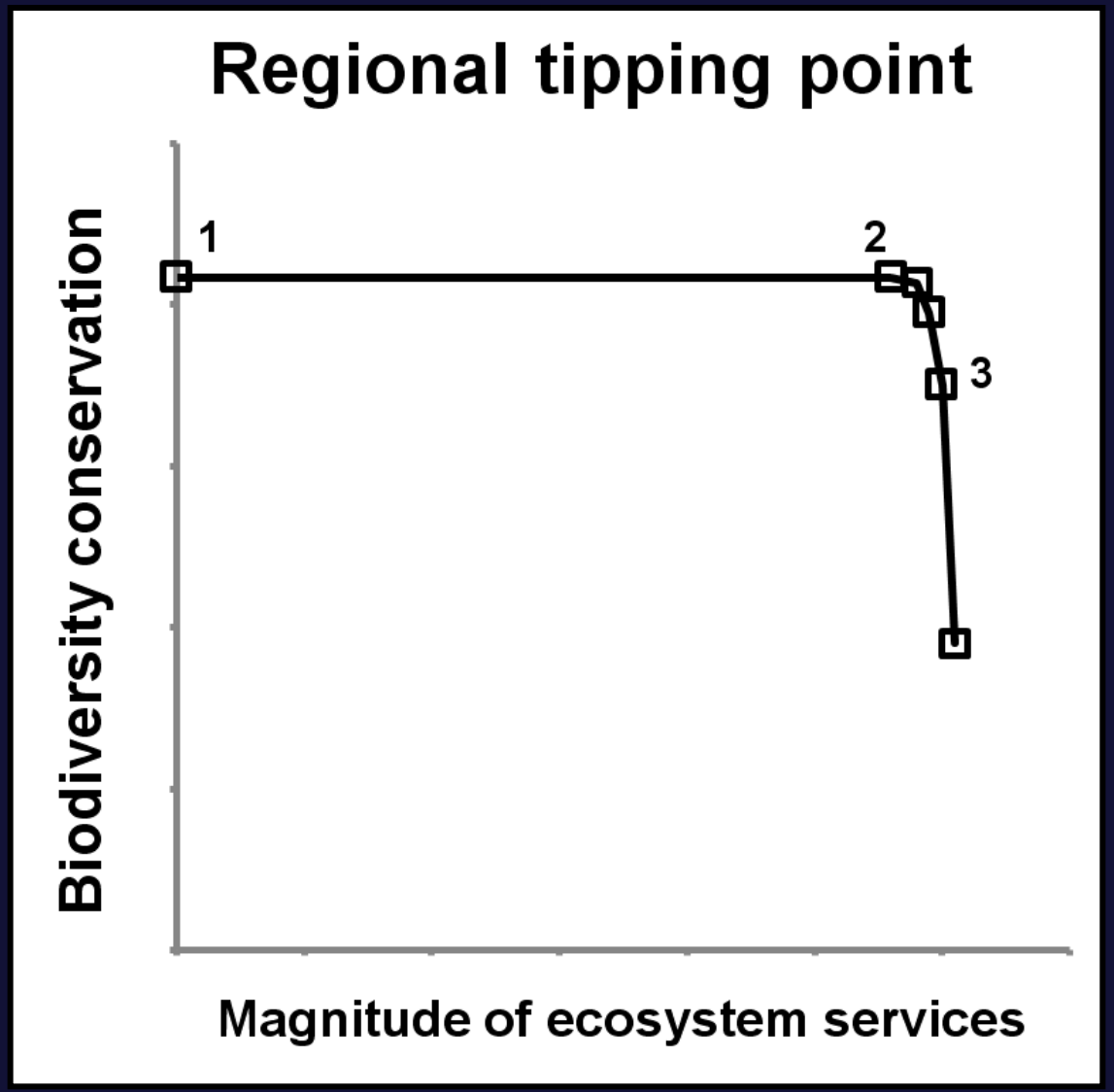
Solid squares = 100 conserved areas. Hollow squares (1-3) = 240 conserved areas.



Increases in magnitude of estimated ecosystem services values can move initial high-biodiversity SCP solutions towards a tipping point in which capacity for regional biodiversity conservation collapses.

for 240 conserved areas, biodiversity conservation levels remain high as ecosystem services magnitude increases (abscissa), until a tipping point is reached.

Solutions 1-3 from previous slide are shown.



Conclude that conservation of current benefits, even when they imply total protection of biodiversity in that place, may mean collapse in capacity for preservation of options for the future.

• Faith DP (2012) TEEB and Planet under Pressure conferences, proceedings.
• Faith DP et al (2001) A biodiversity conservation plan for Papua New Guinea based on biodiversity trade-offs analysis. *Pac. Conserv. Biol*. 6, 304-324.

With these lessons in mind, now look at phylogeny and sustainable use

REPORT OF THE
EVALUATION
OF THE BIOTA-FAPESP
PROGRAM and BIOprospecTA

3 to 11 July 2011
USP, São Carlos, SP. Brazil

The 7th Evaluation Meeting of the BIOTA-FAPESP Program and the Evaluation Meeting of BIOprospecTA were concluded on July 11, 2011 at FAPESP's headquarters in São Paulo.

Called for
"further development of the phylogenetic framework to facilitate exploration and assessments, in order to provide a solid basis of sustainable use of the biodiversity…"

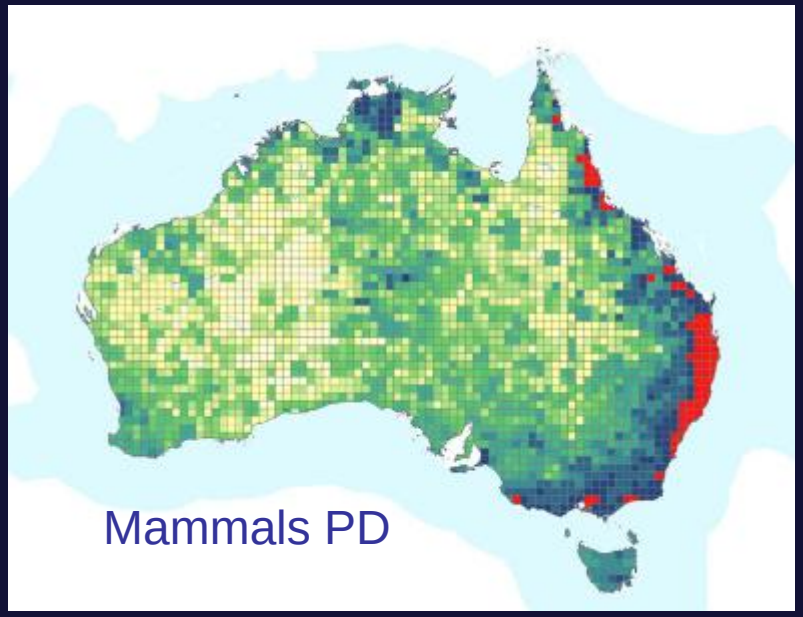
DIVERSITAS
an international programme of biodiversity science

BioGENESIS

Providing an evolutionary framework for biodiversity science

Faith et al (2010) Evosystem services: an evolutionary perspective on the links between biodiversity and human well-being. *COSUST*

Phylogenetic diversity and evolutionary heritage



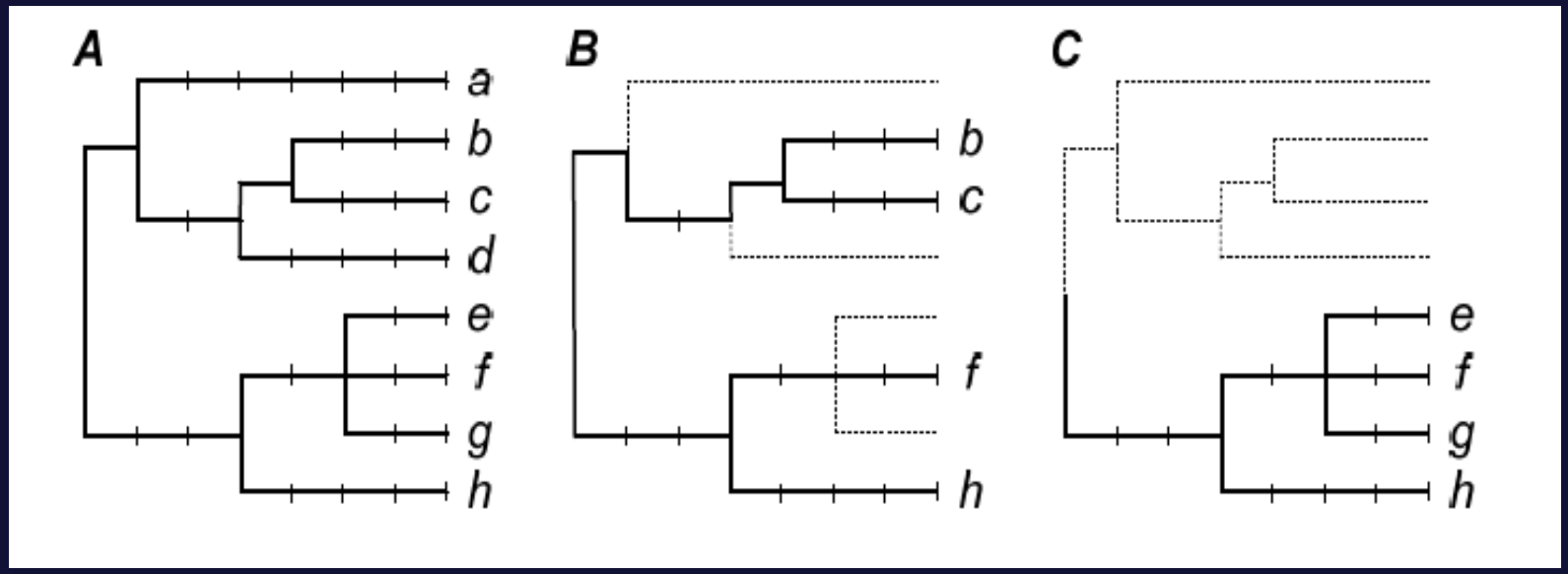
aceas
Australian Centre for Ecological Analysis & Synthesis

INTEGRATING MEASURES OF DIVERSITY AND ENDEMISM

Heritage and Wildlife Division,
Department of Sustainability, Environment, Water, Populations and Communities

PD – phylogenetic diversity

PD of a set of taxa = length of spanning path of the set on the phylogeny
(how much of the tree travelled over if connect up those taxa on the tree)

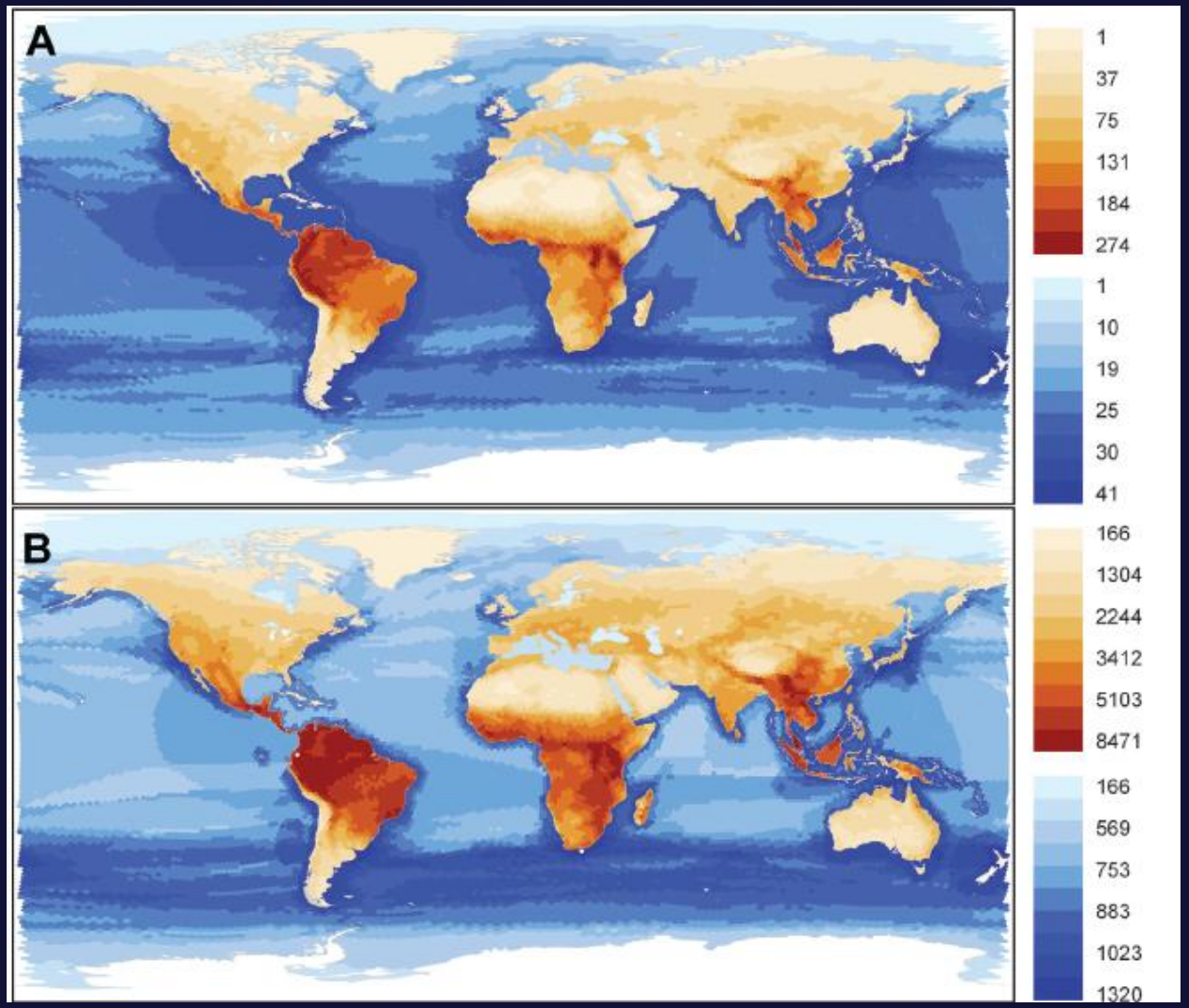


PD measures “feature diversity”

scenario *B* represents more feature diversity

Faith DP. *Biological Conservation* (1992).
Faith DP. *Cladistics* (1992) 8:361-373.

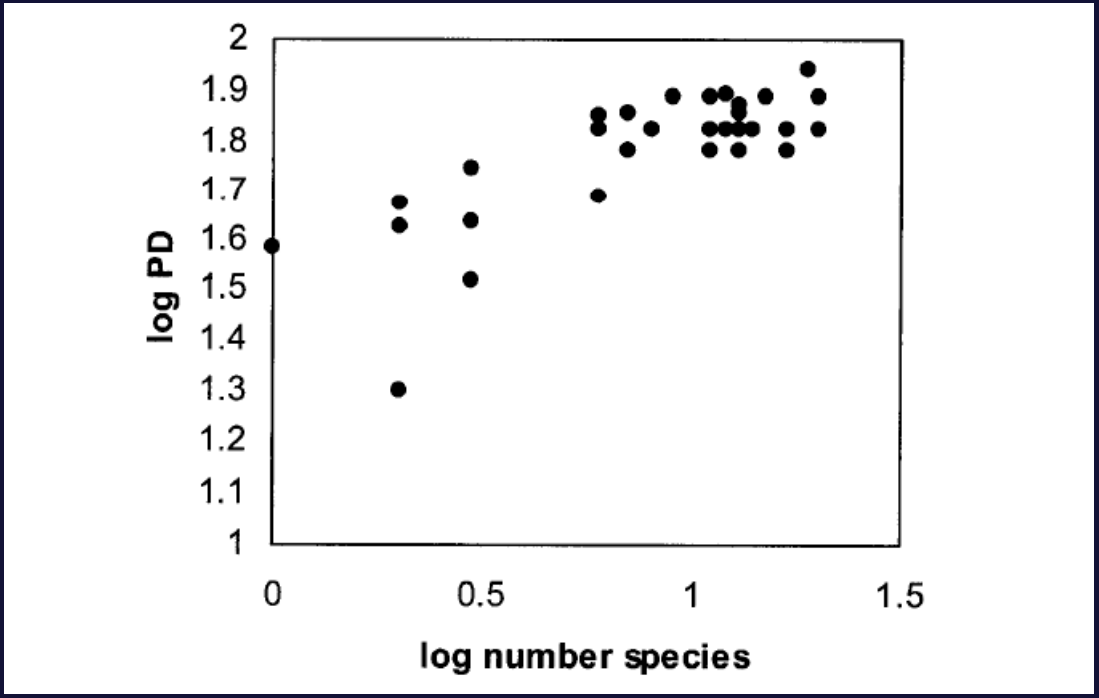
Total PD often looks the same as total species diversity



Schipper, et al. *Science* 322, 225 (2008)

The PD – species relationship

- When number of species sampled is plotted against the PD value of the set, PD defines a species–phylogenetic diversity curve - analogous to species–area curve
- Random taxon samples of different sizes from phylogenetic tree produce a roughly linear relationship in log–log space (Faith & Williams, 2006; Faith 2008)

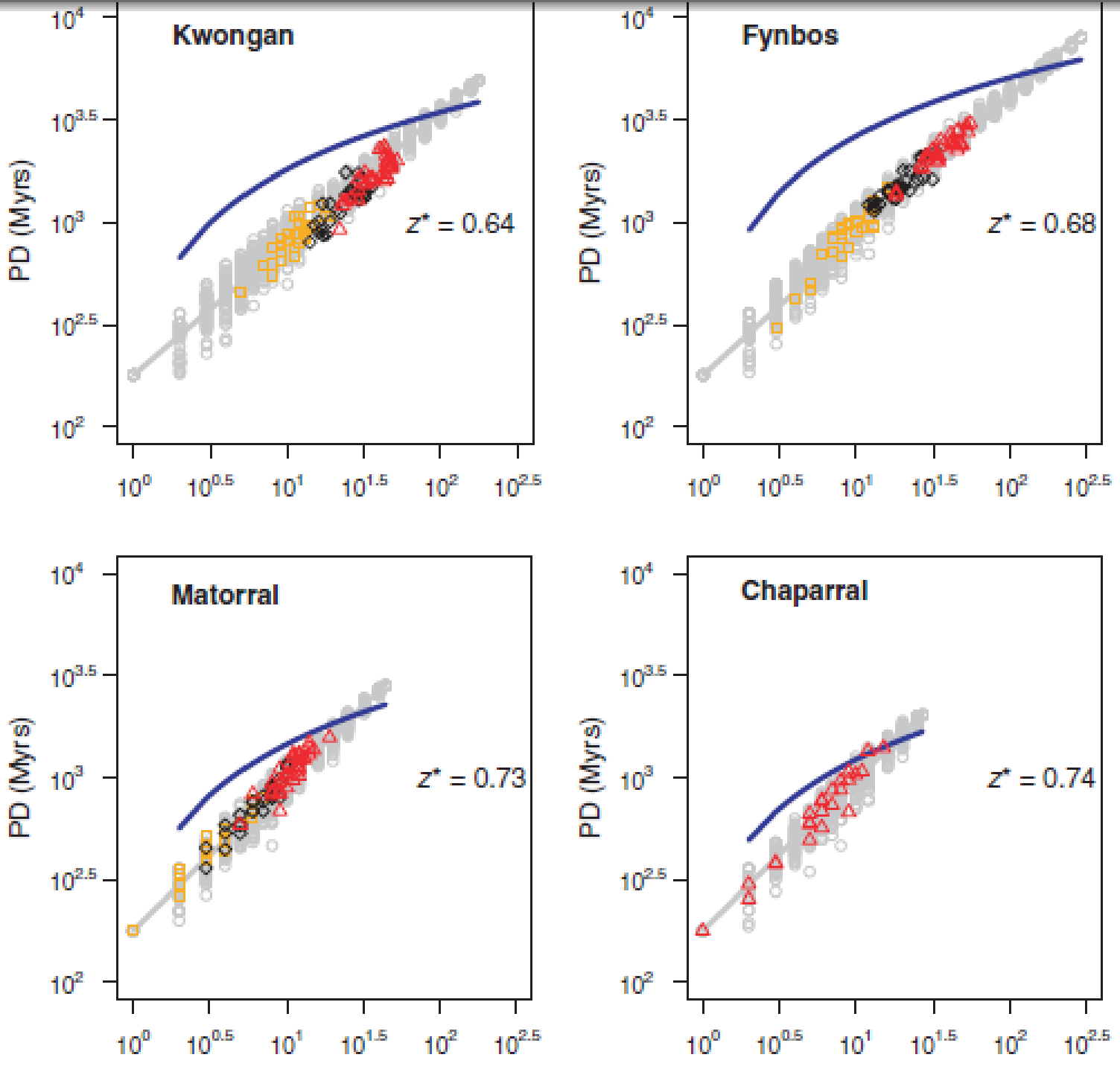


Morlon et al (2011) found empirical support for this proposed power law model.

PD curves for 4 phylogenetic trees from 4 Mediterranean-type ecosystems.

For each nominated species richness value, S, randomly sample S species and calculate PD (do this say 100 times).

Species-PD relationship well fit by a power law for all four phylogenies.


Kwongan
Fynbos
Matorral
Chaparral
PD (Myrs)
$z^* = 0.64$
$z^* = 0.68$
$z^* = 0.73$
$z^* = 0.74$
10^4
$10^{3.5}$
10^3
$10^{2.5}$
10^2
10^0
$10^{0.5}$
10^1
$10^{1.5}$
10^2
$10^{2.5}$

Mammal species richness map (top) looks a lot like mammal PD map (bottom)

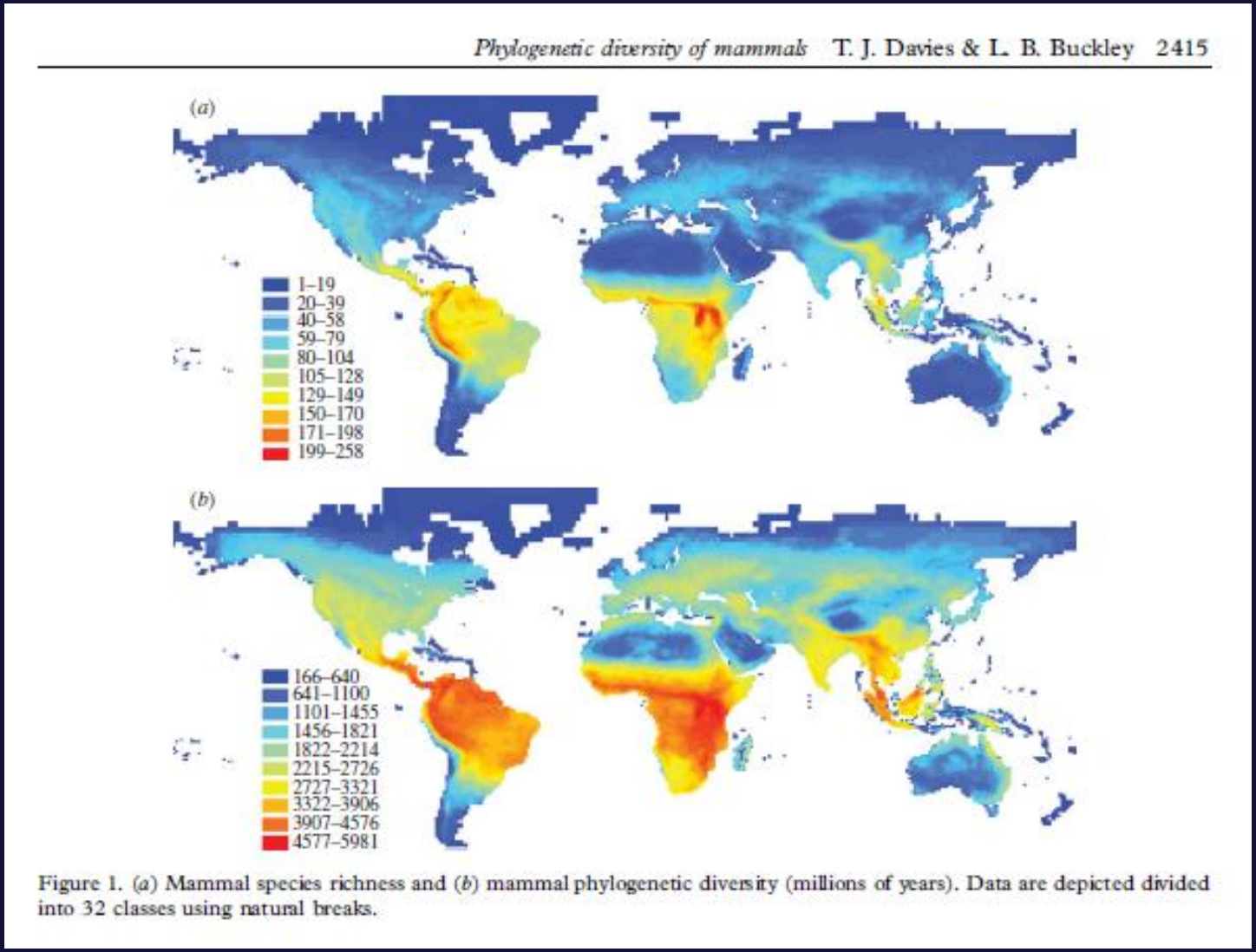
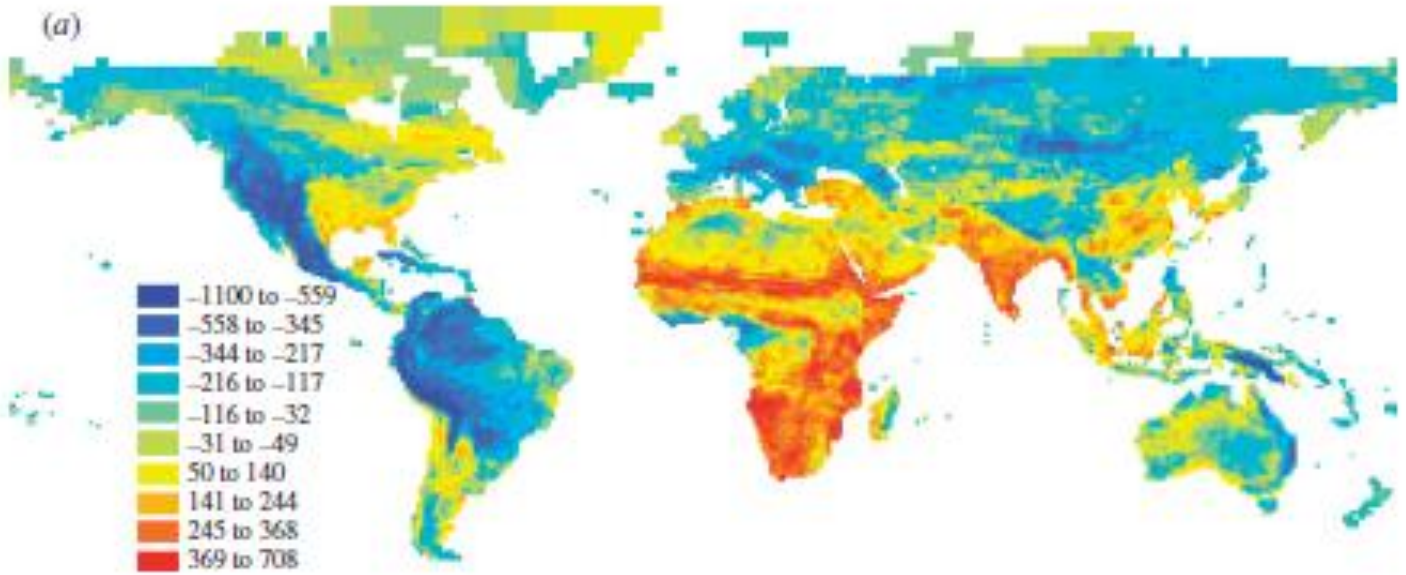
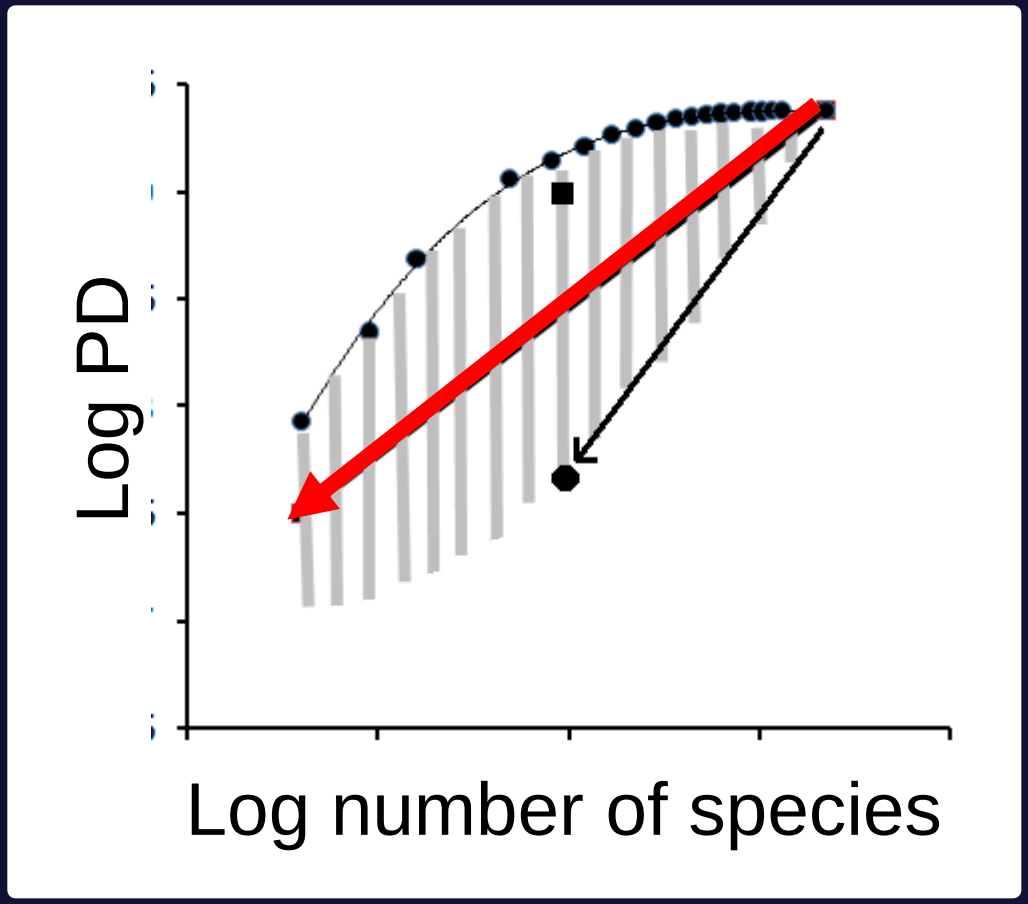


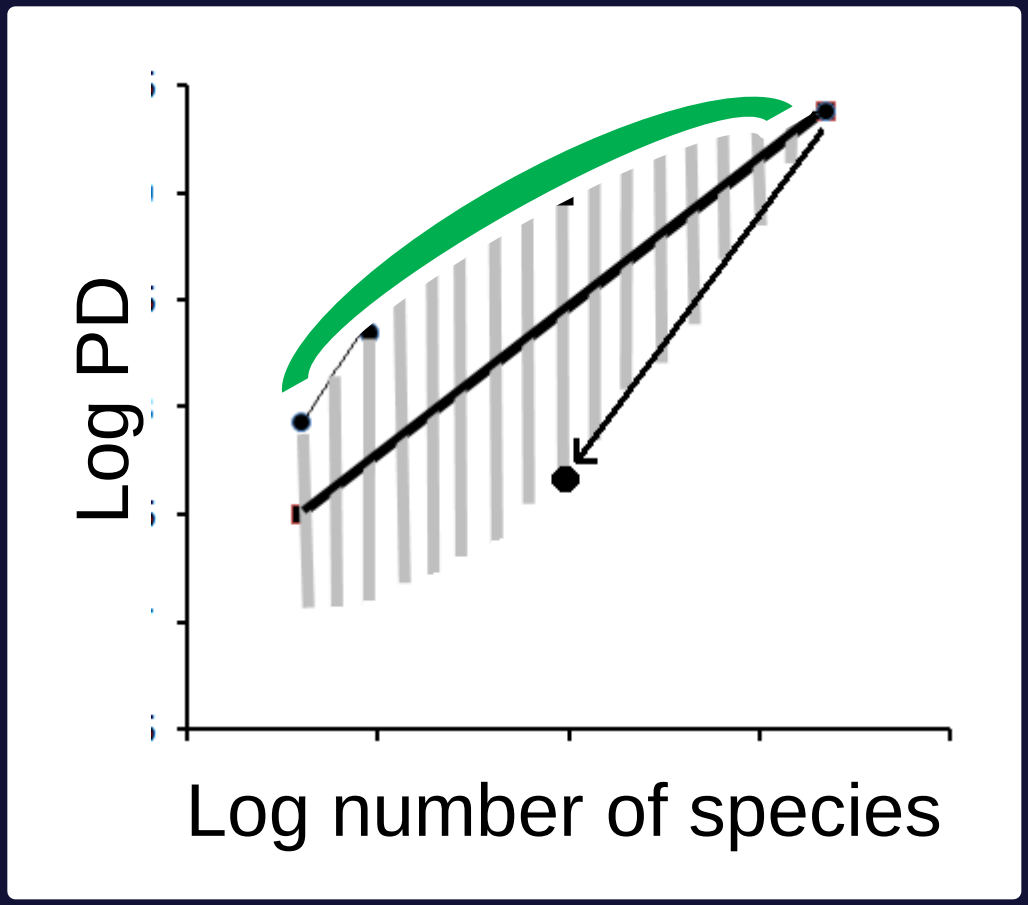
Figure 1. (*a*) Mammal species richness and (*b*) mammal phylogenetic diversity (millions of years). Data are depicted divided into 32 classes using natural breaks.

…but the residuals from a model linking PD and species richness show geographic patterns

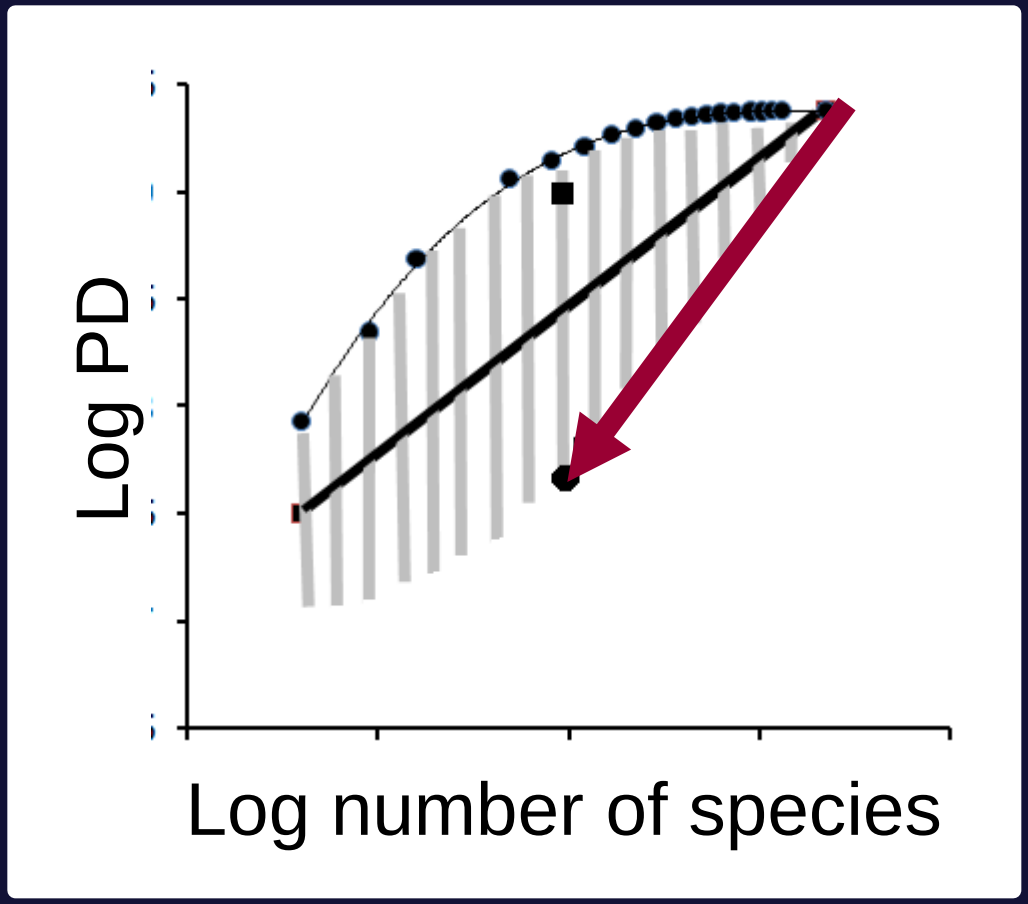




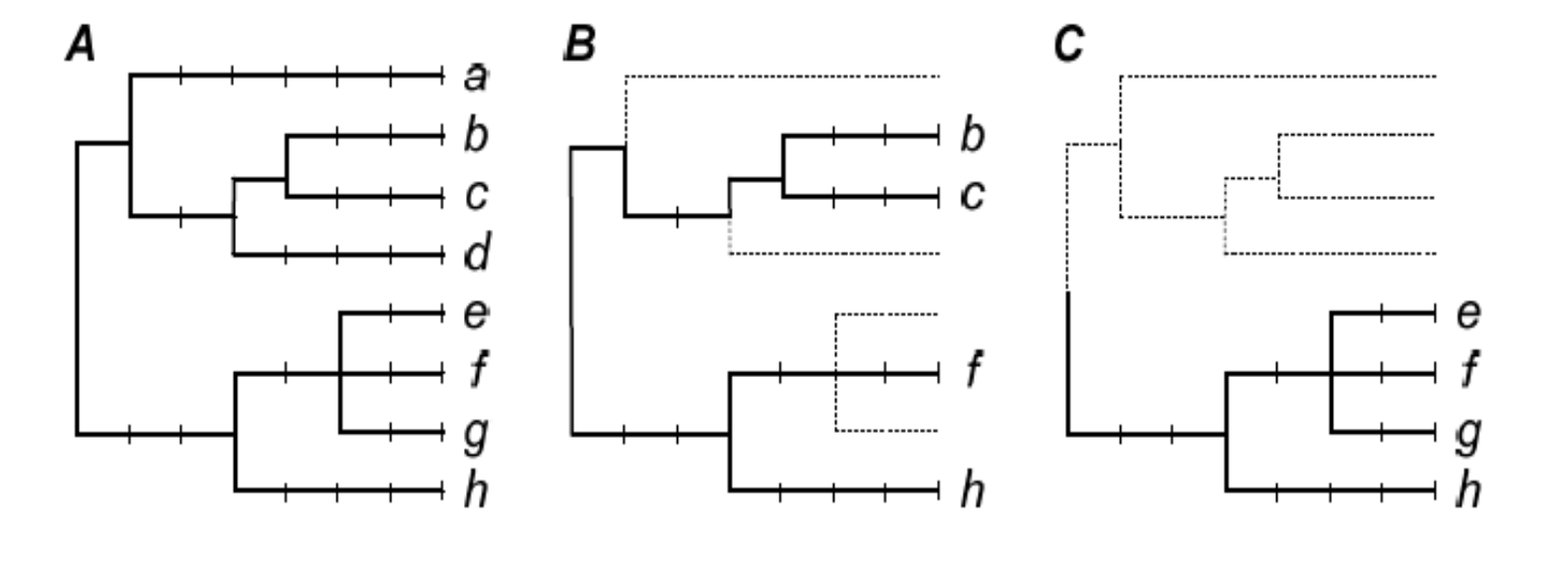
Random selection



Efficient selection

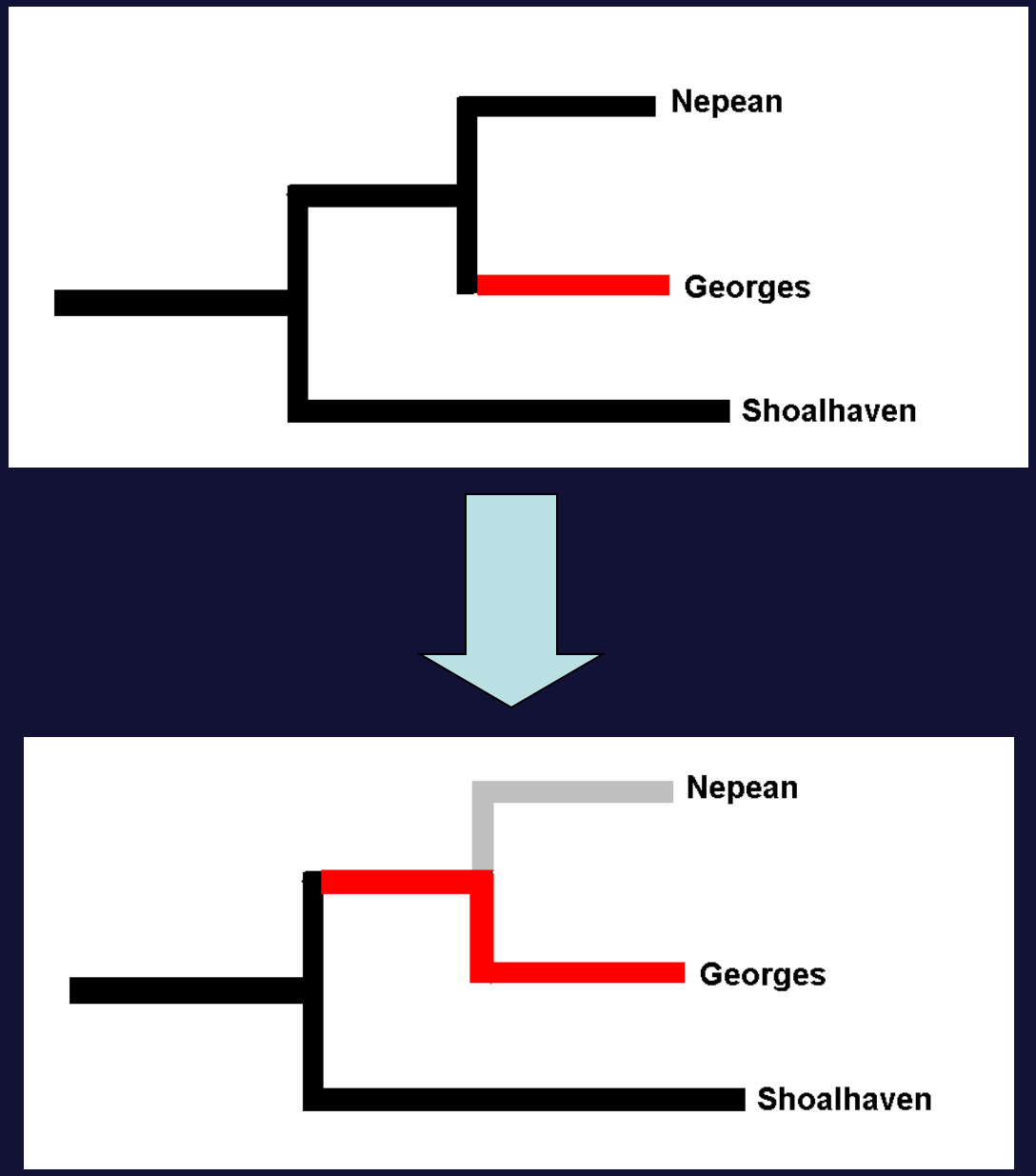


Perverse selection

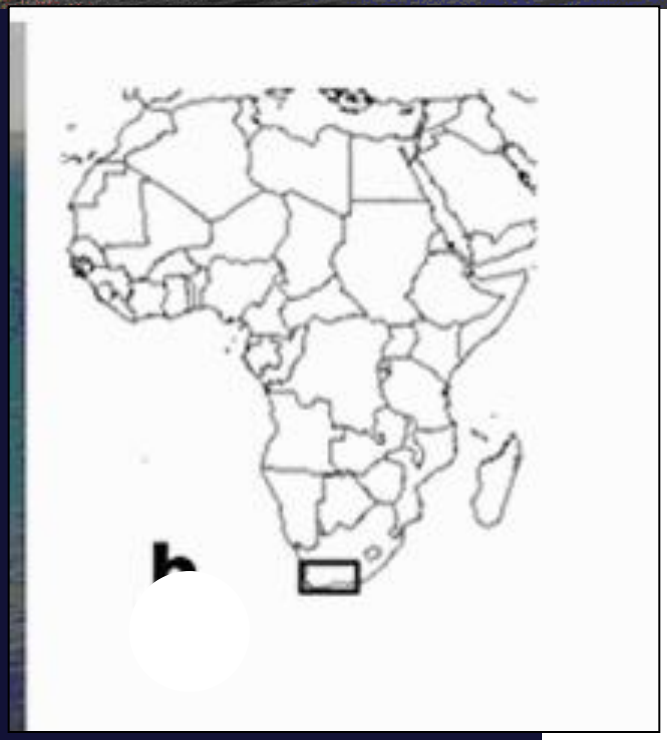


Phylogenetic ecology - take any conventional species-level index and re-express as a PD-based measure

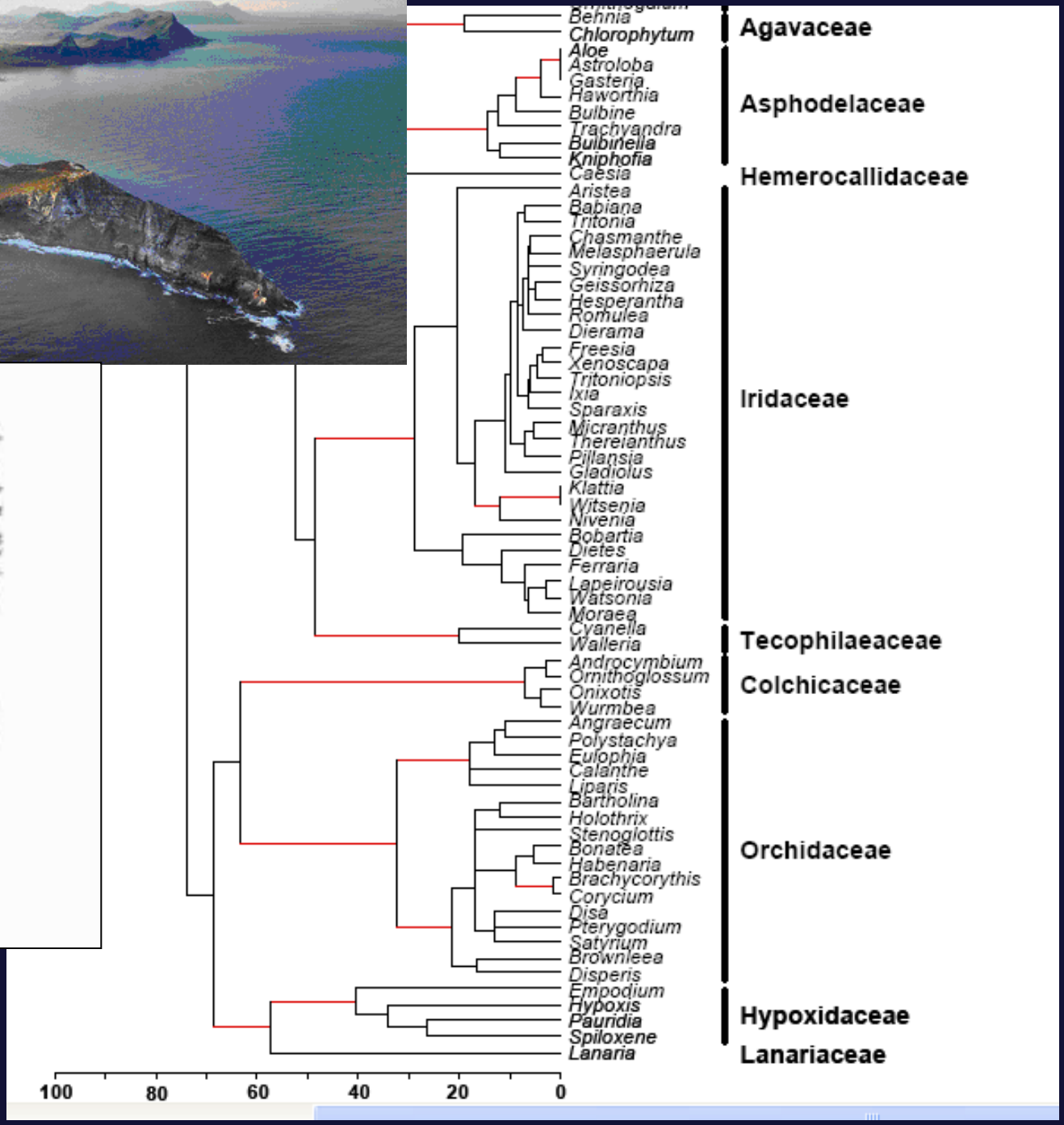
Richness = total PD
Expected diversity = expected PD
PD-Complementarity (gains & losses)
PD-Endemism (e.g. Faith et al 2004; Faith 1994)
PD-Dissimilarity between communities
PD analogues of Shannon-Weiner index and Simpson's index



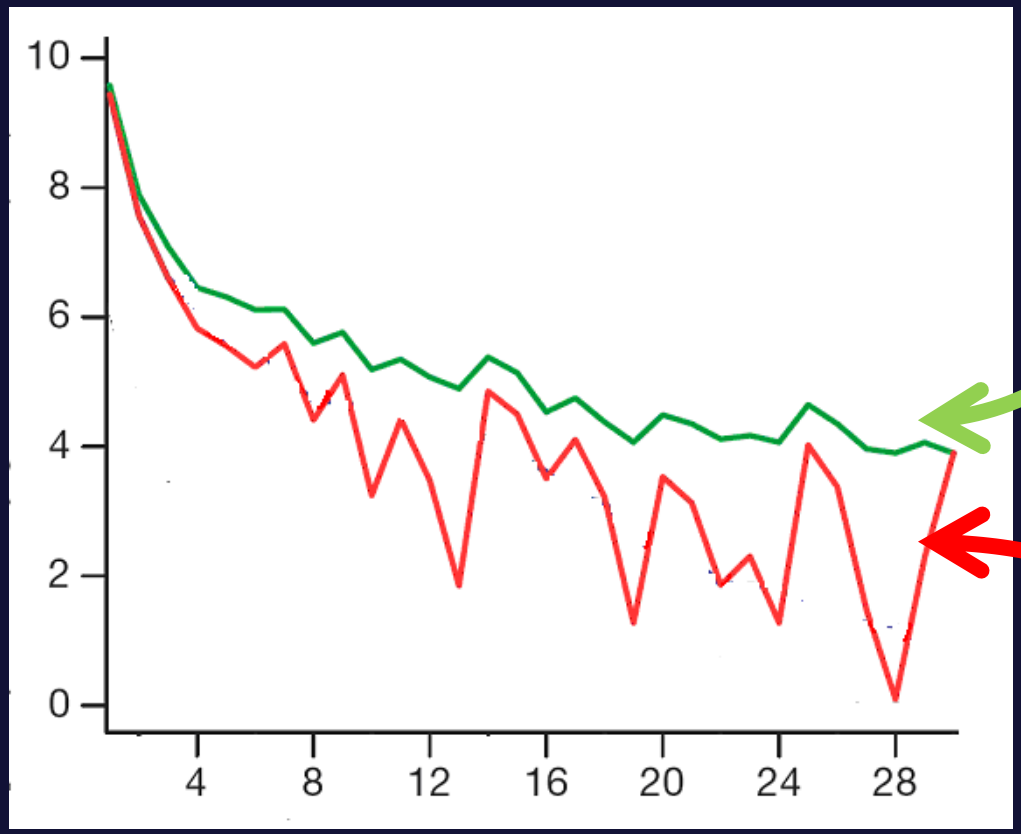
Faith, D. P. 2008. Phylogenetic diversity and conservation.
In *Conservation Biology: Evolution in Action*. Oxford University Press.



Forest et al. (2007) *Nature*



PD and the Cape hotspot: species counting highlights the western portion but PD highlights the eastern portion



the PD that you could gain

does not match

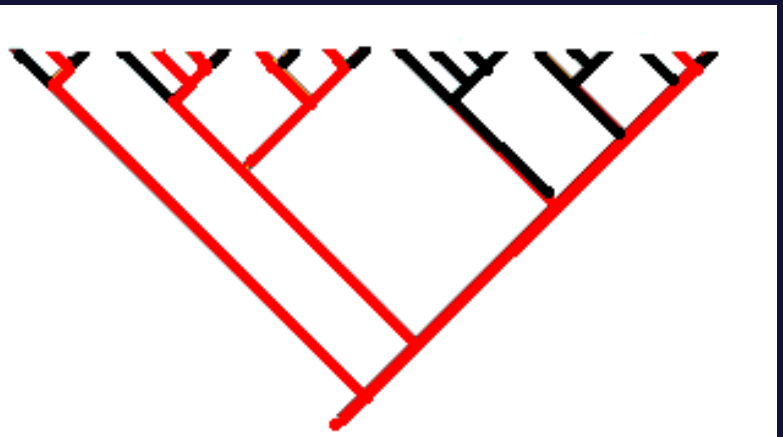
the PD that you do gain

Forest et al *Nature* 2007

Will the impacts of climate change on PD be large or small?

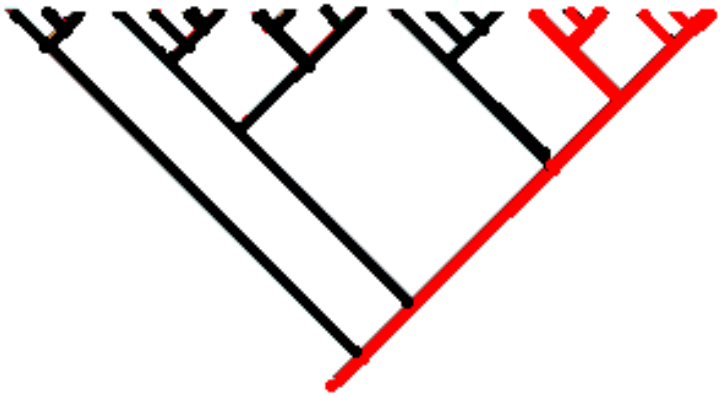
Yesson, C. and A. Culham. 2006.

- ***small*** **loss of PD or evolutionary potential for given species loss**



red = surviving PD

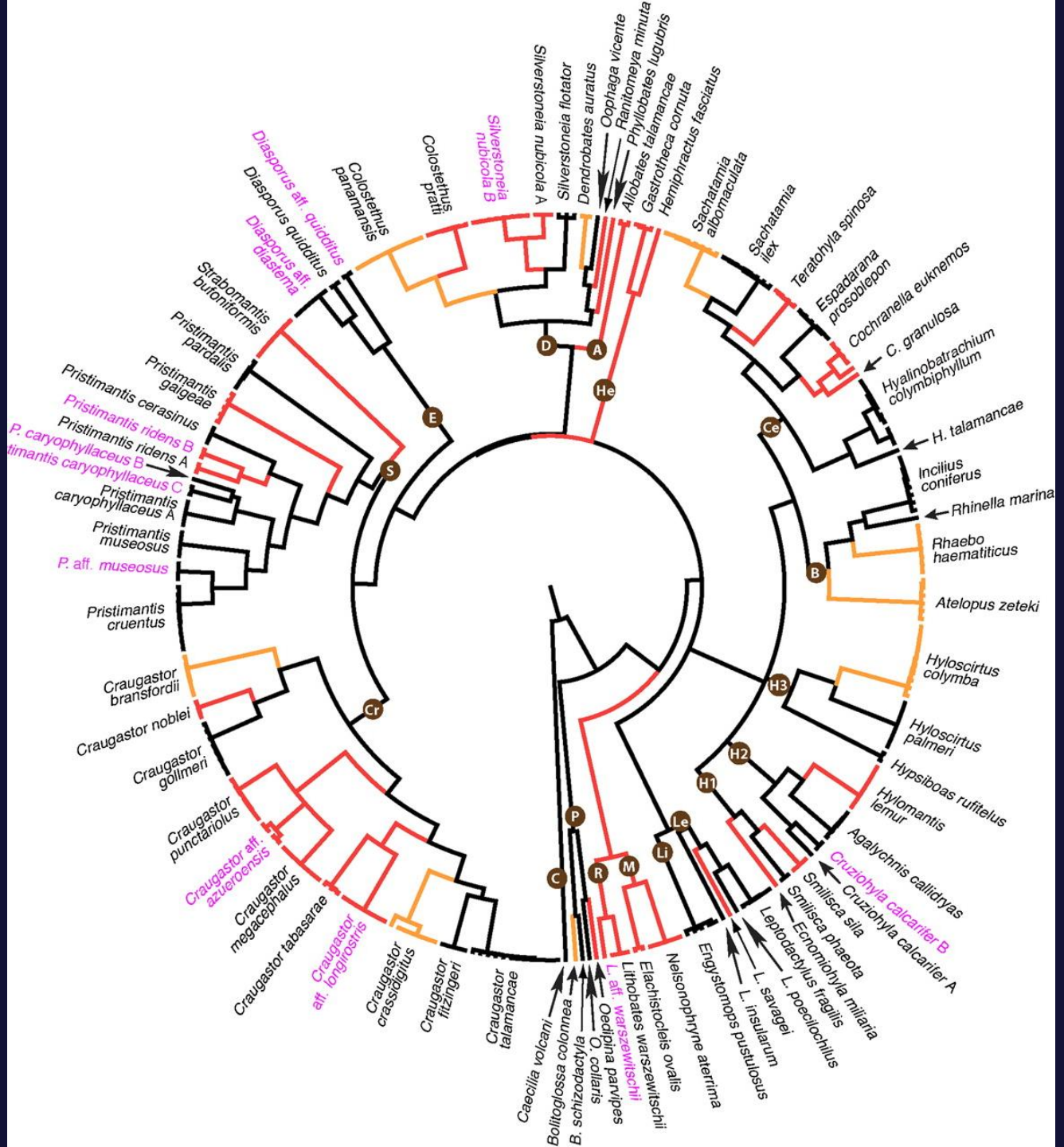
- ***large*** **loss of PD or evolutionary potential for given species loss**



Epidemic disease decimates amphibian abundance, species diversity, and evolutionary history in the highlands of central Panama

Red and Orange= large decline in abundance

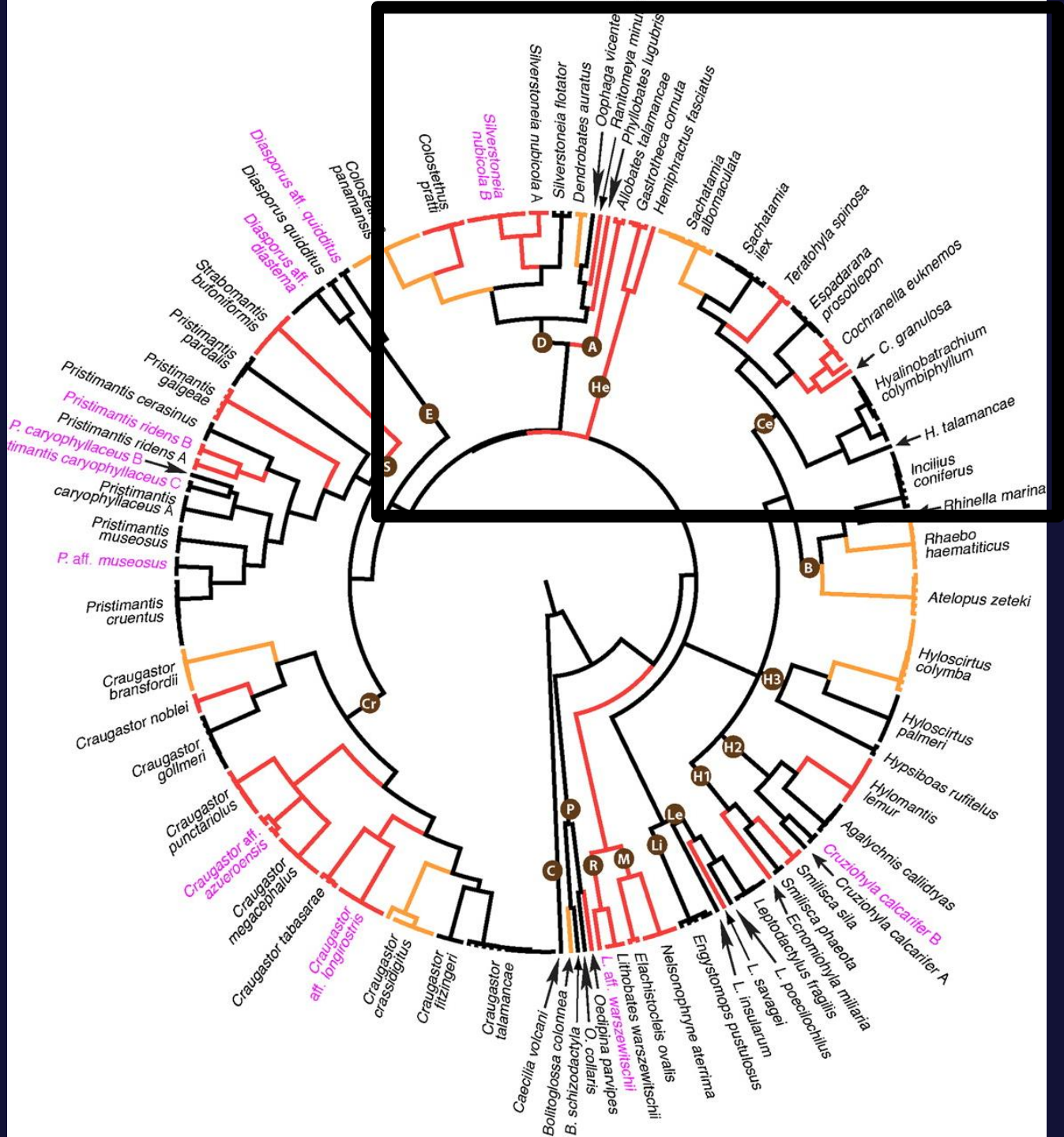
Crawford et al *PNAS* 2010

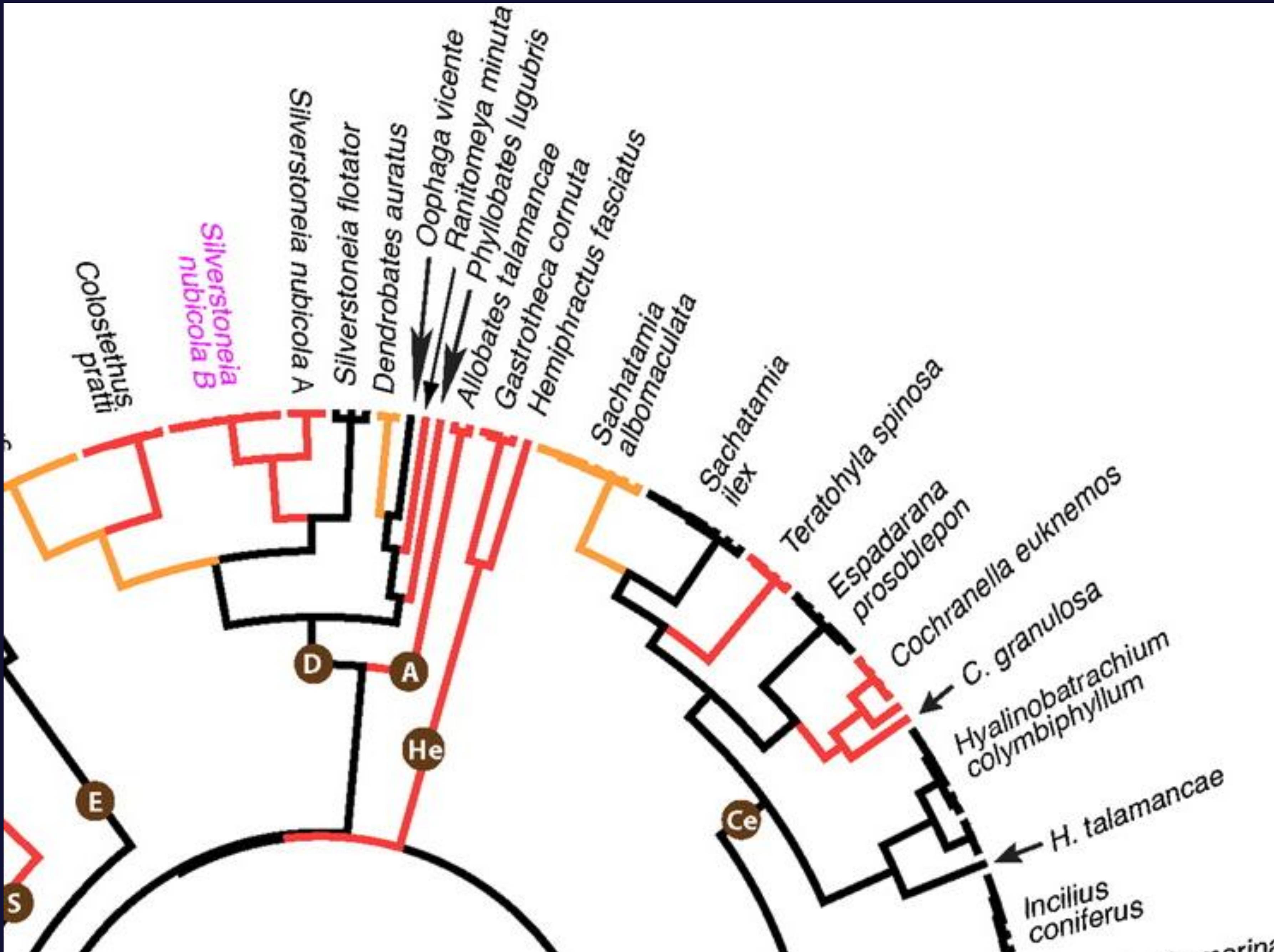


Epidemic disease decimates amphibian abundance, species diversity, and evolutionary history in the highlands of central Panama

Red and Orange= large decline in abundance

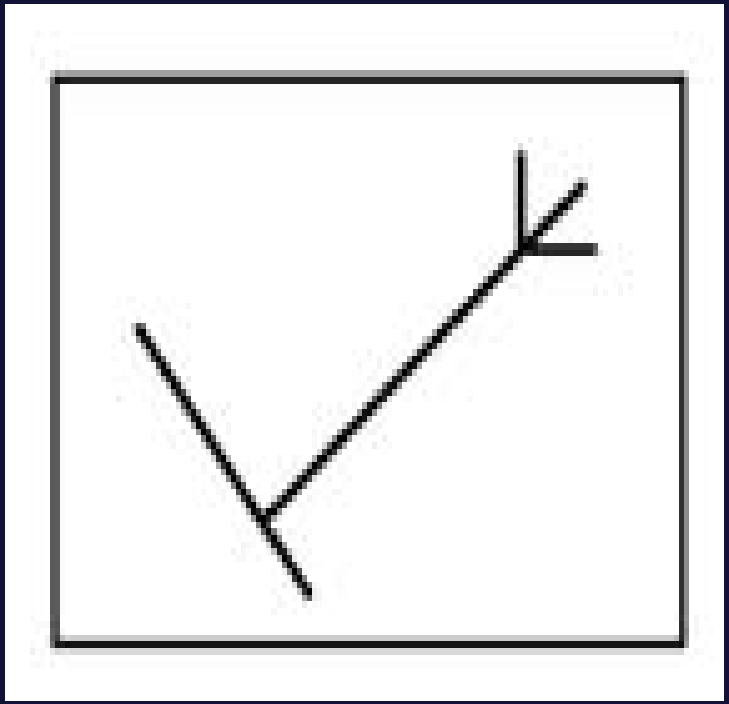
Crawford et al *PNAS* 2010

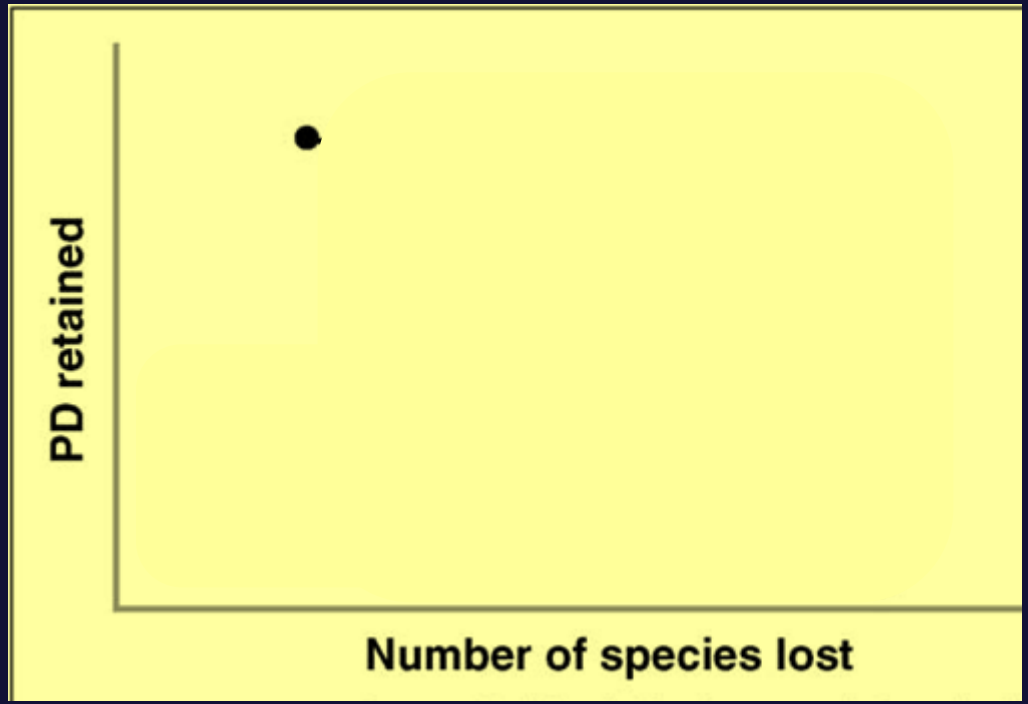



Colostethus pratti
Silverstoneia nubicola B
Silverstoneia nubicola A
Silverstoneia flotator
Dendrobates auratus
Oophaga vicente
Ranitomeya minuta
Phyllobates lugubris
Allobates talamancae
Gastrotheca cornuta
Hemiphractus fasciatus
Sachatamia albomaculata
Sachatamia ilex
Teratohyla spinosa
Espadarana prosoblepon
Cochranella euknemos
C. granulosa
Hyalinobatrachium colymbiphyllum
H. talamancae
Incilius coniferus
D
A
He
E
S
Ce

Phylogenetic diversity and tipping points

PD loss (vertical axis) as species are lost (horizontal axis)
Loss of one species, and loss of a second species imply small PD losses, but loss of the third species is a tipping point
— the deeper ancestral branch and corresponding PD is now lost.

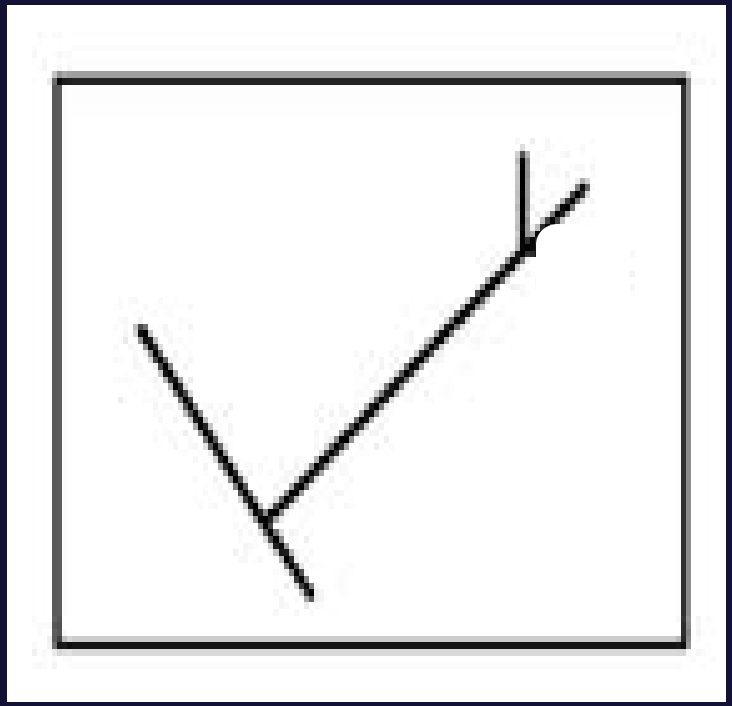


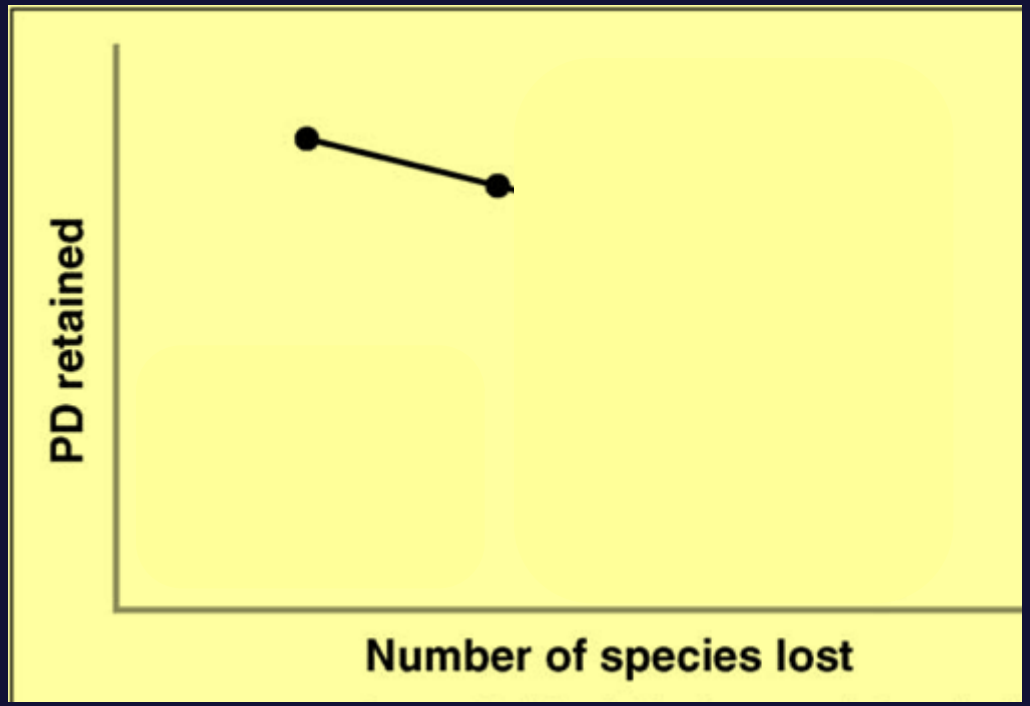


Faith et al (2010) Evosystem services: an evolutionary perspective on the links between biodiversity and human well-being. *COSUST*

Phylogenetic diversity and tipping points

PD loss (vertical axis) as species are lost (horizontal axis)
Loss of one species, and loss of a second species imply small PD losses, but loss of the third species is a tipping point
— the deeper ancestral branch and corresponding PD is now lost.

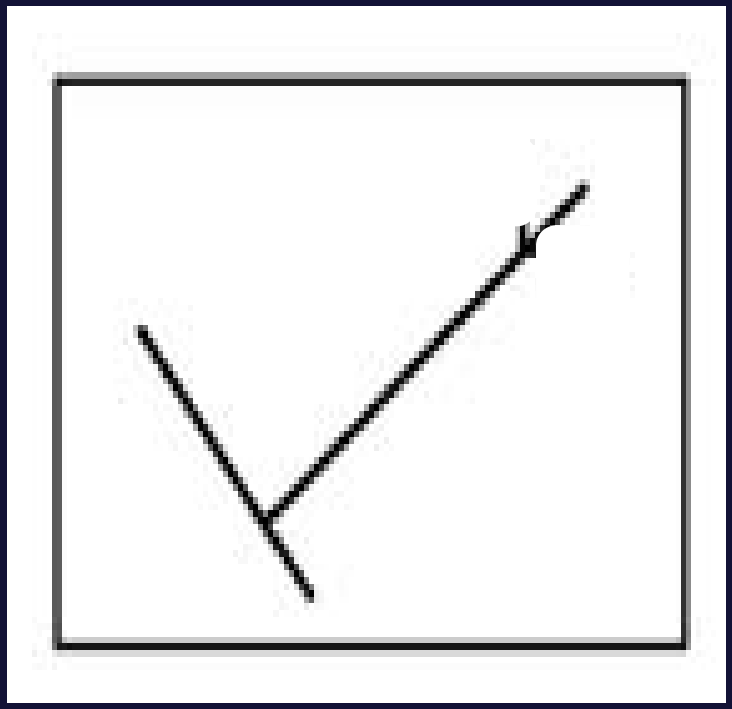


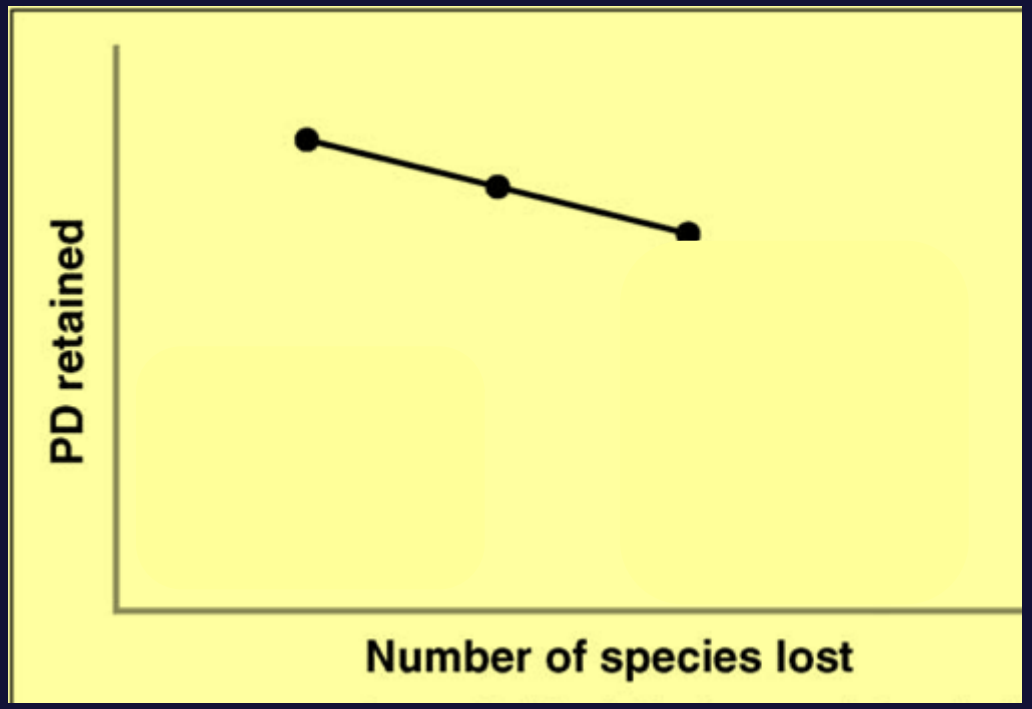


Faith et al (2010) Evosystem services: an evolutionary perspective on the links between biodiversity and human well-being. *COSUST*

Phylogenetic diversity and tipping points

PD loss (vertical axis) as species are lost (horizontal axis)
Loss of one species, and loss of a second species imply small PD losses, but loss of the third species is a tipping point
— the deeper ancestral branch and corresponding PD is now lost.

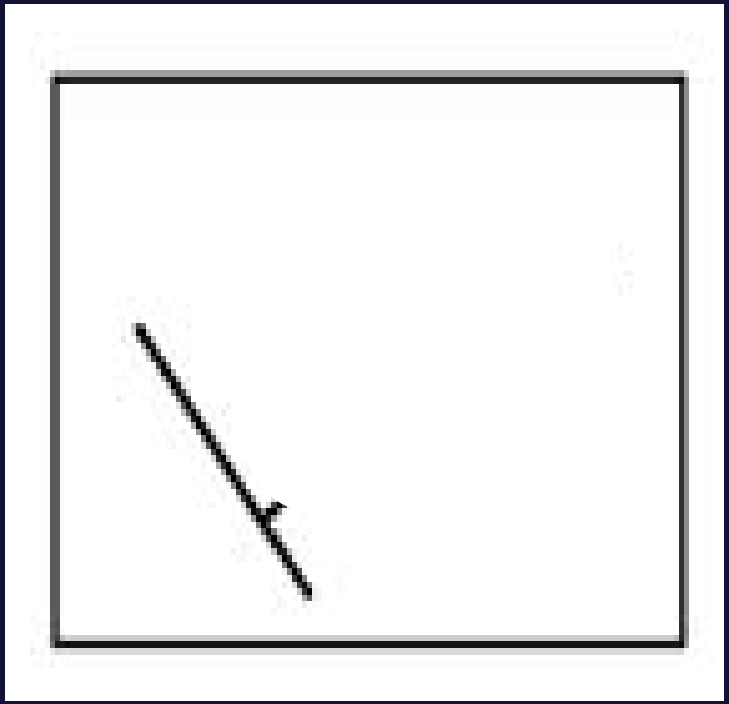




Faith et al (2010) Evosystem services: an evolutionary perspective on the links between biodiversity and human well-being. *COSUST*

Phylogenetic diversity and tipping points

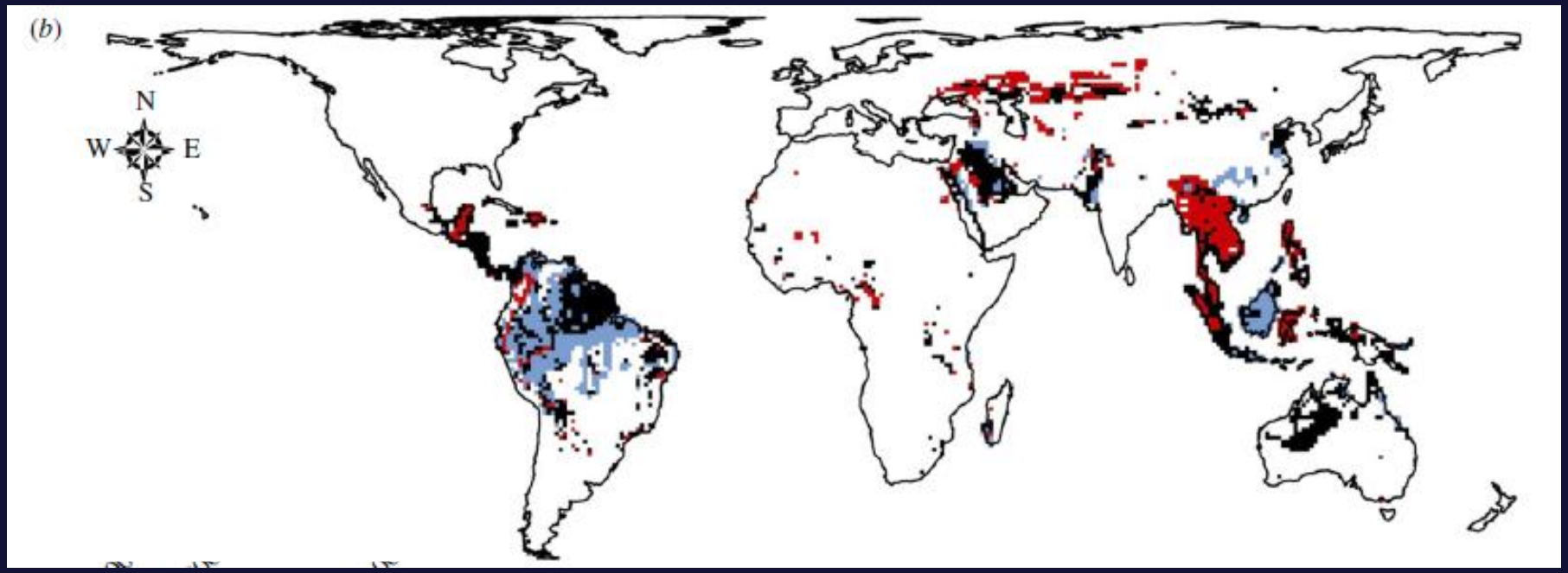
PD loss (vertical axis) as species are lost (horizontal axis)
Loss of one species, and loss of a second species imply small PD losses, but loss of the third species is a tipping point
— the deeper ancestral branch and corresponding PD is now lost.



Faith et al (2010) Evosystem services: an evolutionary perspective on the links between biodiversity and human well-being. *COSUST*

Predicted PD loss with extinction of threatened mammals
Comparison with random losses reveals clumped impacts

Red and black = high loss of deeper branches

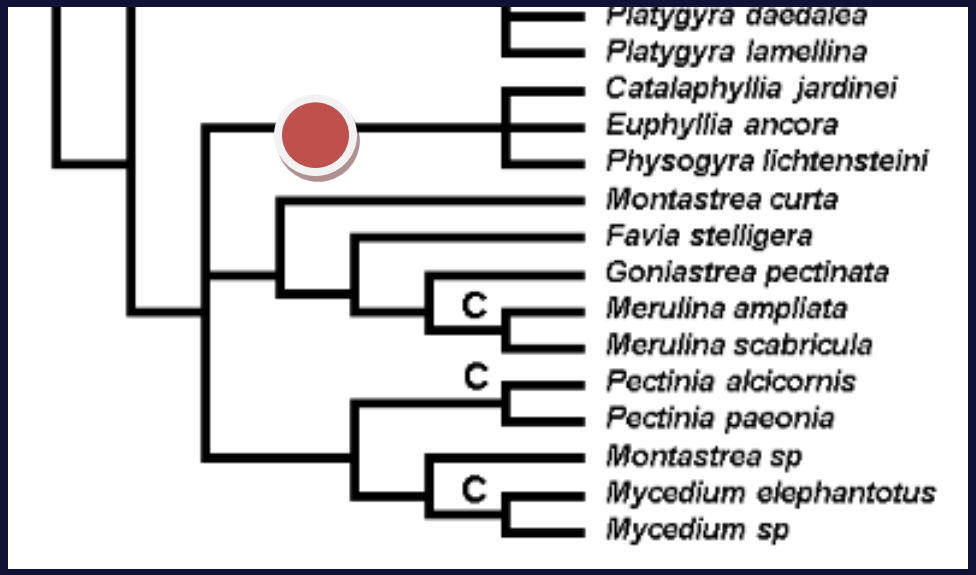


“At regional scales, losses differ dramatically:
several biodiversity hotspots in southern Asia and Amazonia
will lose an unexpectedly large proportion of PD.”

Huang et al (2011) *Biol. Lett.*

Loss of the world's corals

- "the proportion of corals (57.8%) exceeds that of all terrestrial animal groups assessed to date.."
- Carpenter et al (2008) *Science*



sometimes entire clades fall into IUCN threatened classes

phylogenetic risk analysis

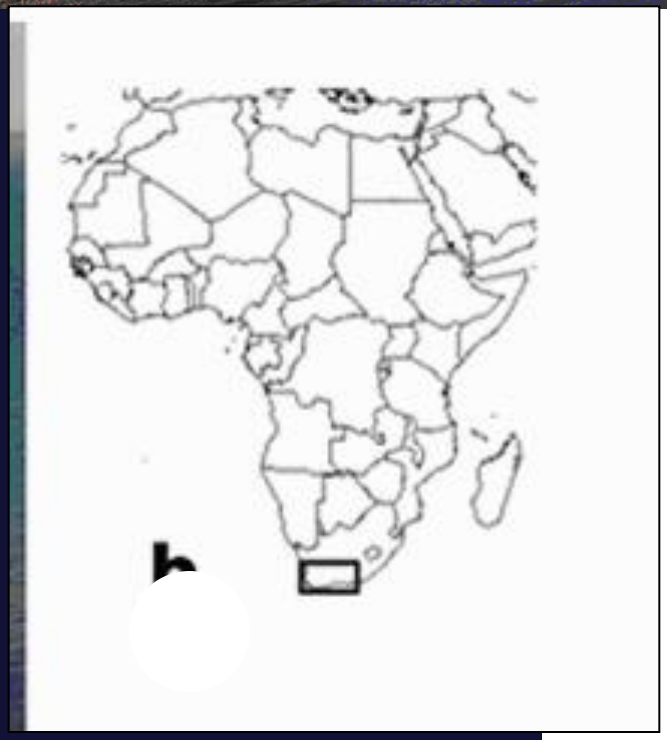
- Faith DP and ZT Richards (to appear) Implications of climate change for the tree of life. *Biology*

The phylogenetic sustainable use problem:

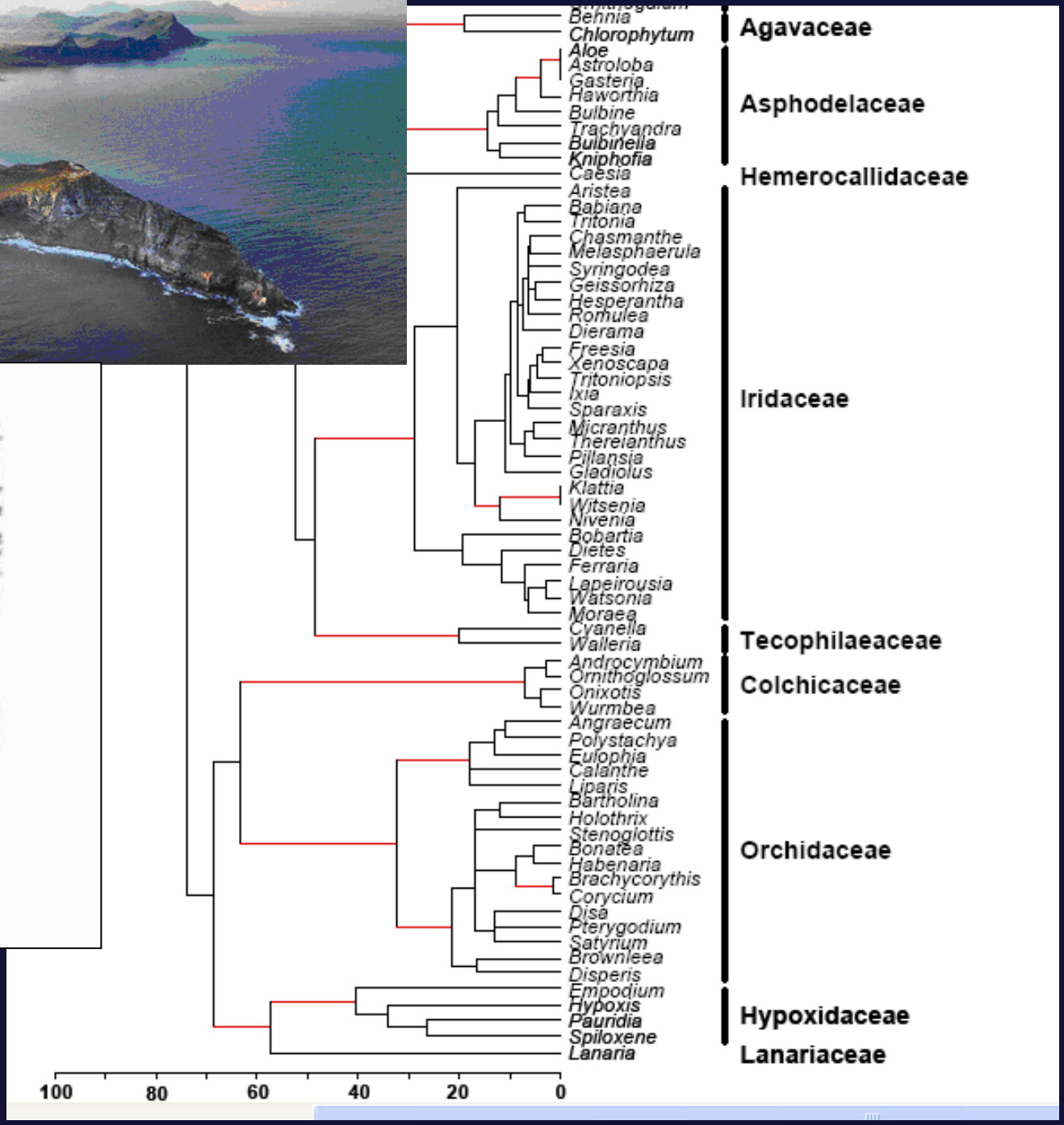
How do we combine conservation of PD and known useful species? Will protecting the useful species also protect PD?

- Phylogenetically clumped impacts can be bad when we consider PD loss

- Phylogenetically clumped known benefits may not help when selecting species for conservation of PD

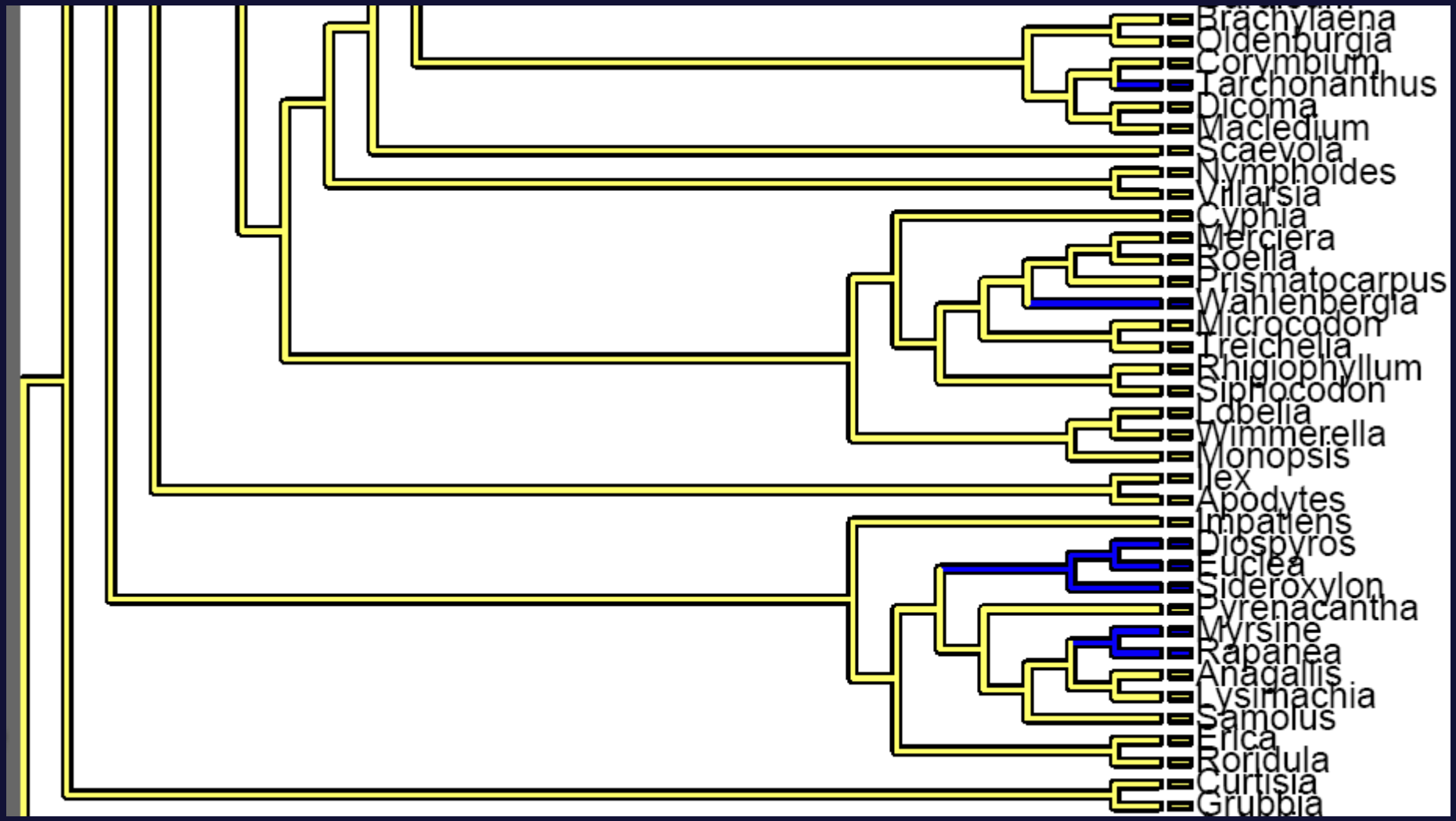


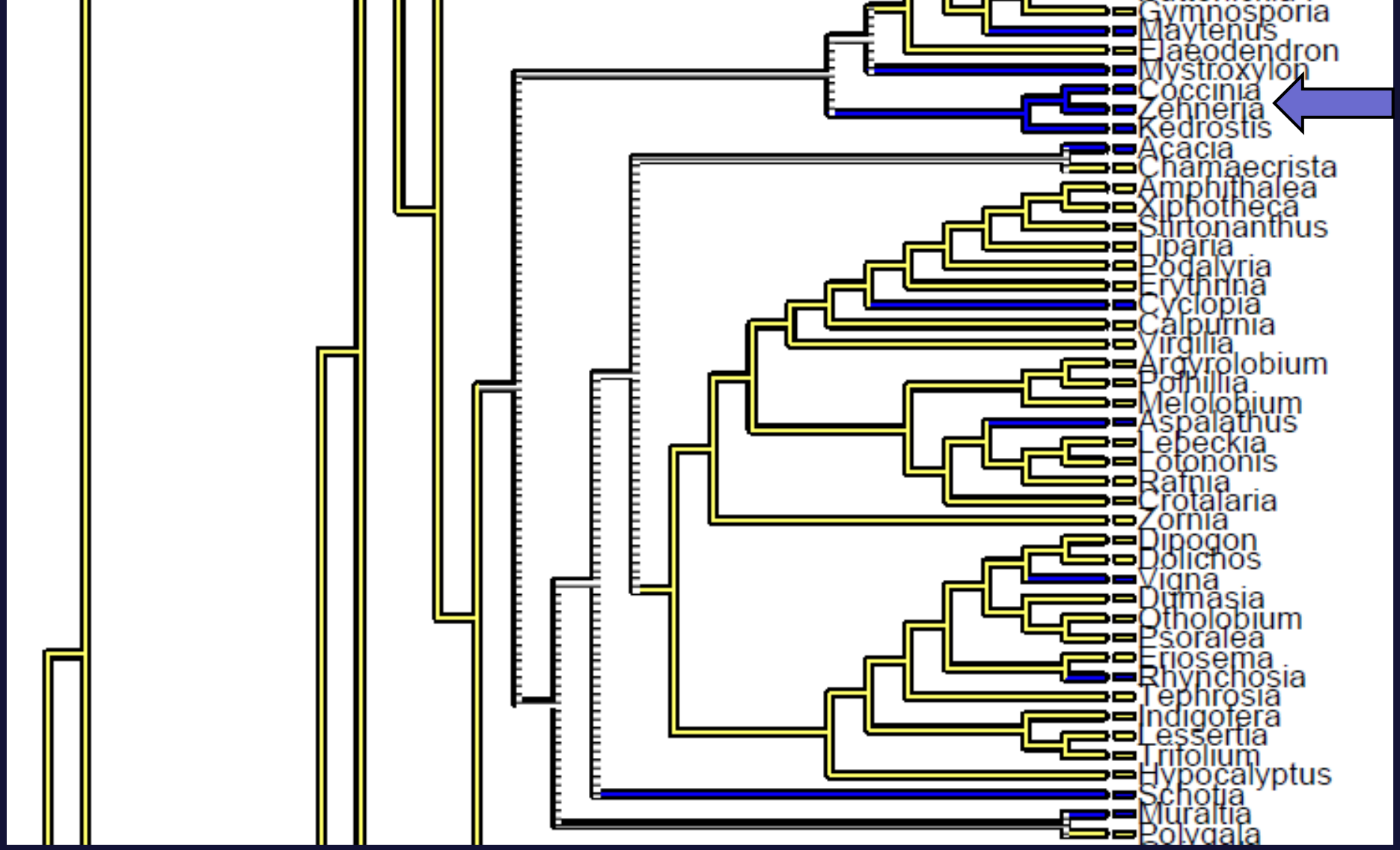
Forest et al. (2007) *Nature*



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)

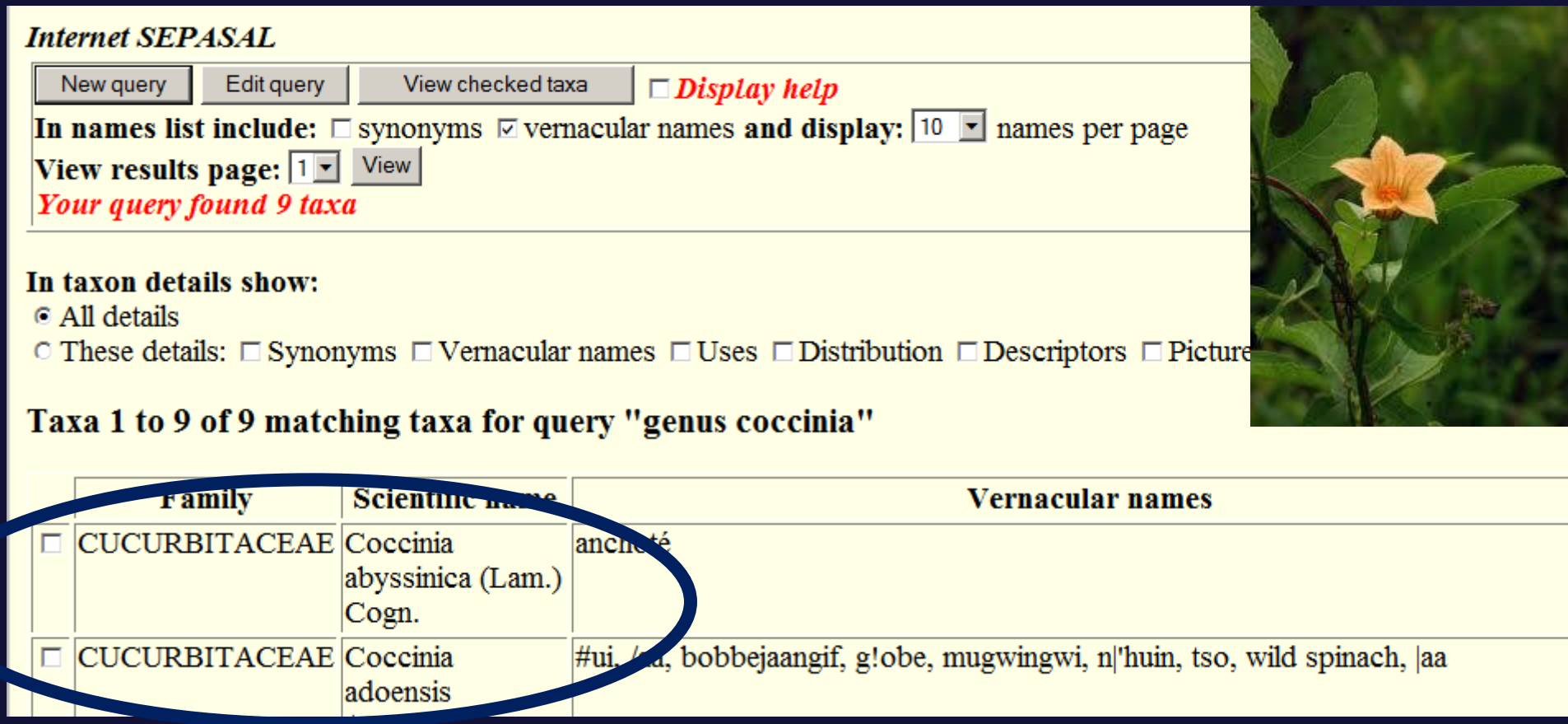



Gymnosporia
Maytenus
Elaeodendron
Mystroxylon
Coccinia
Zehneria
Kedrostis
Acacia
Chamaecrista
Amphithalea
Xiphotheca
Stirtonanthus
Liparia
Podalyria
Erythrina
Cyclopia
Calpurnia
Virgilia
Argyrolobium
Polhillia
Melolobium
Aspalathus
Lebeckia
Lotononis
Rafnia
Crotalaria
Zornia
Dipogon
Dolichos
Vigna
Dumasia
Otholobium
Psoralea
Eriosema
Rhynchosia
Tephrosia
Indigofera
Lessertia
Trifolium
Hypocalyptus
Schotia
Muraltia
Polygala

Food uses

Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL)

Reports on published scientific information on the uses and related properties of tropical and subtropical ‘wild’ and semi-domesticated plants, with a focus on Africa.



Internet SEPASAL

New query | Edit query | View checked taxa | Display help

In names list include: synonyms, vernacular names **and display:** 10 names per page

View results page: 1 View

Your query found 9 taxa

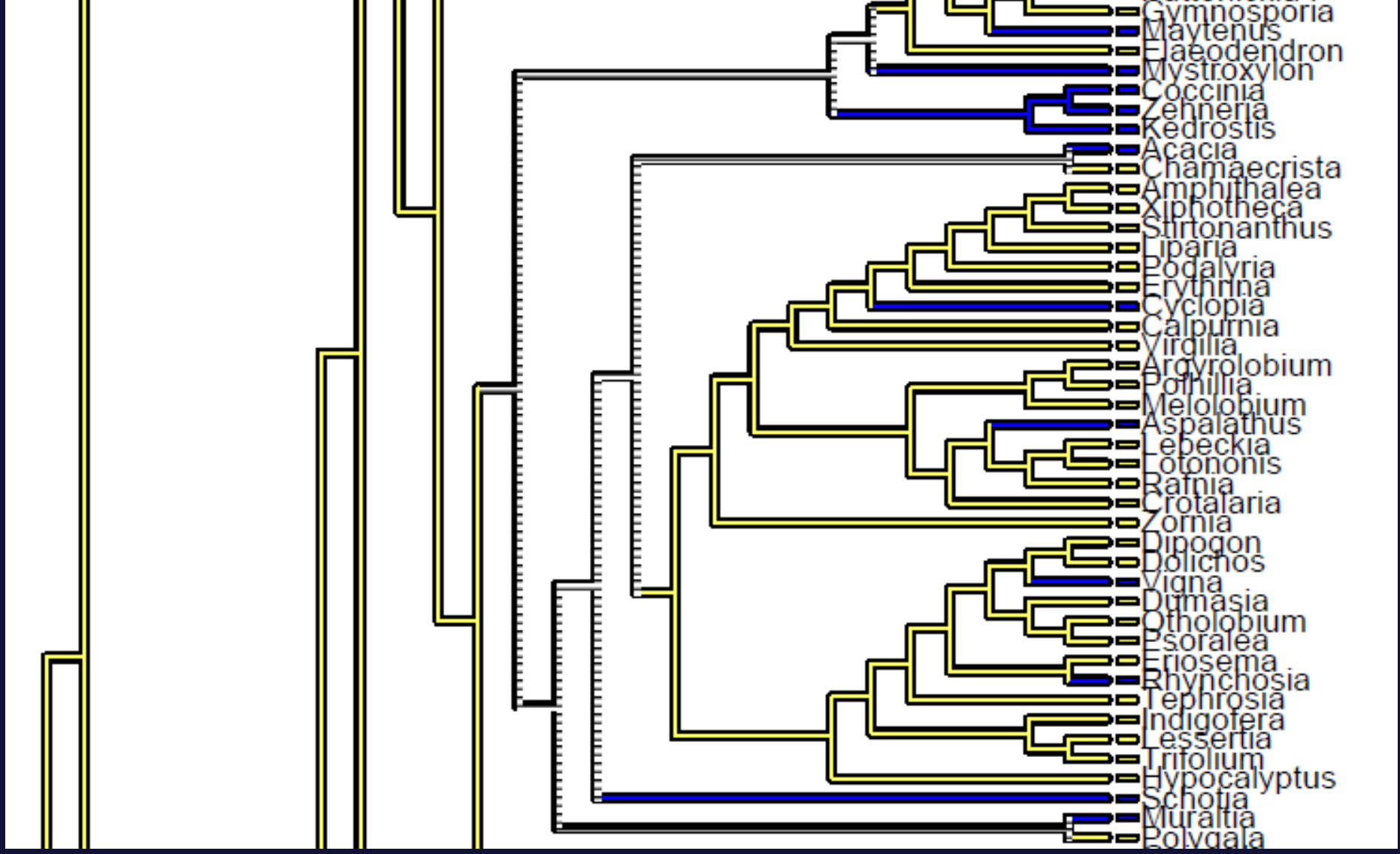
In taxon details show:

All details

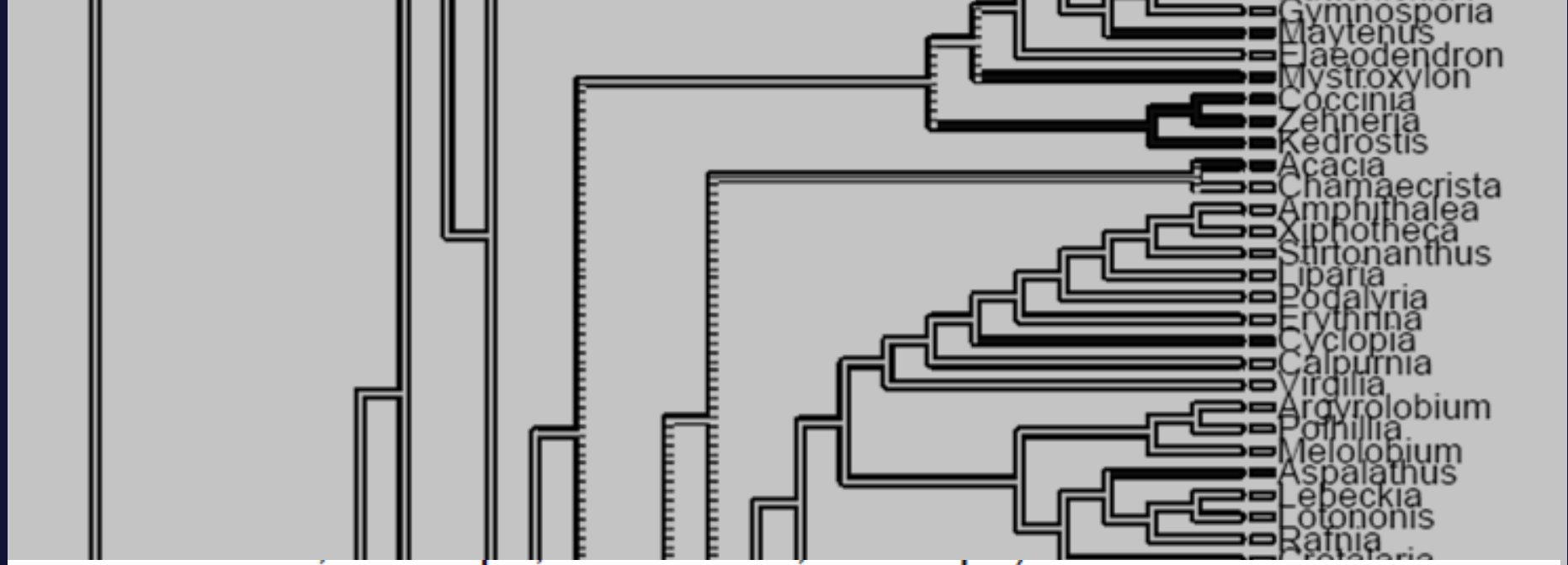
These details: Synonyms Vernacular names Uses Distribution Descriptors Picture

Taxa 1 to 9 of 9 matching taxa for query "genus coccinia"

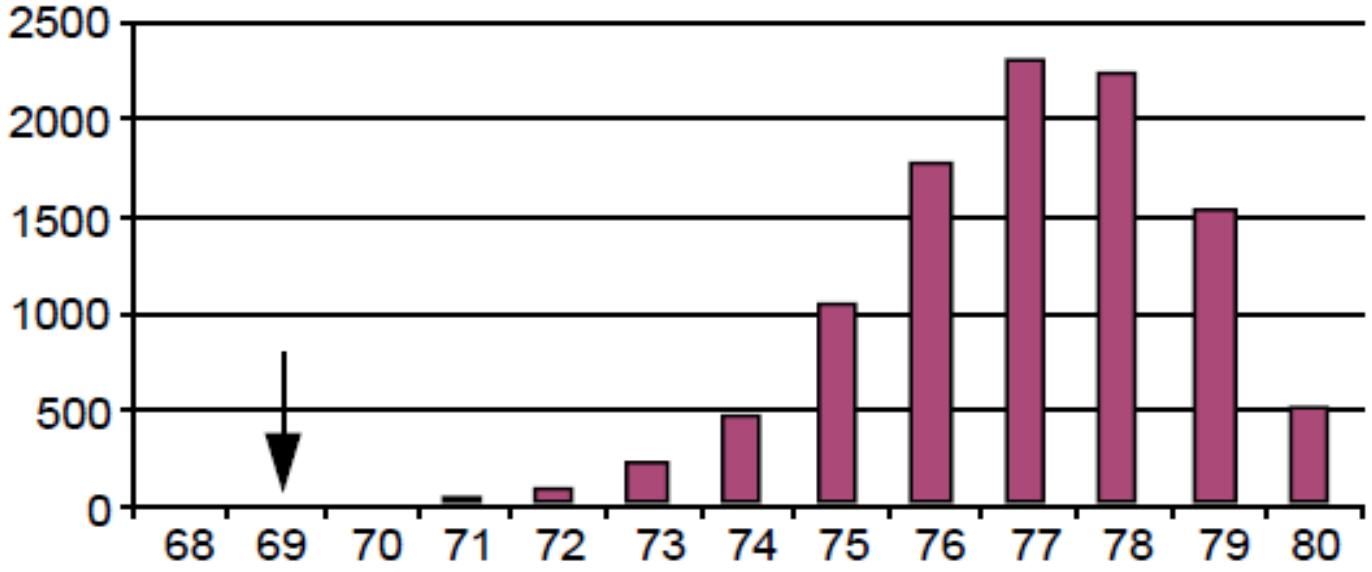
Family	Scientific name	Vernacular names
CUCURBITACEAE	Coccinia abyssinica (Lam.) Cogn.	anch té
CUCURBITACEAE	Coccinia adoensis	#ui, /a, bobbejaangif, g!obe, mugwingwi, n|'huin, tso, wild spinach, |aa

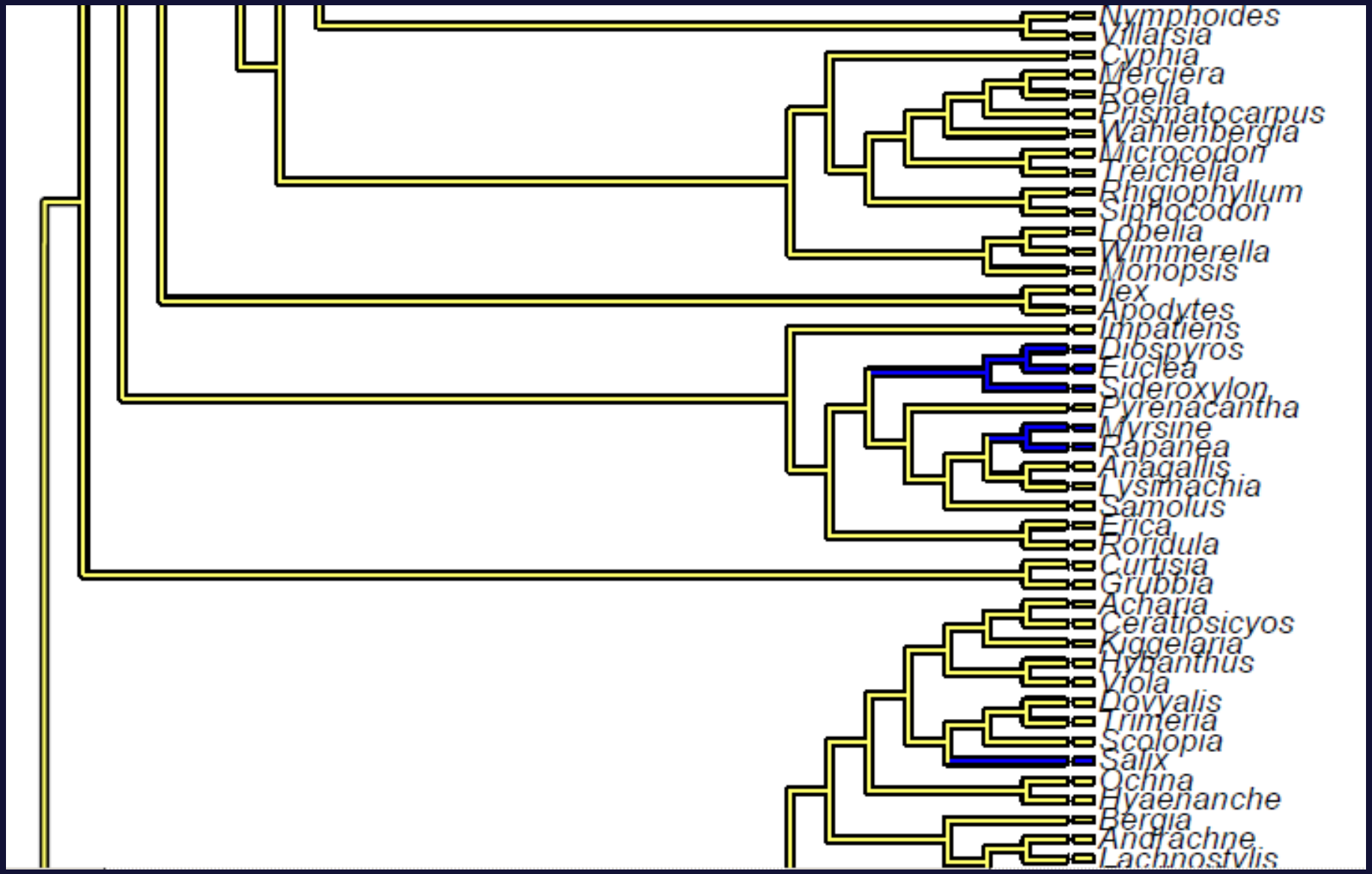

Gymnosporia
Maytenus
Elaeodendron
Mystroxylon
Coccinia
Zehneria
Kedrostis
Acacia
Chamaecrista
Amphithalea
Xiphotheca
Stirtonanthus
Liparia
Podalyria
Erythrina
Cyclopia
Calpurnia
Virgilia
Argyrolobium
Polhillia
Melolobium
Aspalathus
Lebeckia
Lotononis
Rafnia
Crotalaria
Zornia
Dipogon
Dolichos
Vigna
Dumasia
Otholobium
Psoralea
Eriosema
Rhynchosia
Tephrosia
Indigofera
Lessertia
Trifolium
Hypocalyptus
Schotia
Muraltia
Polygala

Food uses

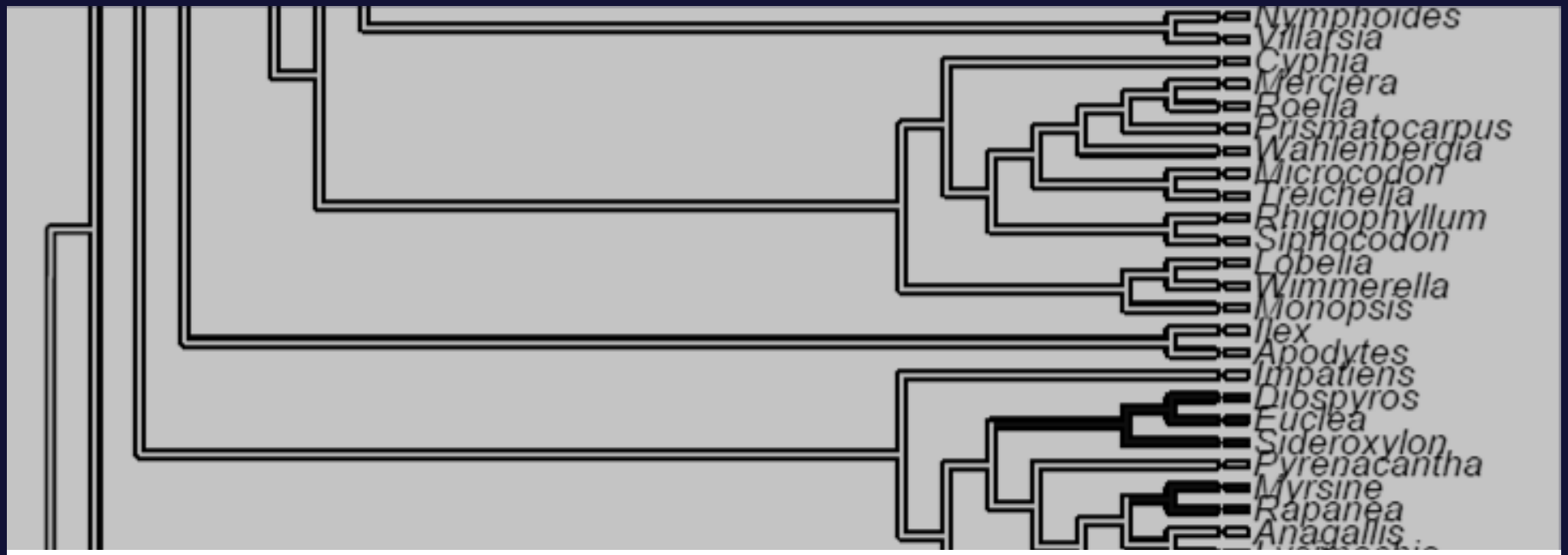

Gymnosporia
Maytenus
Elaeodendron
Mystroxylon
Coccinia
Zehneria
Kedrostis
Acacia
Chamaecrista
Amphithalea
Xiphotheca
Stirtonanthus
Liparia
Podalyria
Erythrina
Cyclopia
Calpurnia
Virgilia
Argyrolobium
Polhillia
Melolobium
Aspalathus
Lebeckia
Lotononis
Rafnia

Food uses

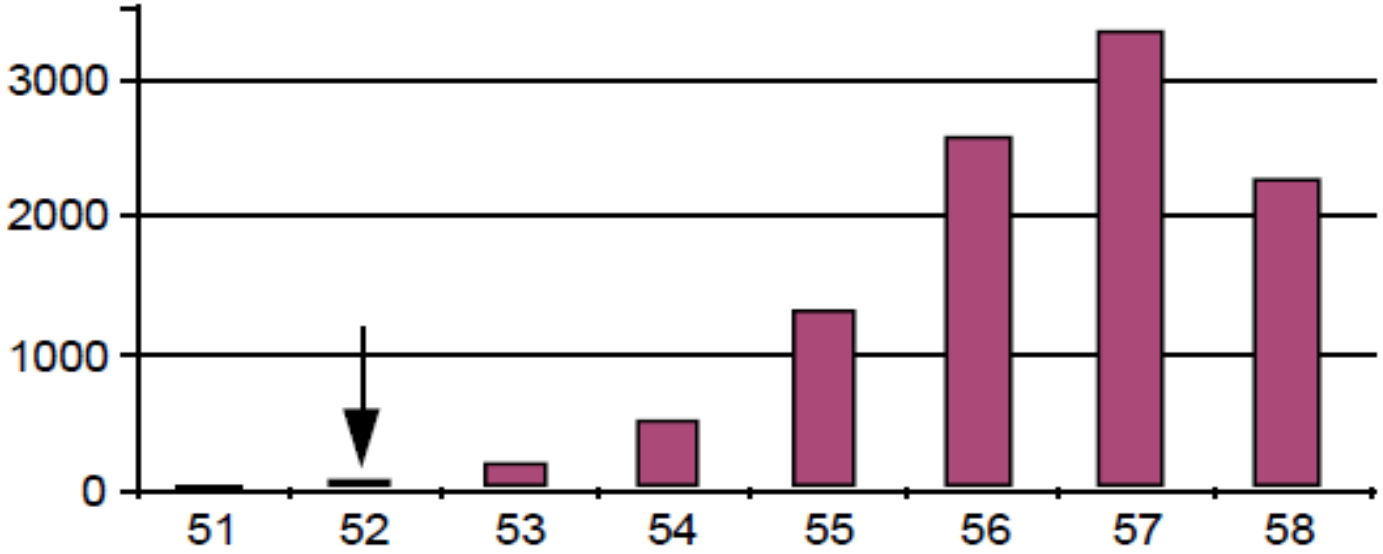

2500
2000
1500
1000
500
0
68
69
70
71
72
73
74
75
76
77
78
79
80

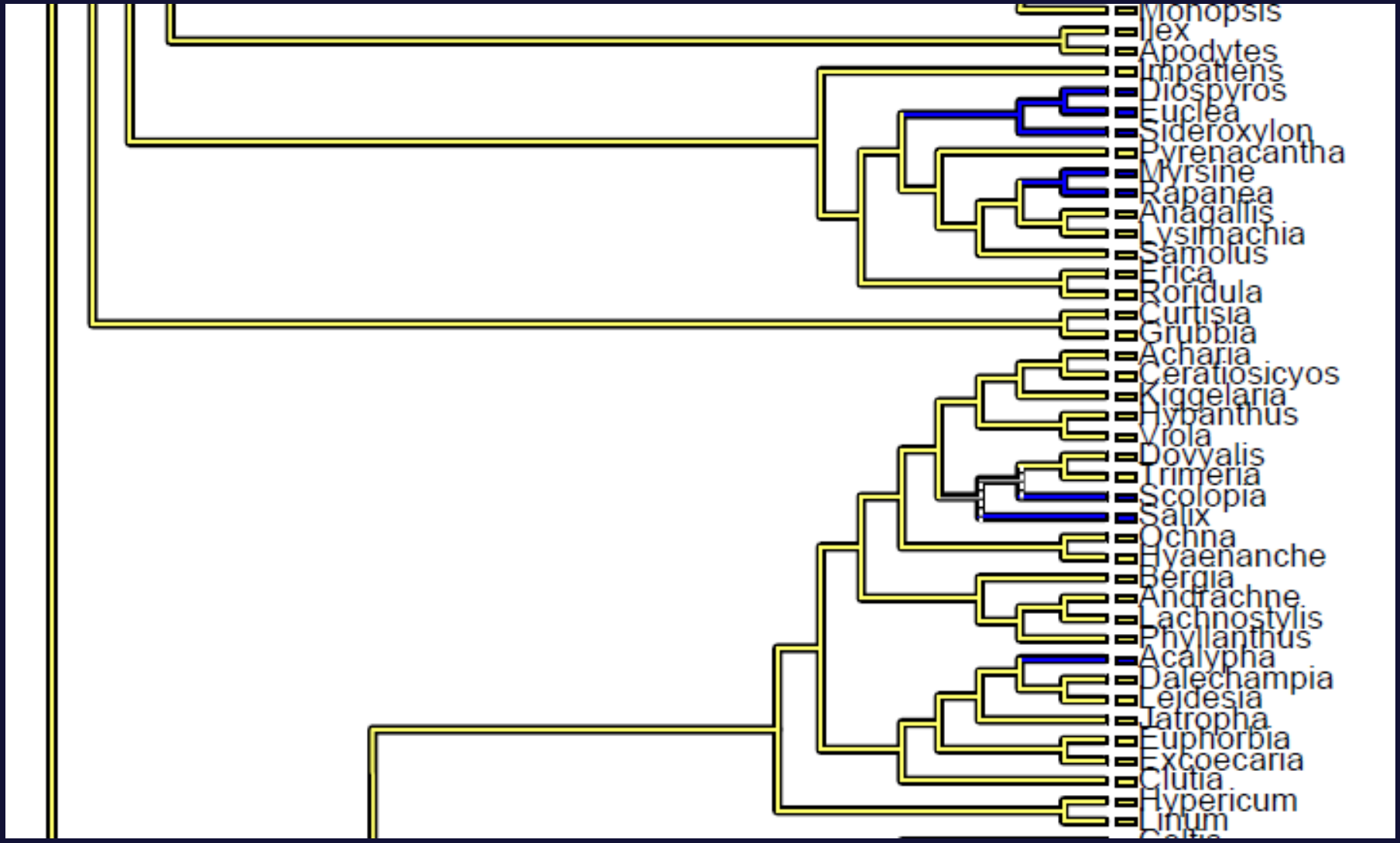


Medicinal uses

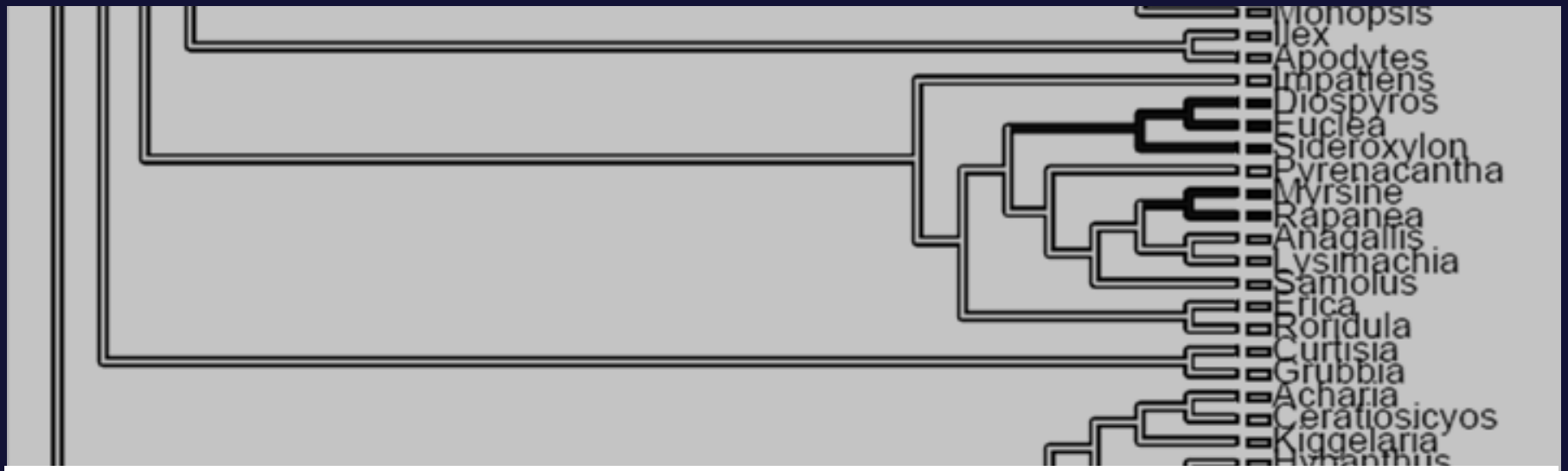


Medicinal uses

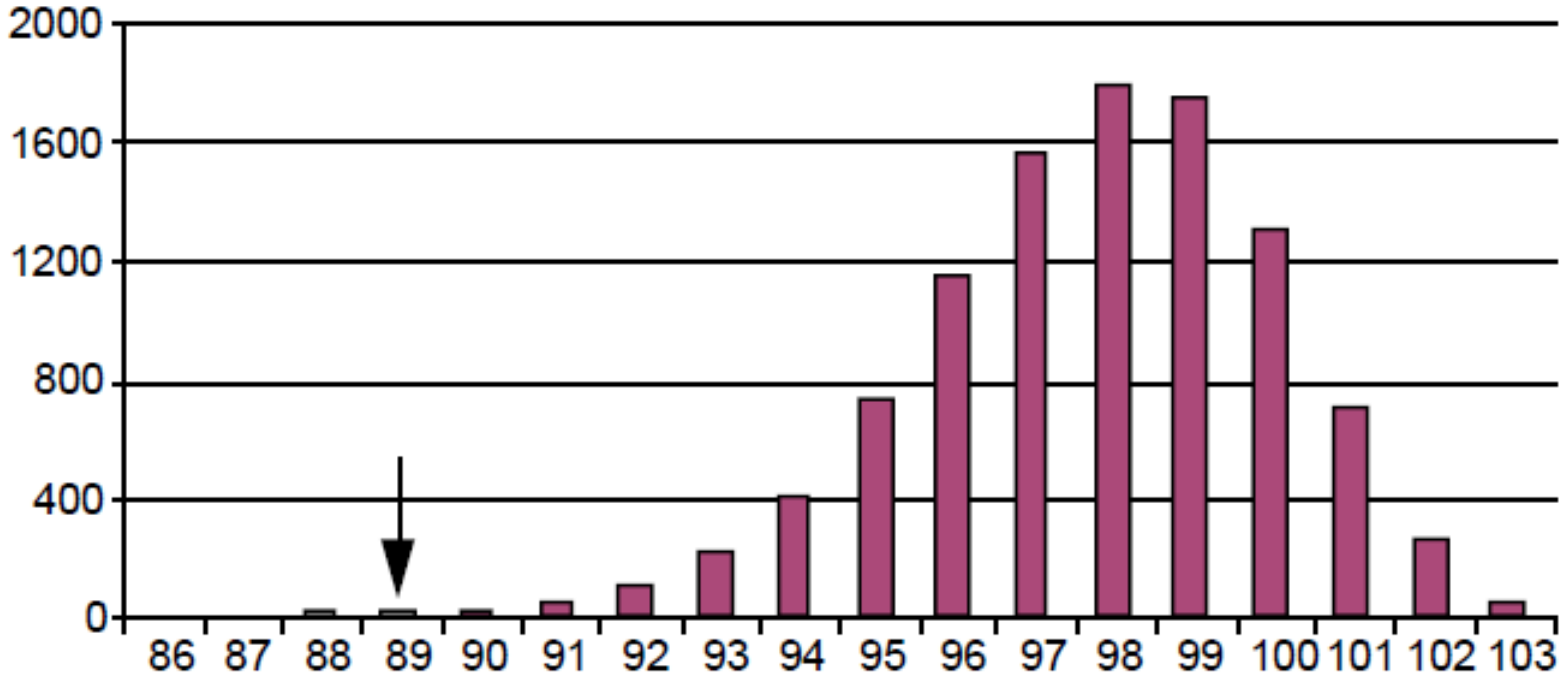



Ilex
Apodytes
Impatiens
Diospyros
Euclea
Sideroxylon
Pyrenacantha
Myrsine
Rapanea
Anagallis
Lysimachia
Samolus
Erica
Roridula
Curtisia
Grubbia
Acharia
Ceratiosicyos
Kiggelaria
Hybanthus
Viola
Dovyalis
Trimeria
Scolopia
Salix
Ochna
Hyaenanche
Bergia
Andrachne
Lachnostylis
Phyllanthus
Acalypha
Dalechampia
Lejdesia
Jatropha
Euphorbia
Excoecaria
Clutia
Hypericum
Linum

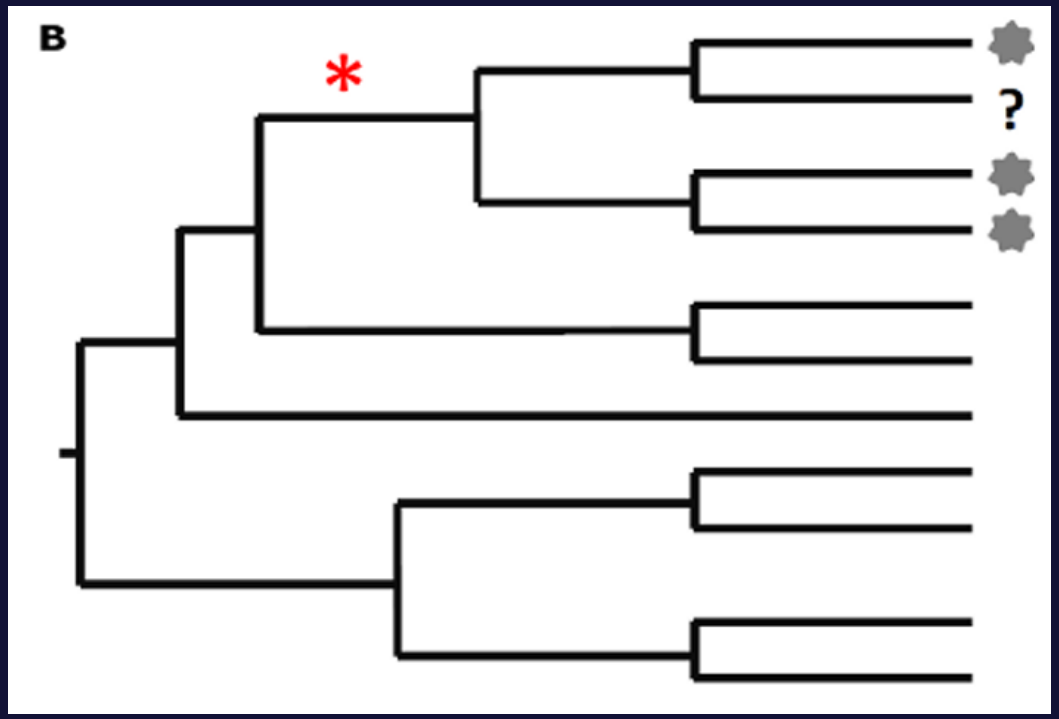
Other uses


Ilex
Apodytes
Impatiens
Diospyros
Euclea
Sideroxylon
Pyrenacantha
Myrsine
Rapanea
Anagallis
Lysimachia
Samolus
Erica
Roridula
Curtisia
Grubbia
Acharia
Ceratiosicyos
Kiggelaria

Other uses


2000
1600
1200
800
400
0
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103

Strong phylogenetic signal - three of the four closely related species are medicinal species.
Species with “?” potentially shares medicinal properties with close relatives.



Lagoudakis, et al. (2011) …Example from Pterocarpus Leguminosae). PLoS ONE6(7)

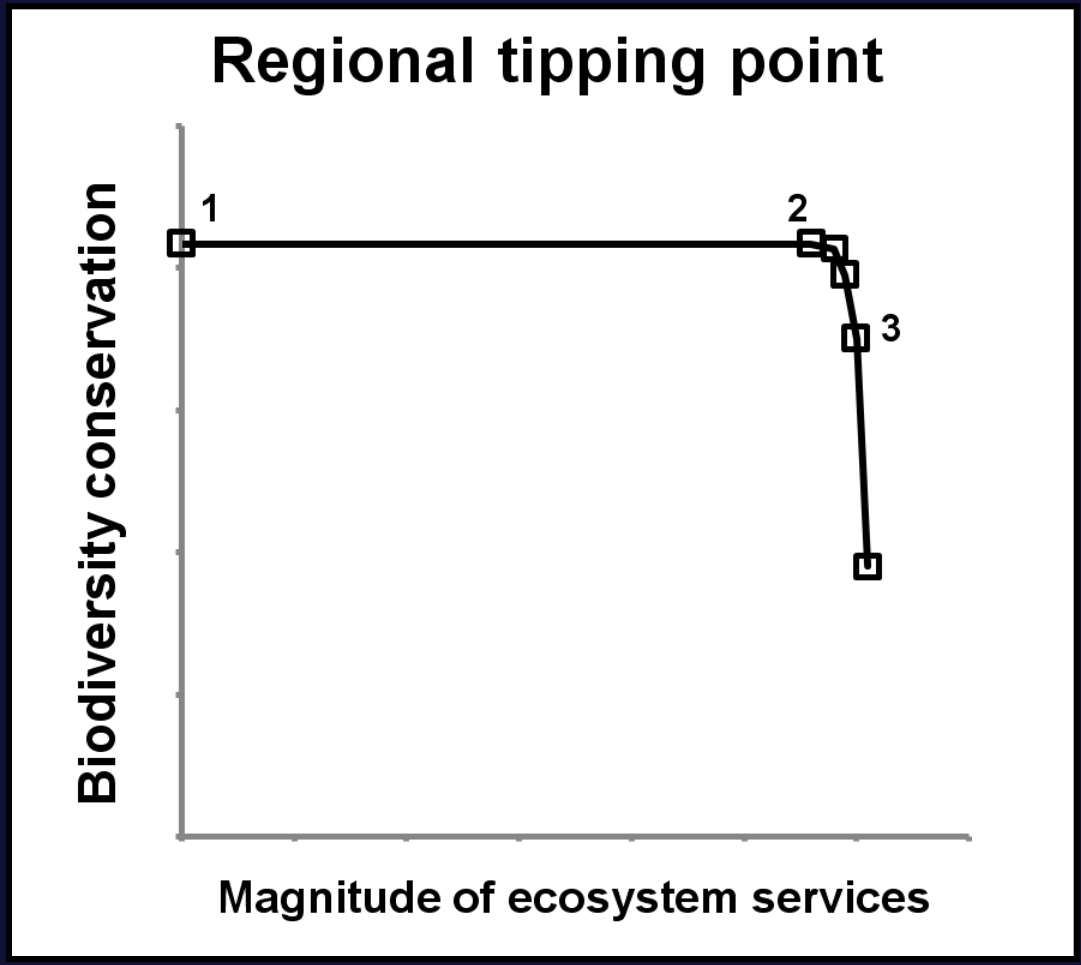
Forest et al findings:

Preserving species of one use-type does not do a good job of protecting species of another use-type

PD the best general predictor over different use-types, so it best captures options for the future

Increases in magnitude of estimated ecosystem services values can move initial high-biodiversity SCP solutions towards a tipping point in which capacity for regional biodiversity conservation collapses.

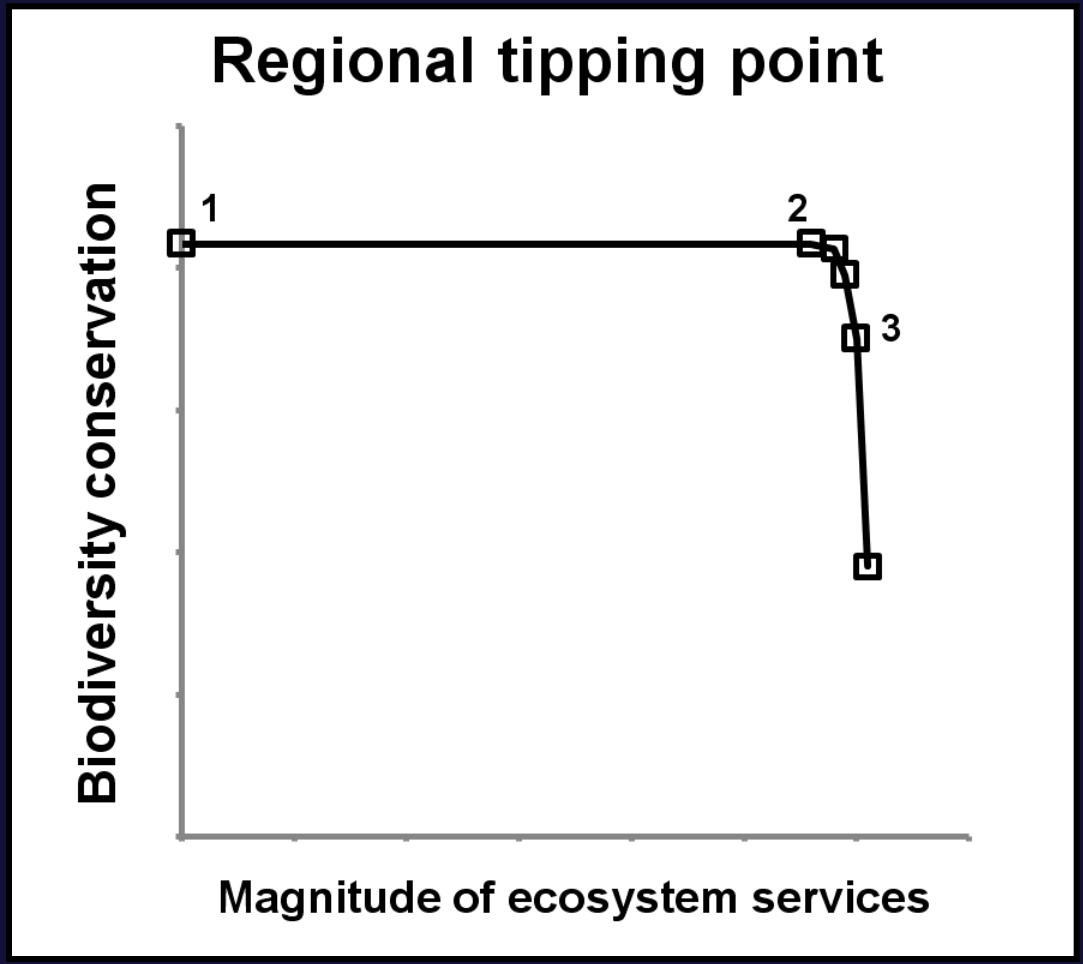
for 240 conserved areas, biodiversity conservation levels remain high as ecosystem services magnitude increases (abscissa), until a tipping point is reached.



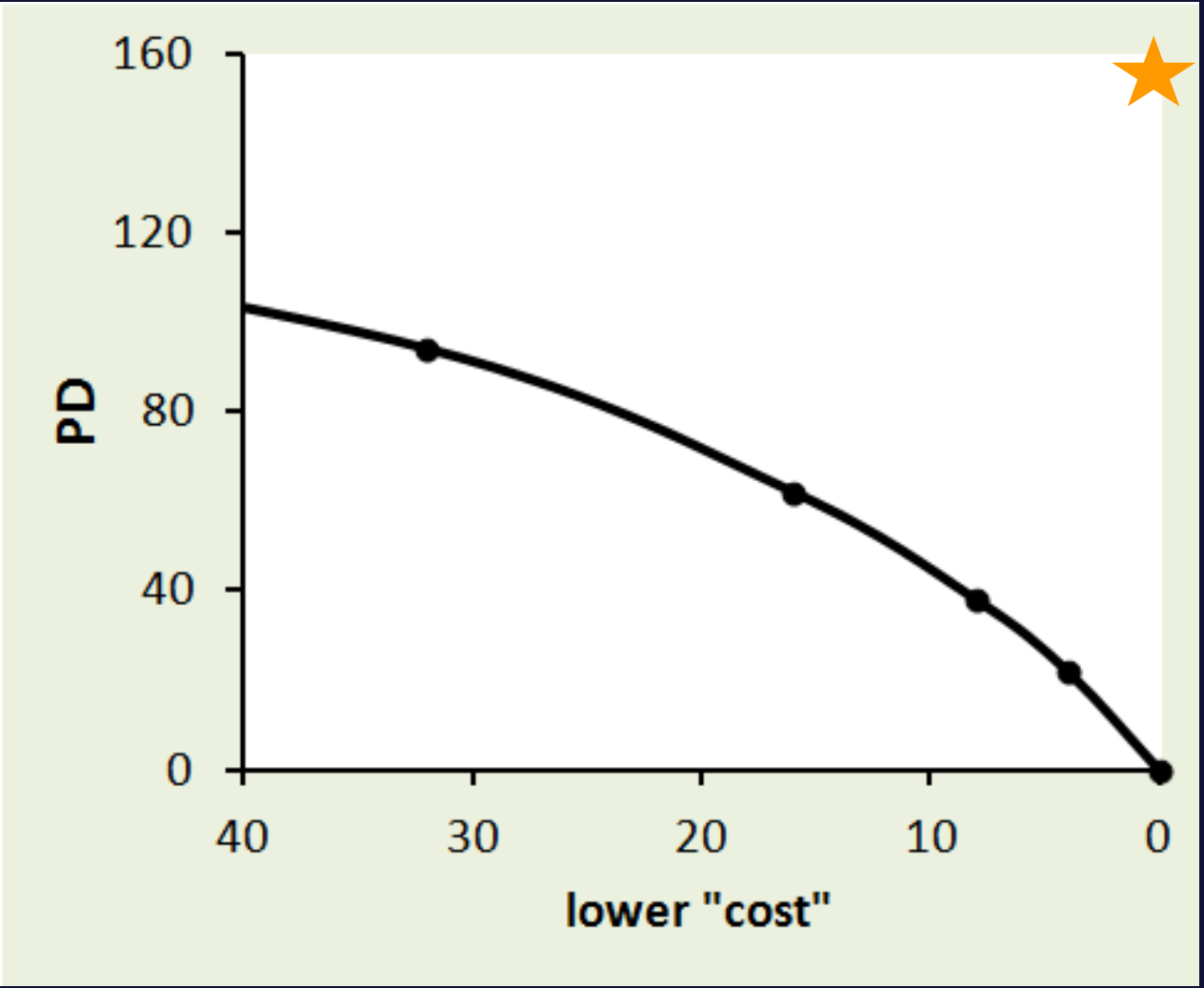
Do increases in magnitude of estimated eVosystem services values move PD solutions towards a tipping point in which capacity for PD conservation collapses?

Use DIVERSITY trade-offs software, modified for PD.

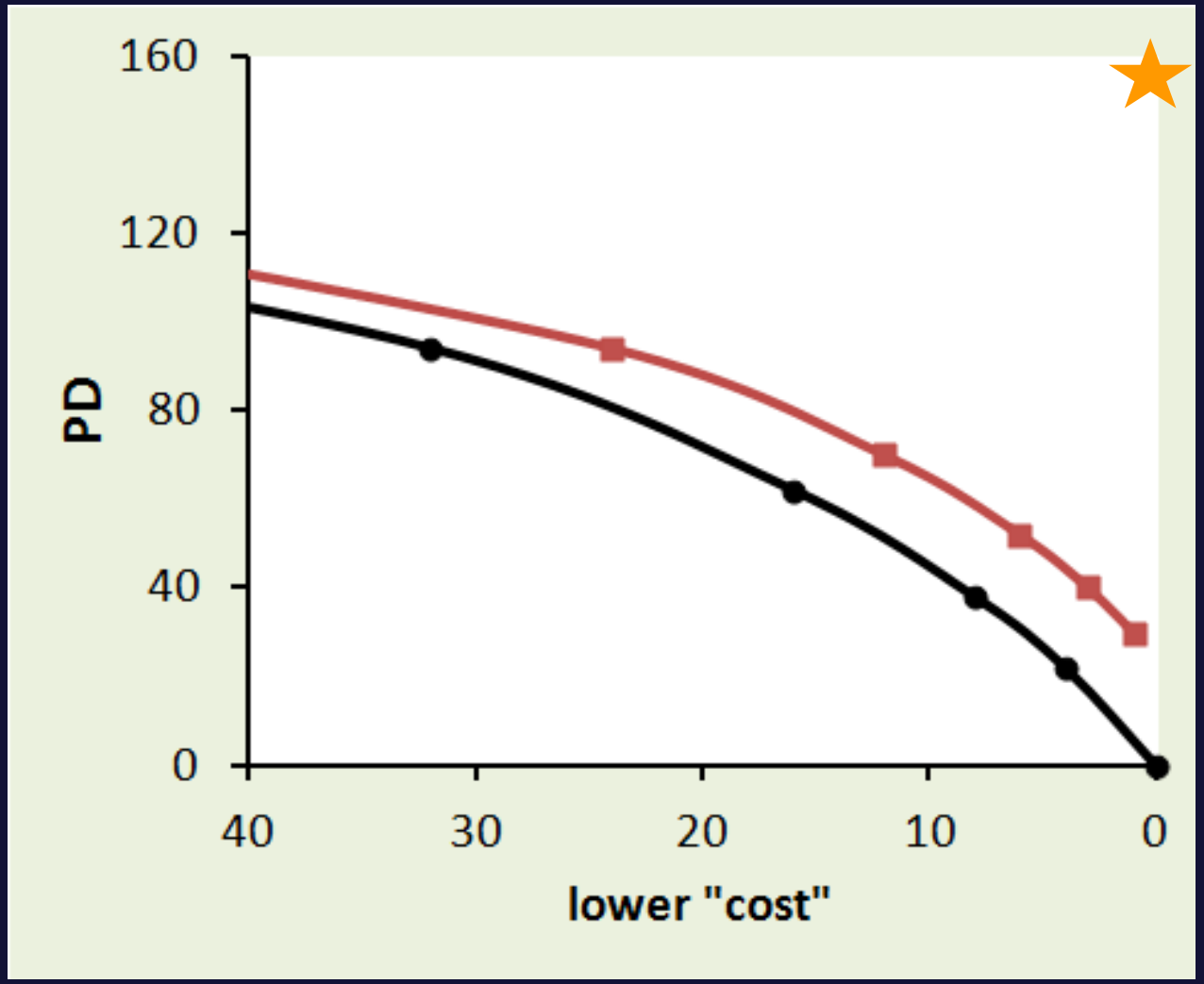
Start with simple simulated phylogenetic trees and conservation costs for species, plus varying assumptions about extent and phylogenetic distribution of known evosystem services



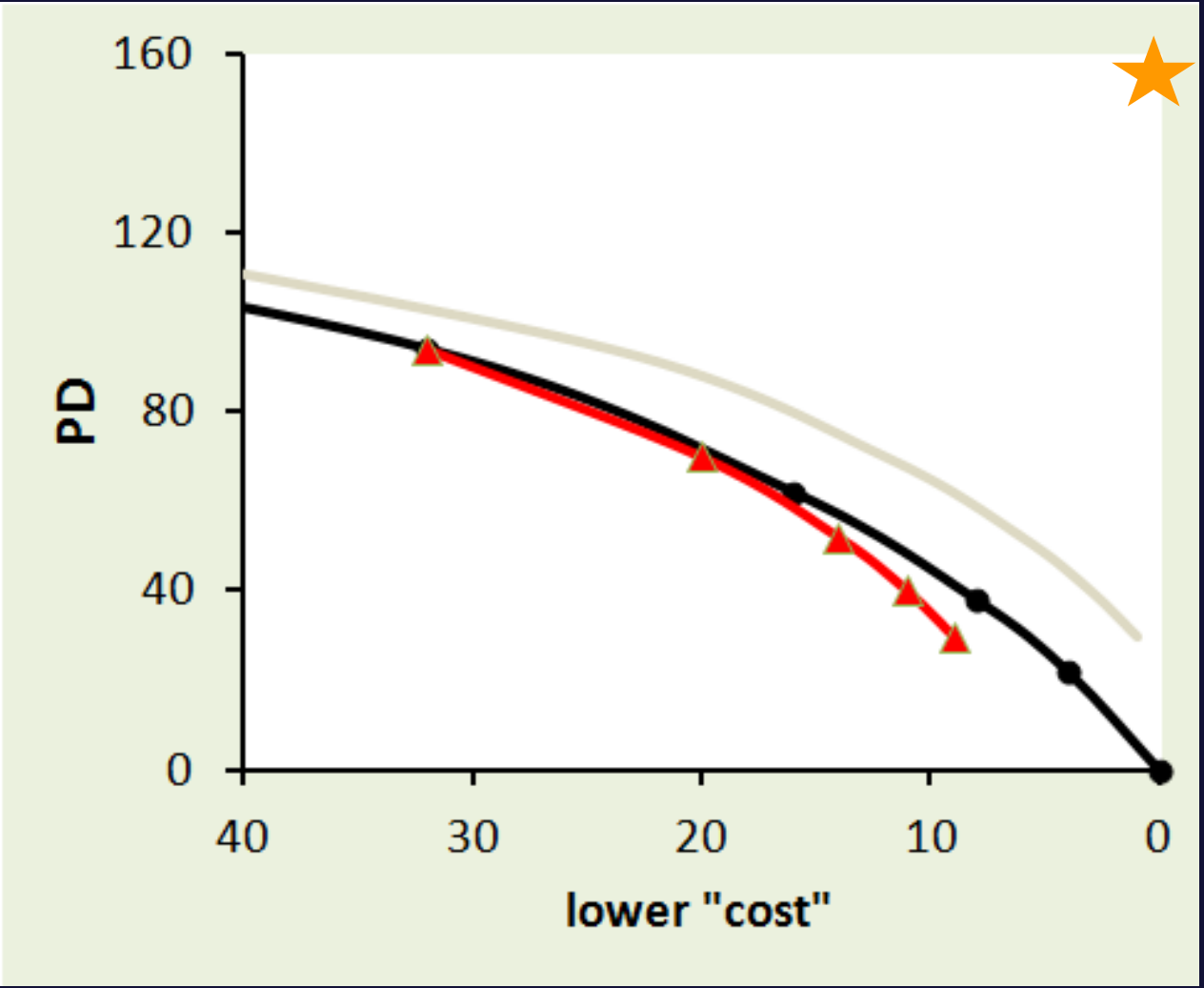
First suppose that no species have known services values



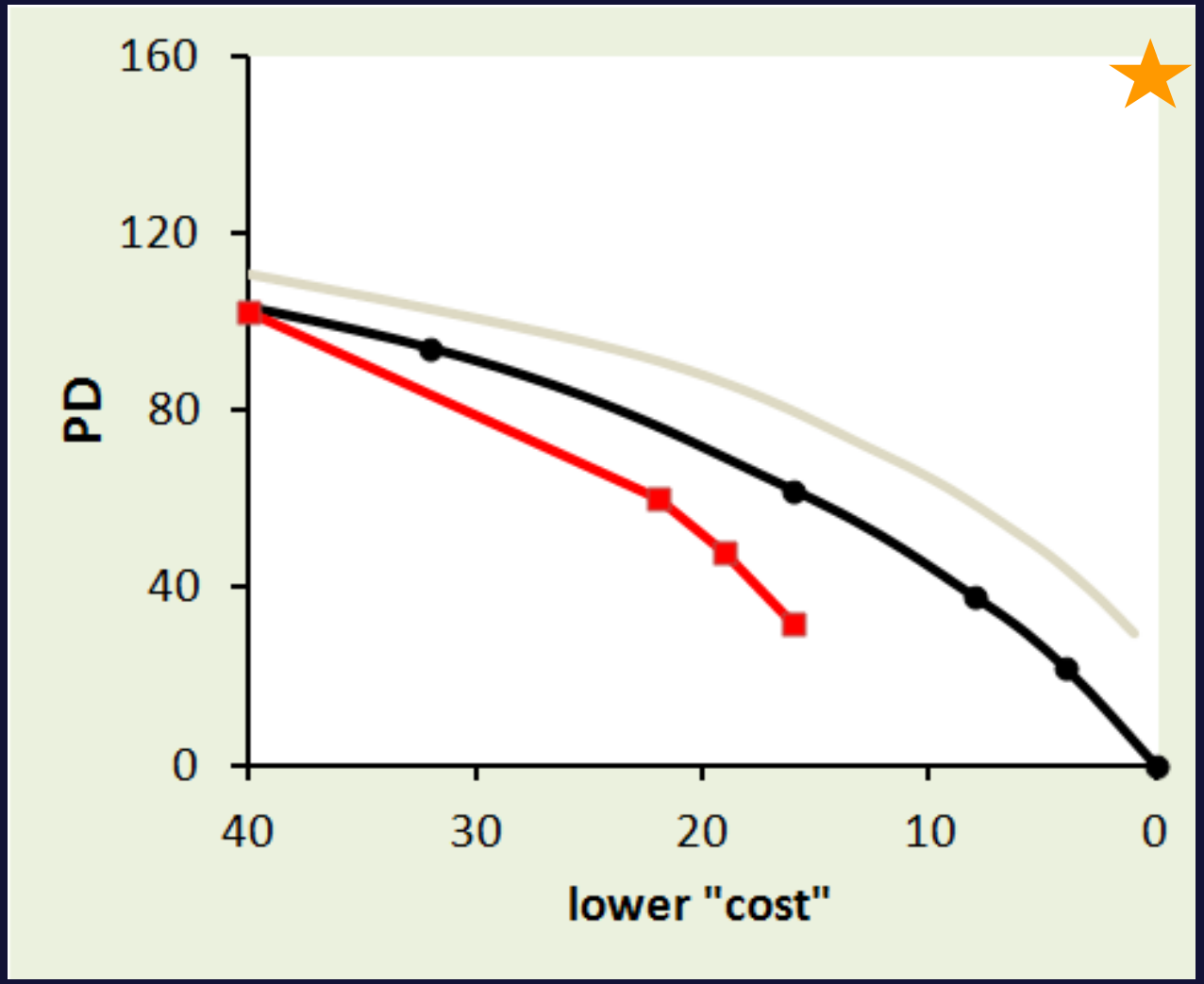
Suppose that some species have known services values and these reduce “costs” of conservation



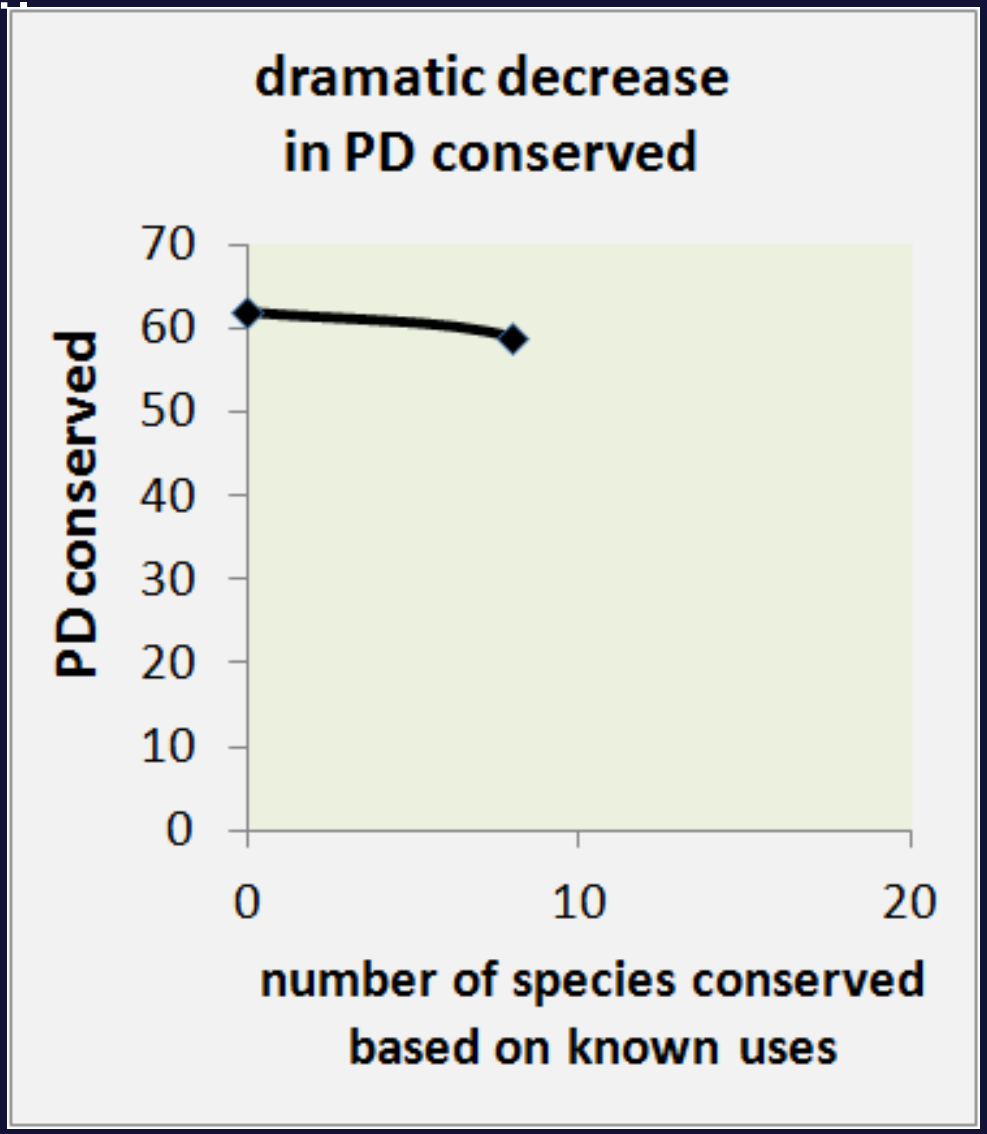
Suppose instead that, while some species have known services values, these do not reduce “costs” of conservation



Suppose instead that, while some species have known services values, these do not reduce “costs” of conservation. If services are phylogenetically clumped, PD conserved drops

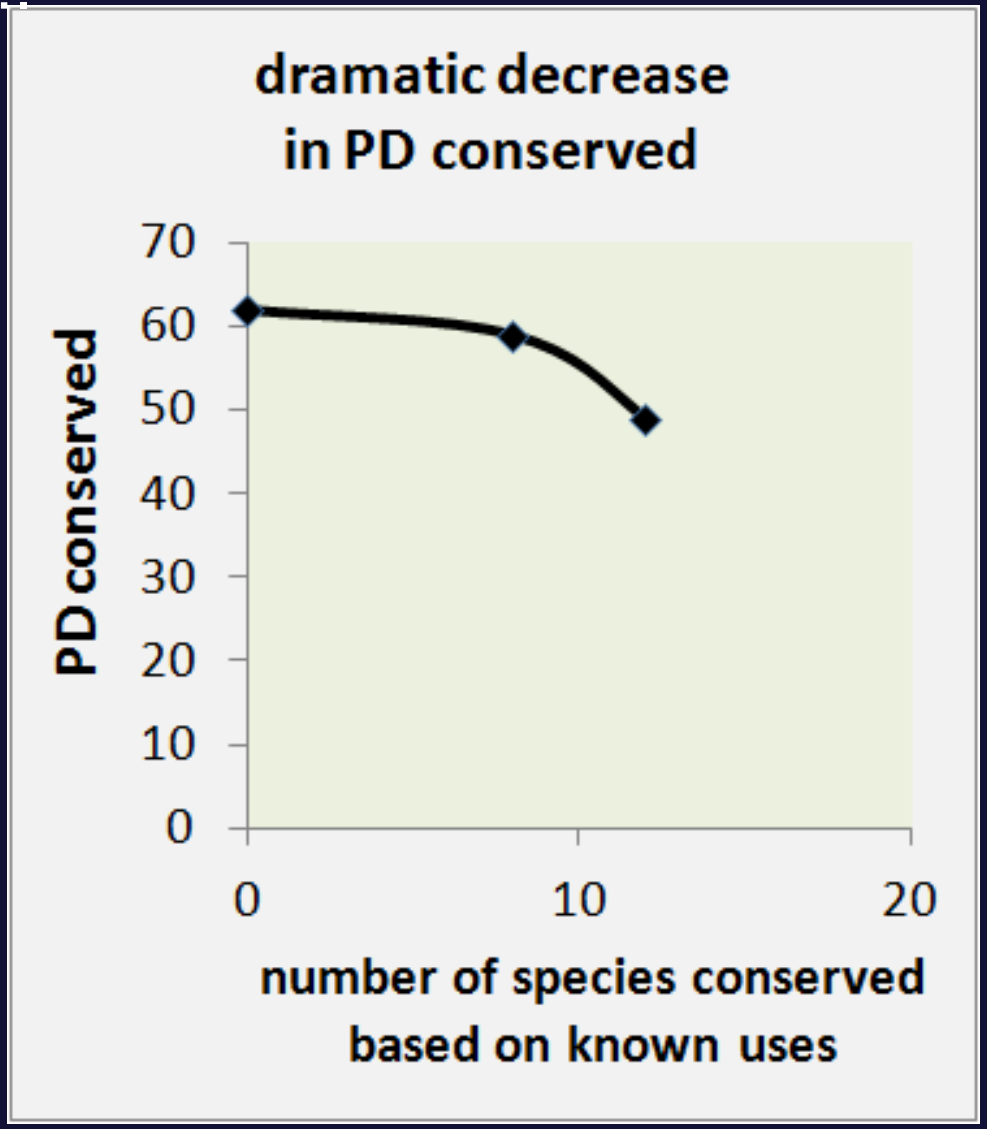


For a given number of species protected, increase in number of known-value species protected initially allows good PD conservation….



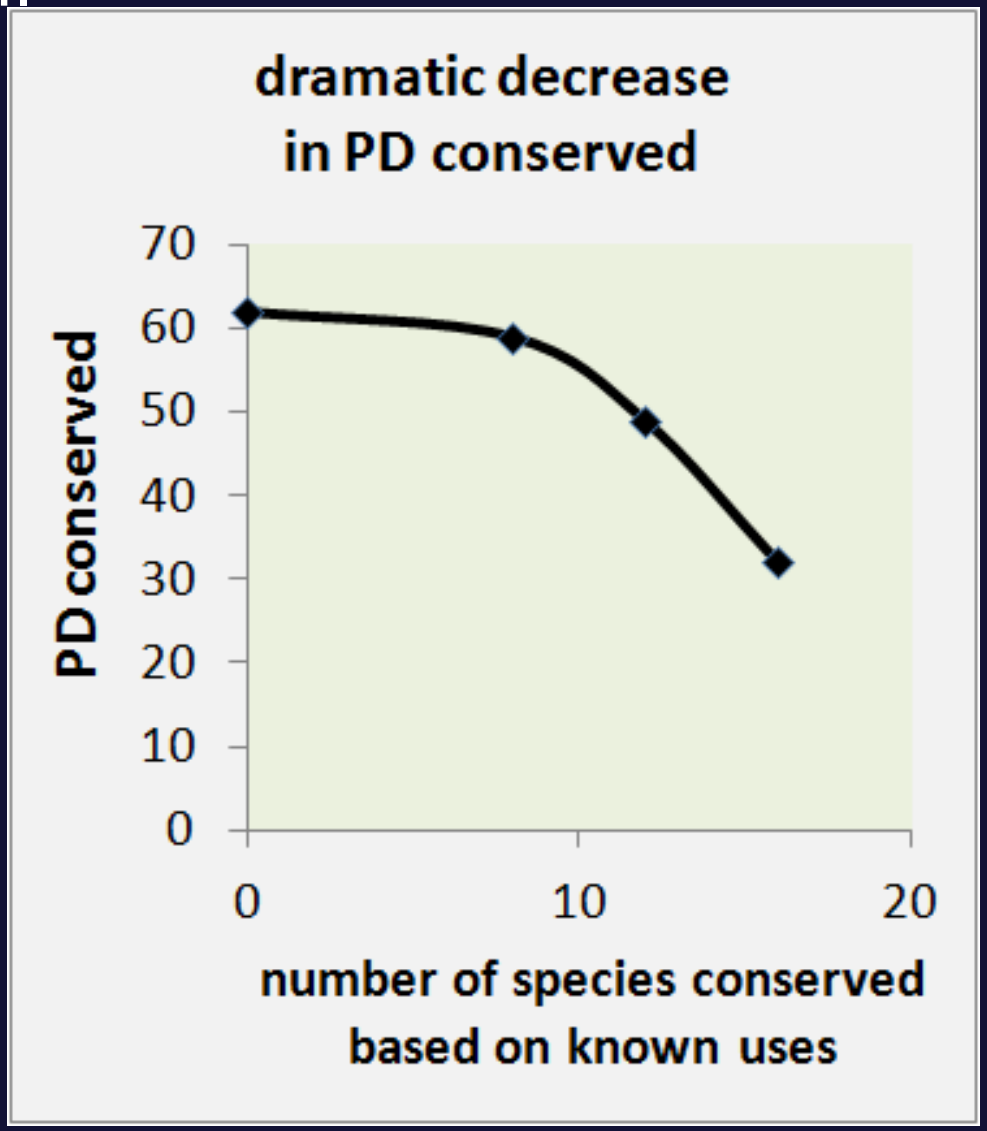
For a given number of species protected, increase in number of known-value species protected initially allows good PD conservation….

But then drops



For a given number of species protected, increase in number of known-value species protected initially allows good PD conservation….

But then drops



conclusions

Phylogeny links to evosystem services and option values – unanticipated future benefits.

The phylogenetic perspective on sustainable use suggests that we need to balance conservation of currently useful species with conservation of overall PD.

Phylogenies and phylogenetic diversity will contribute to decision-making for sustainability and sustainable use.

A global Biodiversity Observation Network: how do we monitor genetic/phylogenetic diversity?

BRAZIL WILL AMEND LAW TO BOOST THE USE OF ITS BIODIVERSITY

05-15-2012 Previous News

The Brazilian government will submit to Congress a project of reform to the Law of Biodiversity approved twelve years ago by the need to increase access to business and scientific resources that can be exploited commercially, officials said.

According to some sources, the current legislation hinders the country's most biodiverse in the world, the researchers on applications of national natural resources and sustainable exploitation nonviable.

The reform will modify some of the articles in the current legislation on access, use and sharing of benefits arising from genetic resources of Brazilian biodiversity, said Carlos Joly, Advisor to the Ministry of Science, Technology and Innovation, in a workshop in Brasilia.