Environmentální rizika biodiverzity

Z5151

GEOGRAFICKÝ ÚSTAV
PŘÍRODOVĚDECKÁ FAKULTA MU

Mgr. Karel Brabec, Ph.D.

brabec@sci.muni.cz

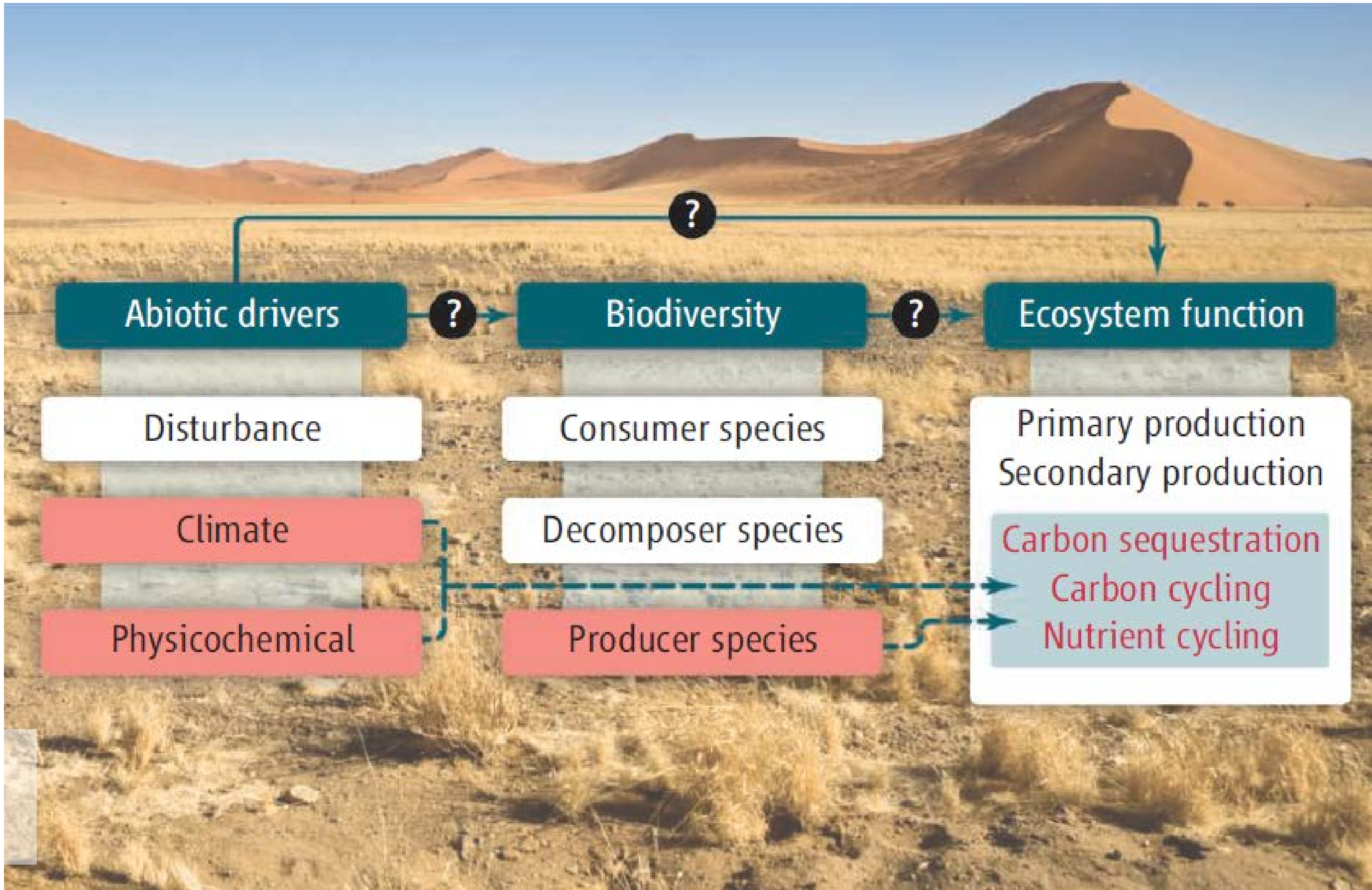
Biodiverzita a ekosystémové procesy

SYLABUS

1) Úvod (struktura ekosystémů, biologická diverzita, ekologické procesy)
2) Biodiverzita – teorie, charakteristiky, řídící faktory
3) Biodiverzita – časo-prostorové aspekty
4) Environmentální rizika (typologie); schéma DPSIR (Řídící faktory, Tlaky, Stavy, Dopady, Odezvy)
5) Ekologie působení stresoru
6) **Biodiverzita a ekosystémové procesy**
7) Vztahy biodiverzity ke klimatu
8) Scénáře změn využití krajiny
9) Změny biotopů (Natura 2000, Ochrana stanovišť)
10) Vliv chemického znečištění na biodiverzitu
11) Biologické invaze
12) Ekosystémové služby
13) Analýza rizik pro biodiverzitu

BIODIVERZITA – PROCESY - FUNKCE

- vliv poklesu biodiverzity na ekosystémové funkce
- dopady na zboží a služby, které ekosystémy poskytují
- narušení biodiverzity na lokální a regionální škále může také snížit rezilienci v rámci vetších prostorových škál jako výsledek degradace ekosystémových funkcí



ECOLOGY
Biodiversity and Ecosystem Function
Guy F. Midgley

EKOSYSTÉMOVÉ PROCESY

Definice

vnitřní vlastnosti ekosystému, kterými ekosystém udržuje jeho integritu.

Na ekosystémové procesy bývá také nahlíženo jako na „funkce ekosystému“

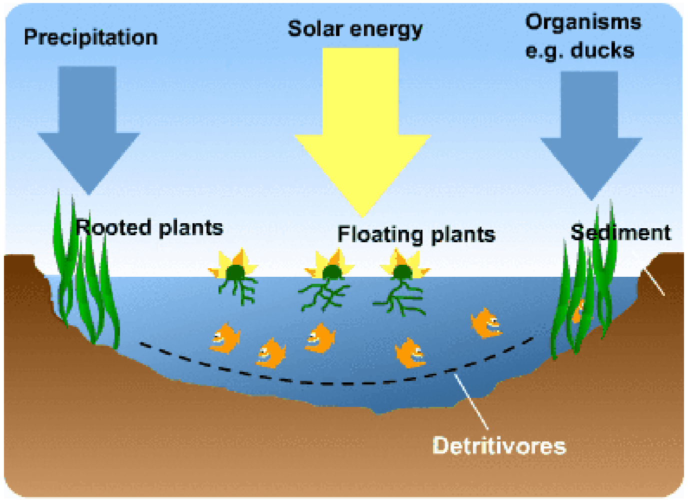
Millennium Ecosystem Assessment (2005)

Ekosystémové procesy

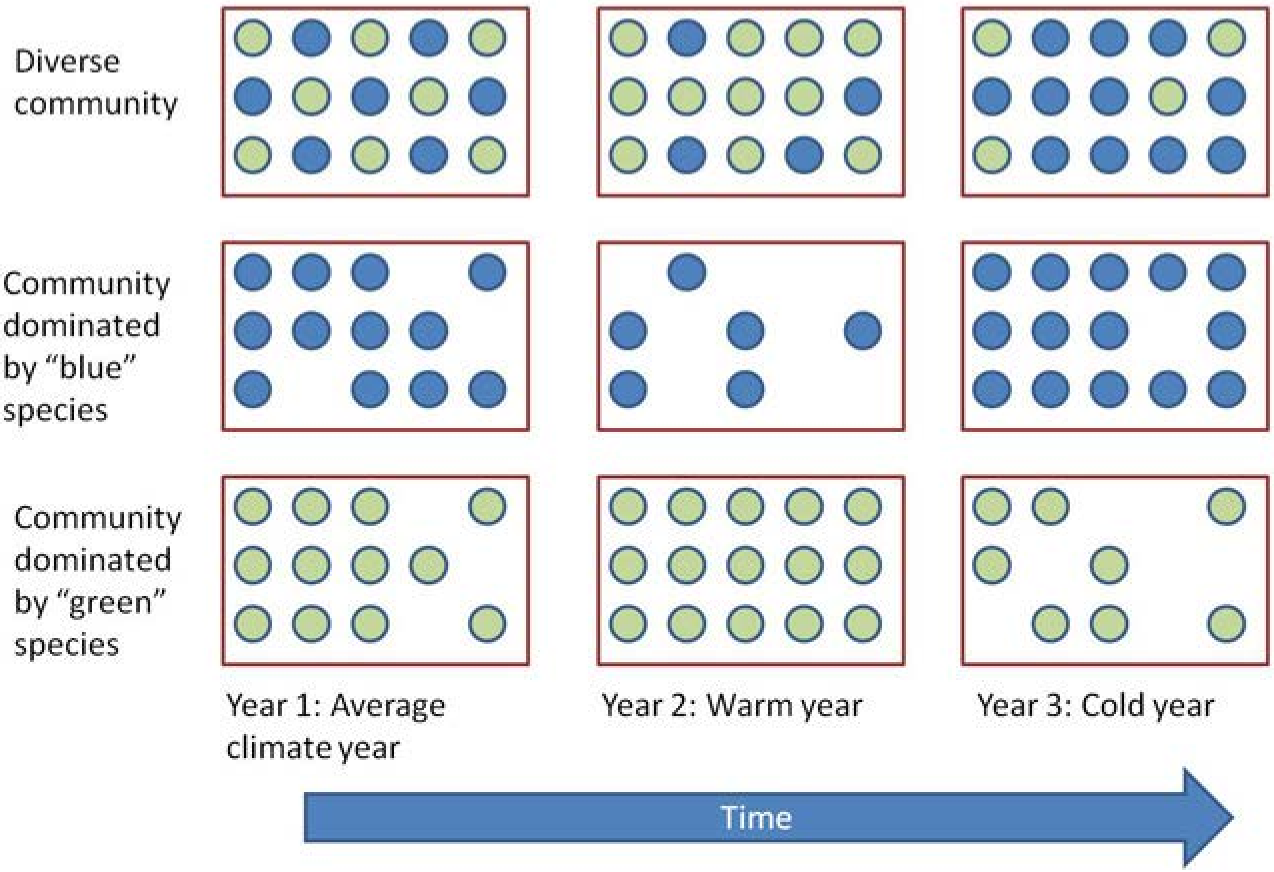
fyzikální, chemické a biologické aktivity a projevy, které spojují organismy s prostředím

Ekosystémové procesy:

- dekompozice
- produkce (rostlinná hmota)
- koloběh živin (nutrient cycling)
- toky živin a energie



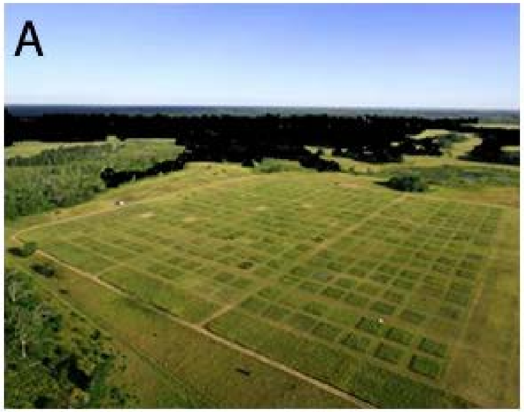
BIODIVERSITA A EKOSYSTÉMOVÉ FUNKCE

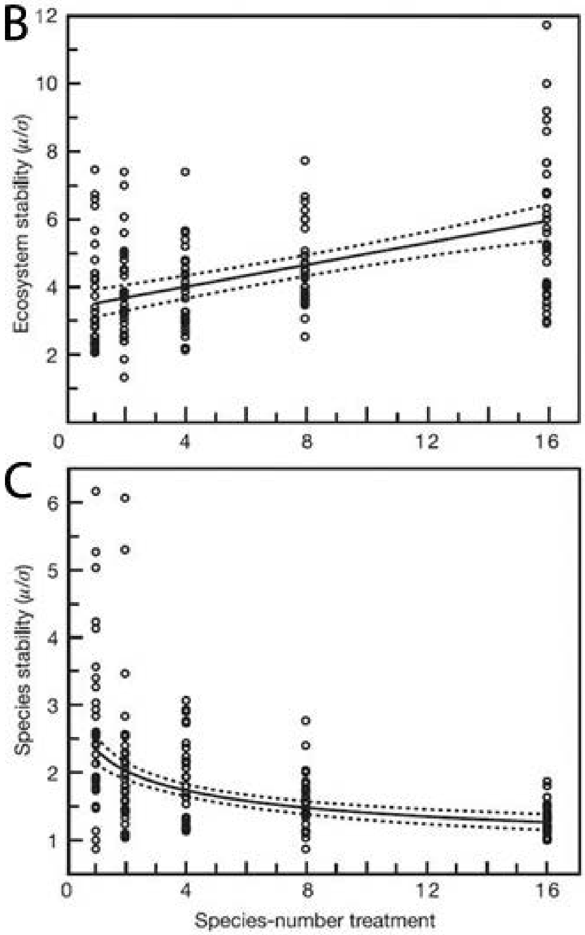


Conceptual diagram showing how increasing diversity can stabilize ecosystem functioning
Cleland, E. E. (2011) Biodiversity and Ecosystem Stability. Nature Education Knowledge 3(10):14
© 2011 Nature Education
(www.nature.com/scitable/knowledge/library/biodiversity-and-ecosystem-stability-17059965)

BIODIVERSITA A EKOSYSTÉMOVÉ FUNKCE

- increasing species diversity would be positively correlated with increasing stability at the ecosystem-level and negatively correlated with species-level stability due to declining population sizes of individual species





A biodiversity experiment at the Cedar Creek Ecosystem Science Reserve (a) demonstrates the relationship between the number of planted species and ecosystem stability (b) or species stability (c).

Cleland, E. E. (2011) Biodiversity and Ecosystem Stability. Nature Education Knowledge 3(10):14

BIODIVERSITA A EKOSYSTÉMOVÉ FUNKCE


SHARE

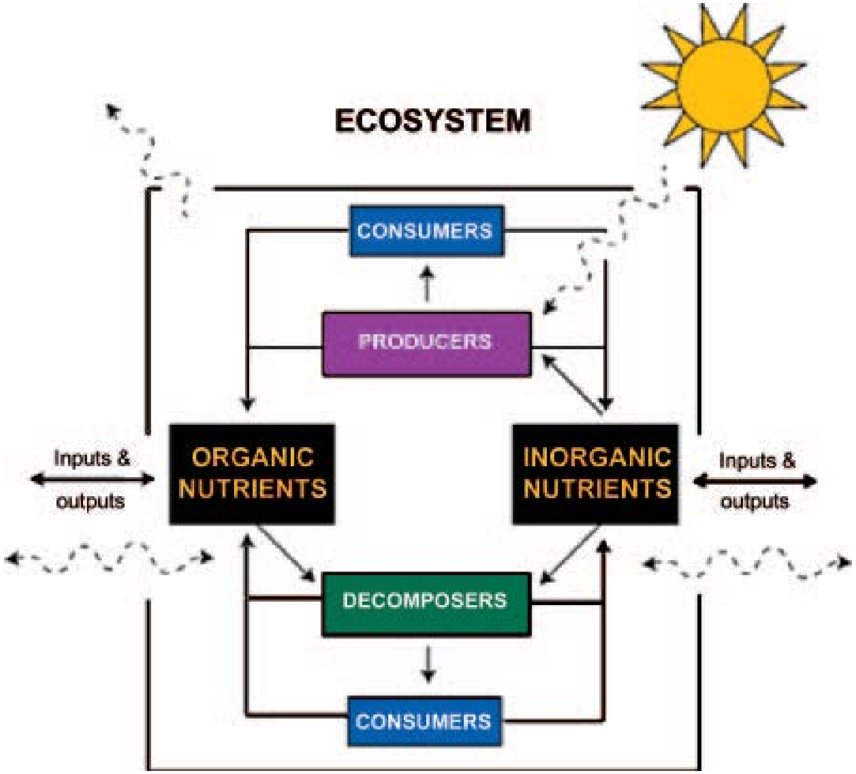
REVIEW

Biodiversity and Ecosystem Functioning: Current Knowledge and Future Challenges

M. Loreau[1,*], S. Naeem[2], P. Inchausti[1], J. Bengtsson[3], J. P. Grime[4], A. Hector[5], D. U. Hooper[6], M. A. Huston[7], D. Raffaelli...

+ See all authors and affiliations

Science 26 Oct 2001:
Vol. 294, Issue 5543, pp. 804-808
DOI: 10.1126/science.1064088


ECOSYSTEM

CONSUMERS

PRODUCERS

ORGANIC NUTRIENTS

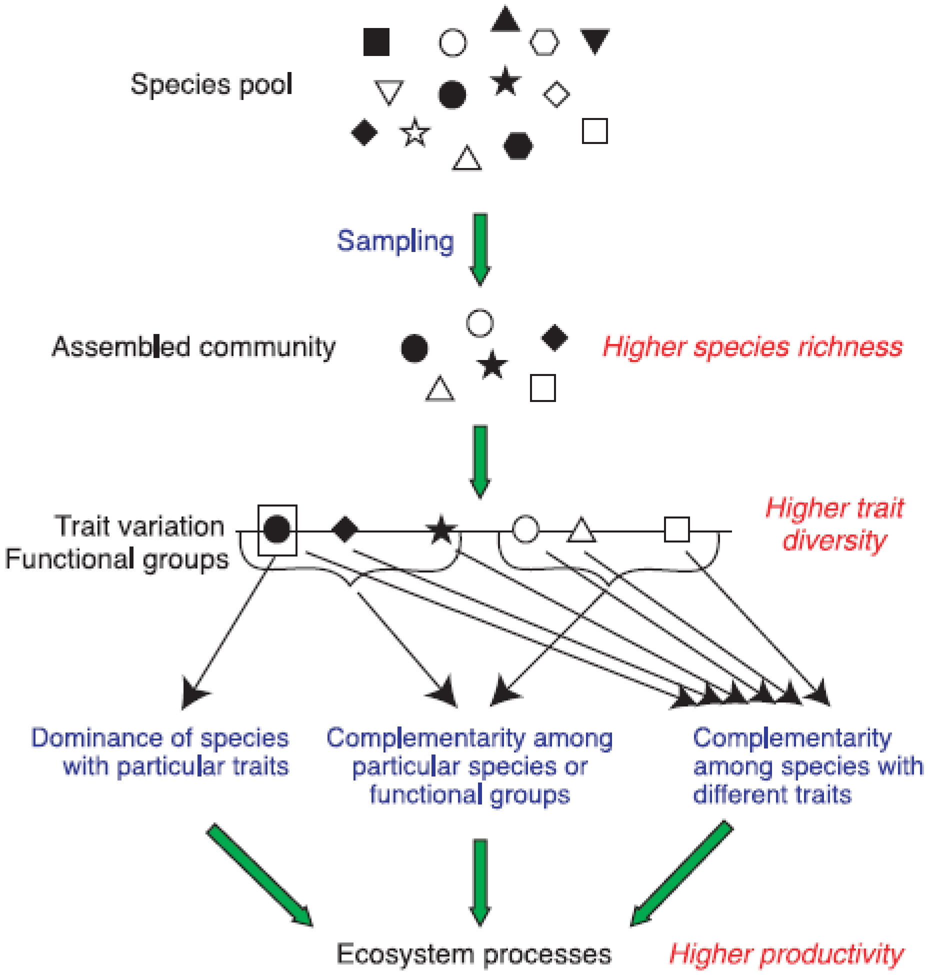
INORGANIC NUTRIENTS

Inputs & outputs

Inputs & outputs

DECOMPOSERS

CONSUMERS


Species pool

Sampling

Assembled community

Higher species richness

Trait variation
Functional groups

Higher trait diversity

Dominance of species with particular traits

Complementarity among particular species or functional groups

Complementarity among species with different traits

Ecosystem processes

Higher productivity

BIODIVERSITY AND ECOSYSTEM FUNCTION

SHARE

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REVIEW

Biodiversity and Ecosystem Functioning: Current Knowledge and Future Challenges

M. Loreau[1,*], S. Naeem[2], P. Inchausti[1], J. Bengtsson[3], J. P. Grime[4], A. Hector[5], D. U. Hooper[6], M. A. Huston[7], D. Raffaelli...

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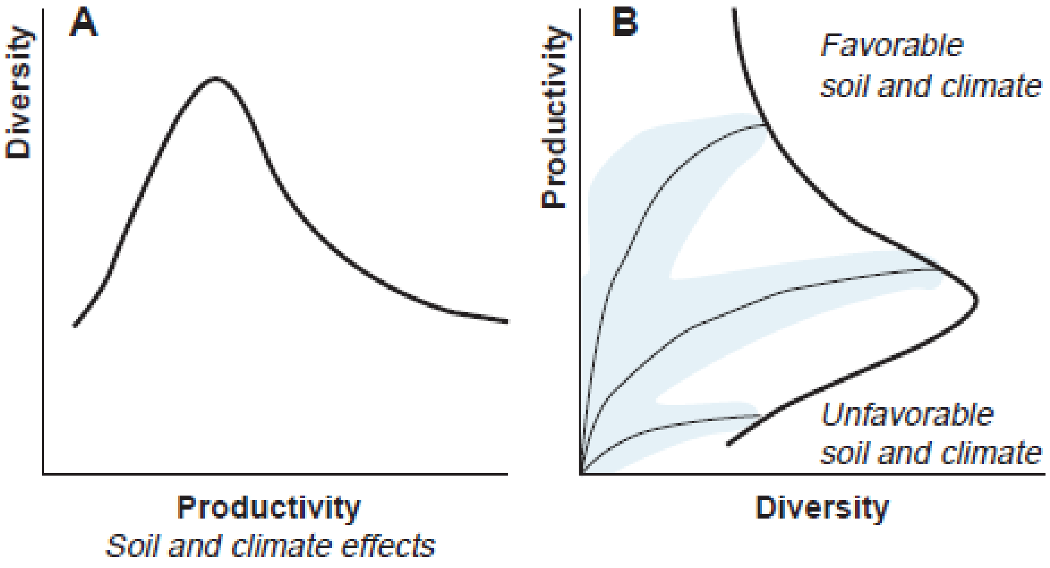


Fig. 4. Hypothesized relationships between (**A**) diversity-productivity patterns driven by environmental conditions across sites, and (**B**) the local effect of species diversity on productivity. (A) Comparative data often indicate a unimodal relationship between diversity and productivity driven by changes in environmental conditions. (B) Experimental variation in species richness under a specific set of environmental conditions produces a pattern of decreasing between-replicate variance and increasing mean response with increasing diversity, as indicated by the thin, curved regression lines through the scatter of response values (shaded areas).

BIODIVERZITA A EKOSYSTÉMOVÉ PROCESY (V DYNAMICKÉ KRAJINĚ)

- vztahy mezi biodiverzitou a funkcemi ekosystémů ovlivňují ekosystémové služby
- většinou studovány formou experimentů na malé ploše a s krátkou dobou trvání; kontrolované podmínky a stabilní složení společenstev
- výzvou je studium reálného prostředí a dynamických společenstev
- existují četné důkazy o tom, že pokles biodiverzity v určitých trofických skupinách se projevuje poklesem jejich biomasy a následně poklesem i efektivity využívání zdrojů

(i) multi-trofická diverzita

(ii) nerovnovážná biodiverzita pod vlivem disturbancí a měnících se podmínek prostředí

(iii) velké prostorové a dlouhé časové škály

Brose U, Hillebrand H. 2016. Biodiversity and ecosystem functioning in dynamic landscapes. Phil. Trans. R. Soc. B 371: 20150267. http://dx.doi.org/10.1098/rstb.2015.0267

(I) MULTI-TROFICKÁ DIVERZITA

Brose U, Hillebrand H. 2016. Biodiversity and ecosystem functioning in dynamic landscapes. Phil. Trans. R. Soc. B 371: 20150267.

(i) multi-trofická diverzita

(ii) nerovnovážná biodiverzita pod vlivem disturbancí a měnících se podmínek prostředí

(iii) velké prostorové a dlouhé časové škály

- multi-trofické vztahy jsou často specifické, zatímco zohlednění autekologických charakteristik druhů umožňuje prediktivní vyhodnocení
- další směřování spočívá ve studiu komplexních společenstev opírající se o ekologickou teorii založenou na průměrné biomase jednotlivých druhů, stechiometrii a účinku faktorů prostředí (např. teplota)

(II) NEROVNOVÁŽNÁ BIODIVERZITA POD VLIVEM DISTURBANCÍ A MĚNÍCÍCH SE PODMÍNEK PROSTŘEDÍ

(i) multi-trofická diverzita

(ii) nerovnovážná biodiverzita pod vlivem disturbancí a měnících se podmínek prostředí

(iii) velké prostorové a dlouhé časové škály

- disturbance a variabilní podmínky prostředí mají přímý i nepřímý vliv na vztahy mezi biodiverzitou a ekosystémovými funkcemi (prostřednictvím počtu druhů, složení společenstev a charakteristik druhů)
- kolísání biodiverzity může výrazně ovlivnit její vazby na ekosystémové funkce

Brose U, Hillebrand H. 2016. Biodiversity and ecosystem functioning in dynamic landscapes. Phil. Trans. R. Soc. B 371: 20150267.

(III) VELKÉ PROSTOROVÉ A DLOUHÉ ČASOVÉ ŠKÁLY

(i) multi-trofická diverzita

(ii) nerovnovážná biodiverzita pod vlivem disturbancí a měnících se podmínek prostředí

(iii) velké prostorové a dlouhé časové škály

- vazby mezi biodiverzitou a ekosystémovými funkcemi na větších prostorových škálách jsou závislé na různých faktorech
- zatímco počet druhů a biomasa společenstva jsou na velkých škálách vysoce důležité, důsledky identity druhů (příslušnost k funkčním gildám/jejich nika v rámci společenstva) a složení společenstva jsou ve velkých škálách méně důležité než na malých
- v rámci dlouhých časových škál masové extinkce představují vážné změny biodiverzity s různorodými účinky na ekosystémové funkce

Brose U, Hillebrand H. 2016. Biodiversity and ecosystem functioning in dynamic landscapes. Phil. Trans. R. Soc. B 371: 20150267.

BIODIVERZITA A EKOSYSTÉMOVÉ PROCESY

- funkce ekosystému: produkce biomasy a využívání zdrojů
- predace v rámci gildy a kompetiční interference = snížená úroveň využívání zdrojů

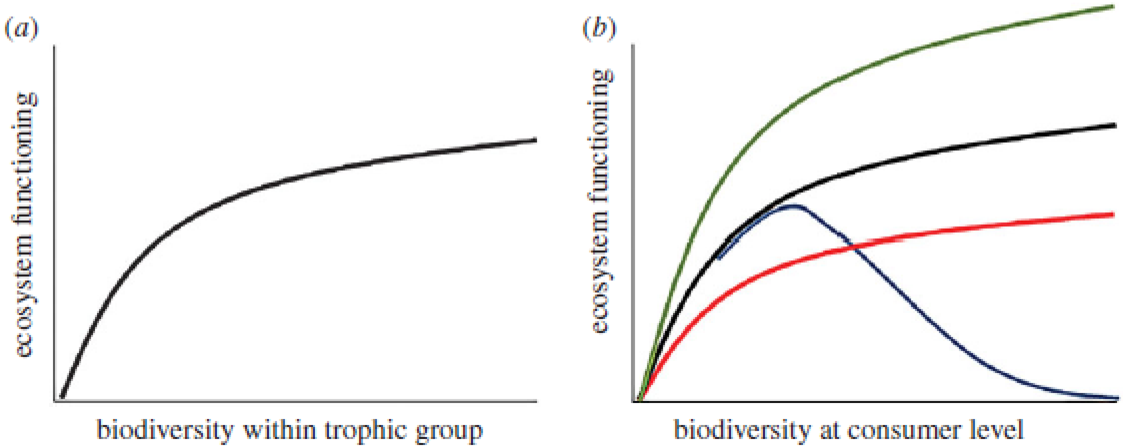


Figure 1. Biodiversity within a trophic level is predicted to enhance ecosystem functioning (biomass production and resource capture) by this trophic group (*a*). However, changes in the degree of intraguild predation or interference competition with increasing consumer diversity may lead to reduced resource capture at higher diversity ((*b*), blue line). Moreover, alterations of biodiversity at the prey level may lead to associational resistance (lower edibility, red line) or prey complementarity (higher edibility, green line).

Brose U, Hillebrand H. 2016
Biodiversity and ecosystem functioning
in dynamic landscapes. Phil. Trans. R. Soc. B
371: 20150267.

STRUKTURA – PROCESY - FUNKCE

Sleď obecný (Clupea harengus)

Vocha mořská (Zostera marina)

Příklad mořského pobřeží

Složení a uspořádání biologických společenstev je určováno procesy (expozice vlnobití, transport sedimentů, přítoky sladké vody) a „strukturami“ (reliéf, sedimenty na pobřeží, salinita).

Struktura příbřežních ekosystémů je výsledkem působení ekosystémových procesů a zároveň je zpětně ovlivňuje. Např. reliéf pobřeží je výsledkem působení vlnobití a zároveň ho ovlivňuje.

- specifické funkce pobřežních ekosystémů
- habitaty příbřežních organismů
- habitatové funkce jsou integrované a hierarchické

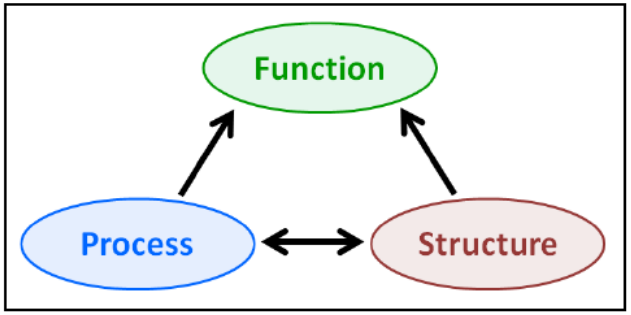


Figure 4.1. Ecosystem processes and structures interact to manifest ecosystem functions such as the provision of habitat (Goetz et al. 2004).

Goetz, F., C. Tanner, C.S. Simenstad, K. Fresh, T. Mumford, and M. Logsdon. 2004. Guiding restoration principles. Puget Sound Nearshore Partnership Technical Report No. 2004-03. Published by Washington Sea Grant Program, University of Washington, Seattle, Washington.

STRUKTURA – PROCESY - FUNKCE

habitat sleďů (funkce) ← struktura vegetace

Sleď obecný (Clupea harengus)

Vocha mořská (Zostera marina)

funkce habitatů vegetace ← struktura sedimentů pláží

Vocha mořská (Zostera marina)

EKOLOGICKÉ PROCESY

Základní ekologické procesy v ekosystémech

- koloběh vody
- biogeochemické cykly (koloběh živin)
- toky energie
- dynamika společenstev (např. jak reaguje složení a struktura ekosystémů na disturbanci (sukcese)

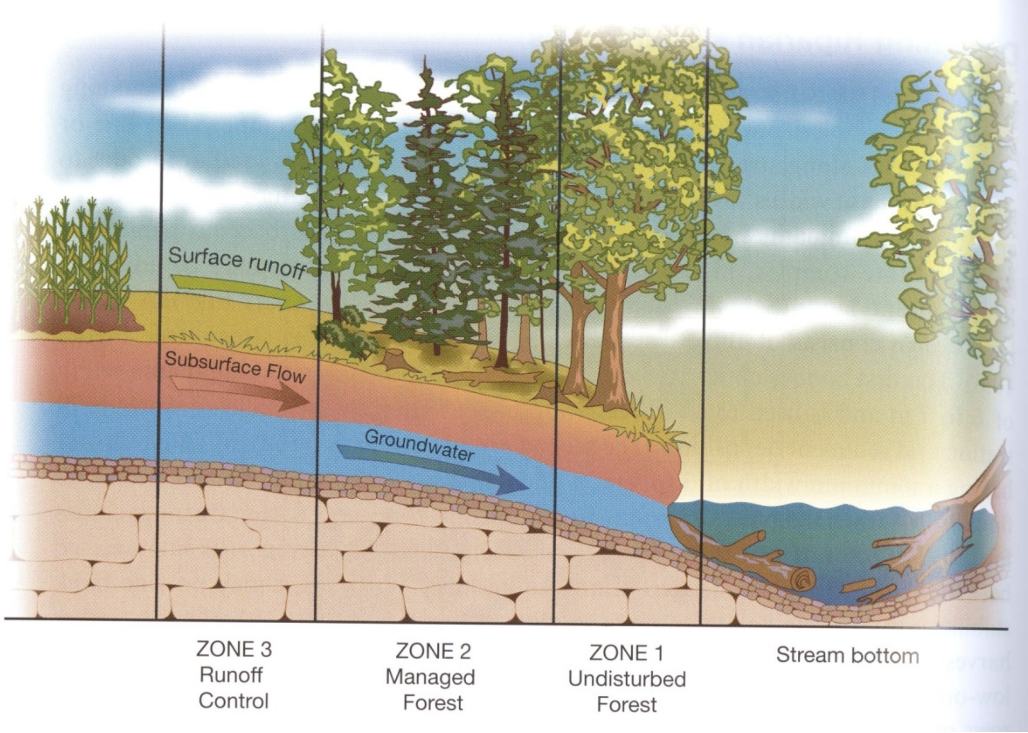
EKOSYSTÉMOVÉ PROCESY

Základní ekosystémové procesy

- water cycle
- mineral cycle
- solar energy flow
- community dynamics (succession)

Joy Livingwell, February 2003

https://managingwholes.com/-ecosystem-processes.htm/

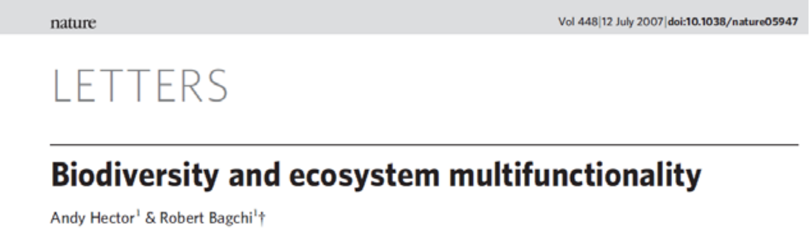


EKOSYSTÉMOVÉ FUNKCE

Ekosystémové funkce jsou biologické, geochemické, fyzikální procesy a součásti, které jsou součástí ekosystému nebo se v něm vyskytují

- v některých přápadech jsou ekosystémové funkce nazývány ekologickými procesy
- ekosystémová funkce „opylení“ je klíčová pro rozmnožování většiny divoce rostoucích rostlin
- tato ekosystémová funkce poskytuje přímý příspěvek do zemědělství ve formě opylení plodin

EKOSYSTÉMOVÉ PROCESY



nature Vol 448|12 July 2007|doi:10.1038/nature05947

LETTERS

Biodiversity and ecosystem multifunctionality

Andy Hector[1] & Robert Bagchi[1]†

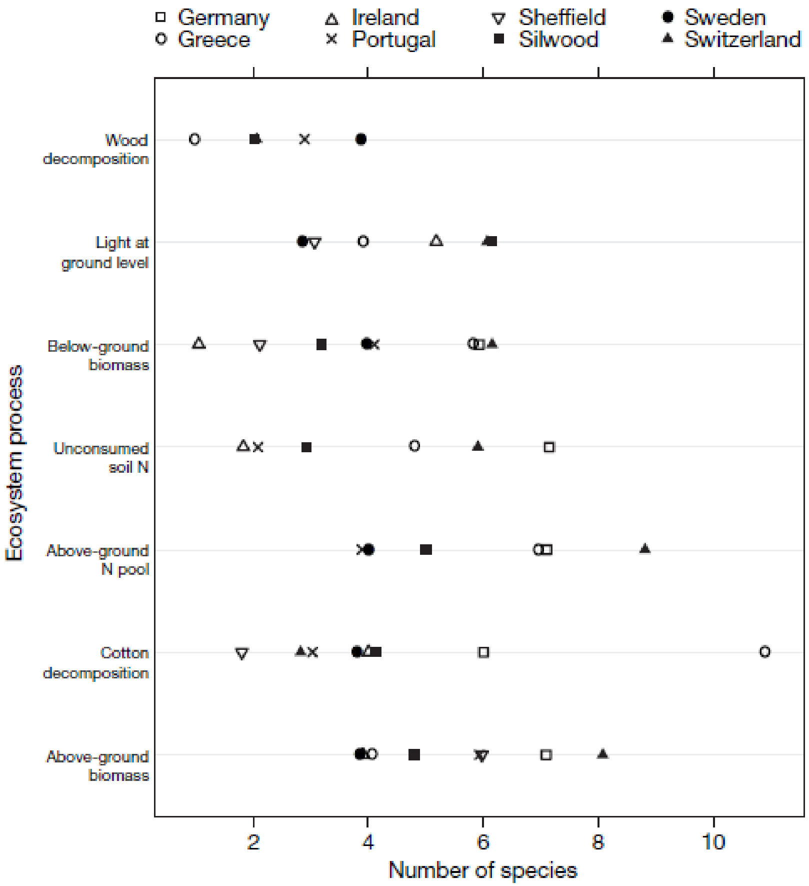
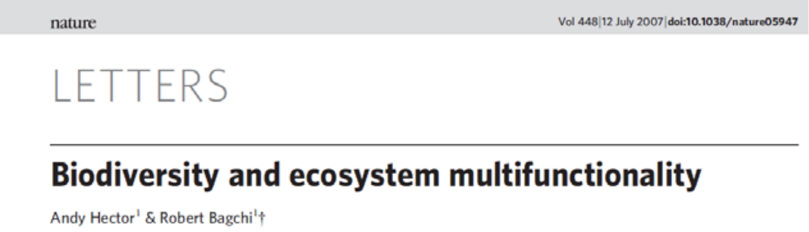


Figure 1 | Number of species with desirable effects on the suite of ecosystem processes measured in the different BIODEPTH project experiments. The number of species was identified by the AIC-based multiple regression (and species with effects with undesirable signs were then excluded).

EKOSYSTÉMOVÉ PROCESY



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LETTERS

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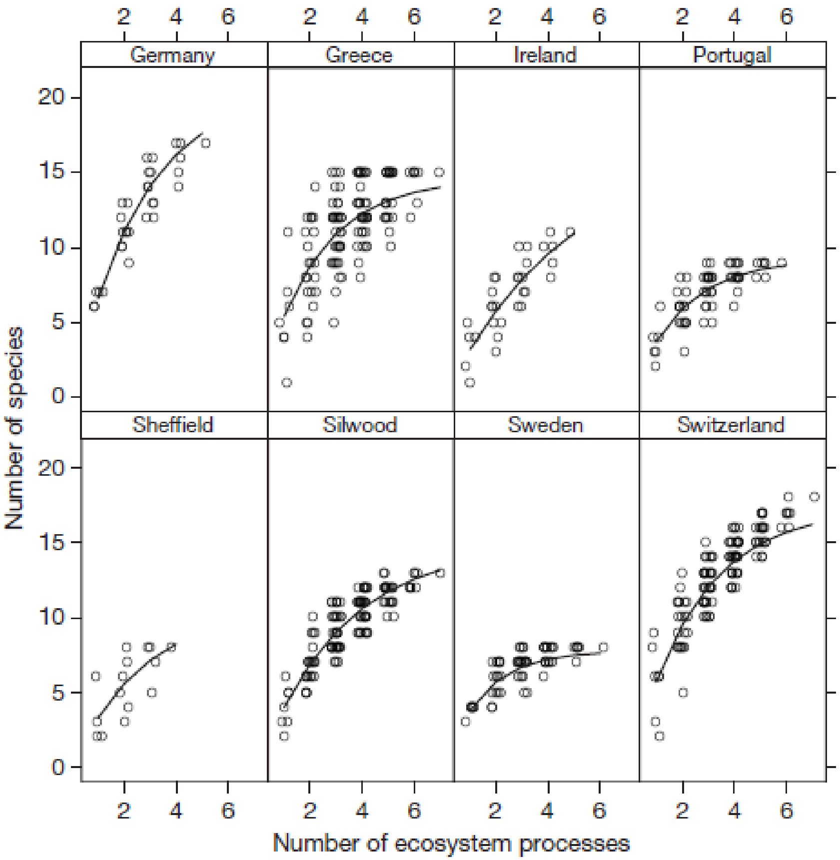


Figure 2 | Positive relationship between the range of ecosystem processes considered and the number of species that affect one or more aspect of ecosystem functioning. The points (jittered for clarity) show numbers of species required for all possible combinations of ecosystem processes. Lines are theoretical predictions from the model based on the average number of species required for a single process, $\bar{x}$, and the average overlap in the sets of species required for each pair of processes, $\bar{o}$, using equation (2).

BIODIVERZITA A PROCESY

EKOLOGICKÁ NIKA

- biodiverzita reaguje na prostředí prostřednictvím ekologických nik jednotlivých druhů
- zjednodušení podmínek prostředí poskytuje menší diverzitu zdrojů
- výsledkem je zjednodušení společenstva z hlediska druhové nebo funkční diverzity
- ekosystémové procesy jsou napojeny převážně prostřednictvím funkční diverzity

FUNKČNÍ BIODIVERZITA

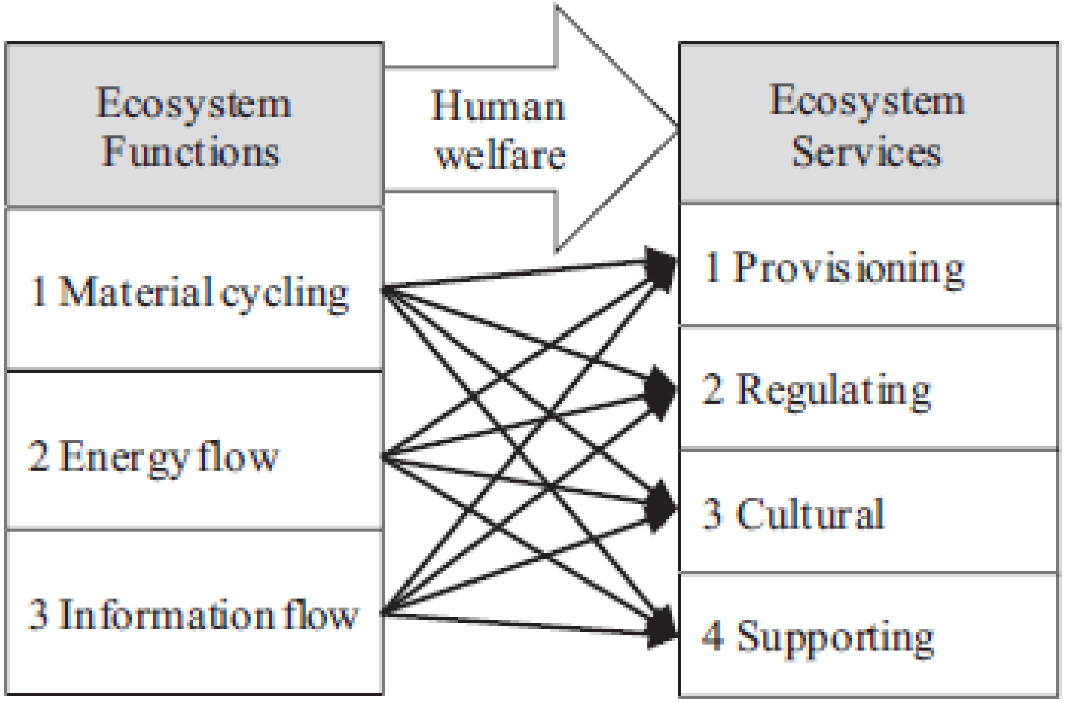
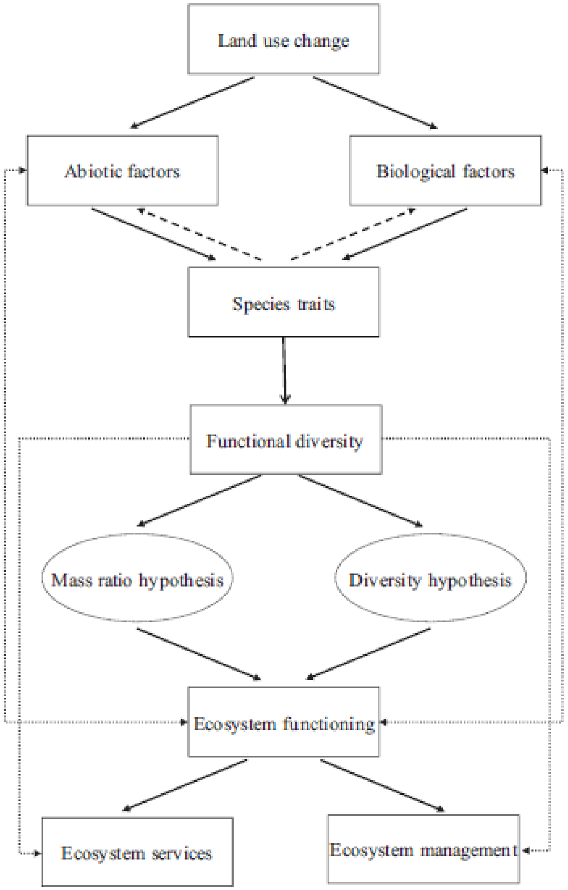


Fig. 1. Relationships between ecosystem functioning and ecosystem services [68]. Ecosystem functioning and services do not necessarily show a one to one correspondence. In some cases a single ecosystem function contributes to two or more ecosystem services whereas in other cases a single ecosystem service is the product of two or more ecosystem functions [55].



Acta Ecologica Sinica 34 (2014) 85–91

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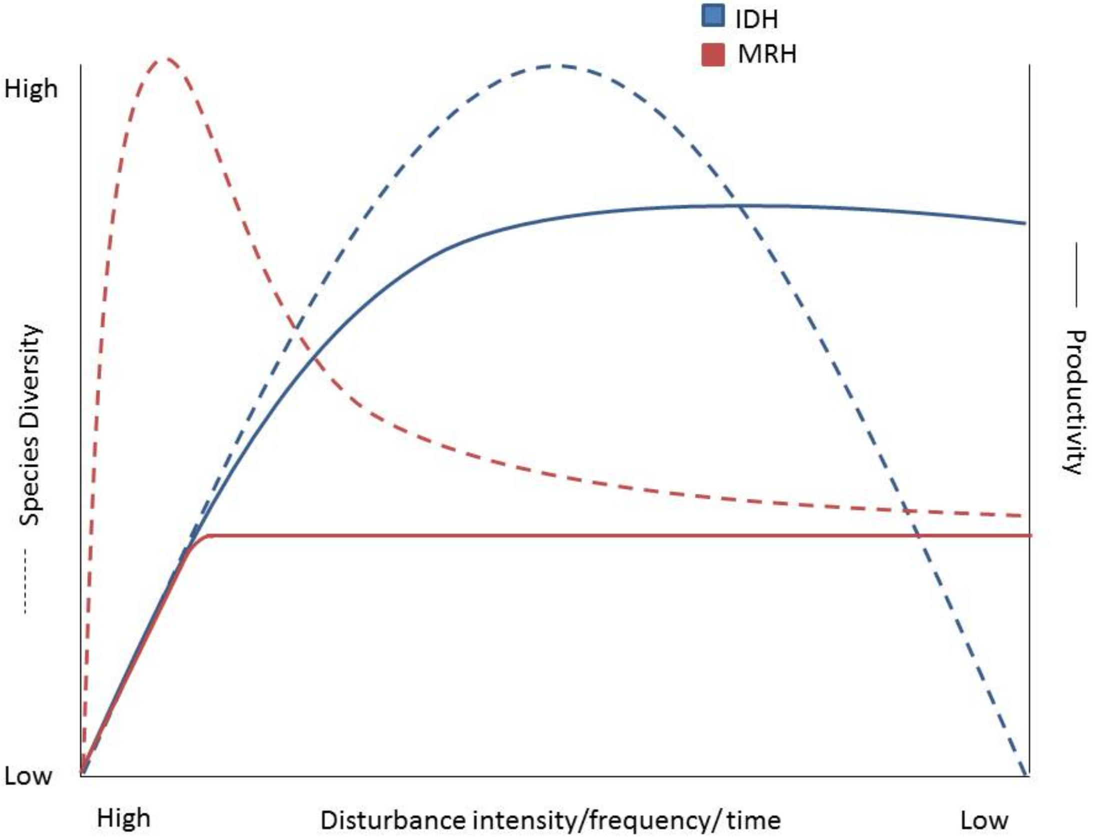
journal homepage: www.elsevier.com/locate/chnaes

Relationships between functional diversity and ecosystem functioning: A review

Yantao Song [a,c], Ping Wang [b], Guangdi Li [a,c], Daowei Zhou [a,*]

FUNKČNÍ BIODIVERZITA

Modified from Kershal and Mallik (2013), theoretical relationships between biomass, species diversity and disturbance according to the Intermediate Disturbance and Mass Ratio Hypotheses.



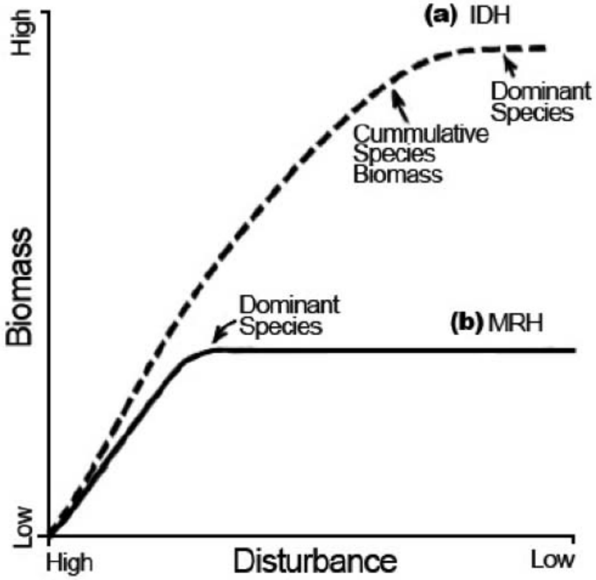


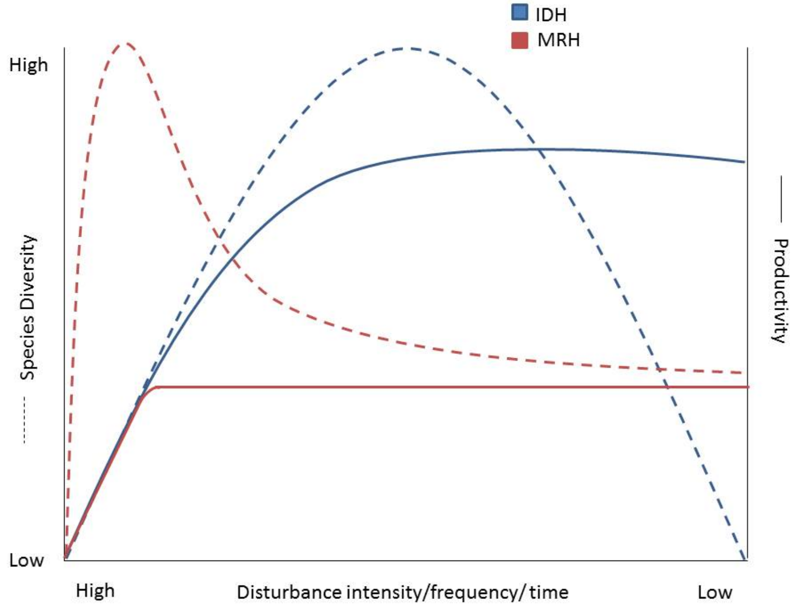
FIG. 2. Predicted relationship between community productivity and disturbance in IDH and MRH. (a) Community productivity (biomass) increases with decreasing disturbance frequency/intensity/time since disturbance until it reaches an equilibrium at climax condition when mostly the long-lived species account for the community biomass, commonly observed in mineral rich productive sites as per IDH. (b) Community productivity (biomass) increases with decreasing disturbance frequency/intensity/time since disturbance until it levels when only a few stress tolerating competitive species achieve dominance and contribute most of the community biomass observed in organic rich, nutrient-poor acidic soil as per MRH.

https://www.biodiverseperspectives.com/2013/08/14/idh-mrh-wtf/

MASS RATIO HYPOTHESIS (MRH)

The Mass Ratio Hypothesis (MRH), on the other hand, proposes that the biological traits of the dominant species contributing to productivity (defined by biomass) are the critical regulators of ecosystem function (Grime, 1998).

MRHis often associated with ecosystems with longer periods between major stand replacing disturbances. It proposes that biodiversity is held lowby the dominance of one or a fewspecies (see right side of the graph, Figure 1b) and that this configuration sustains site productivity

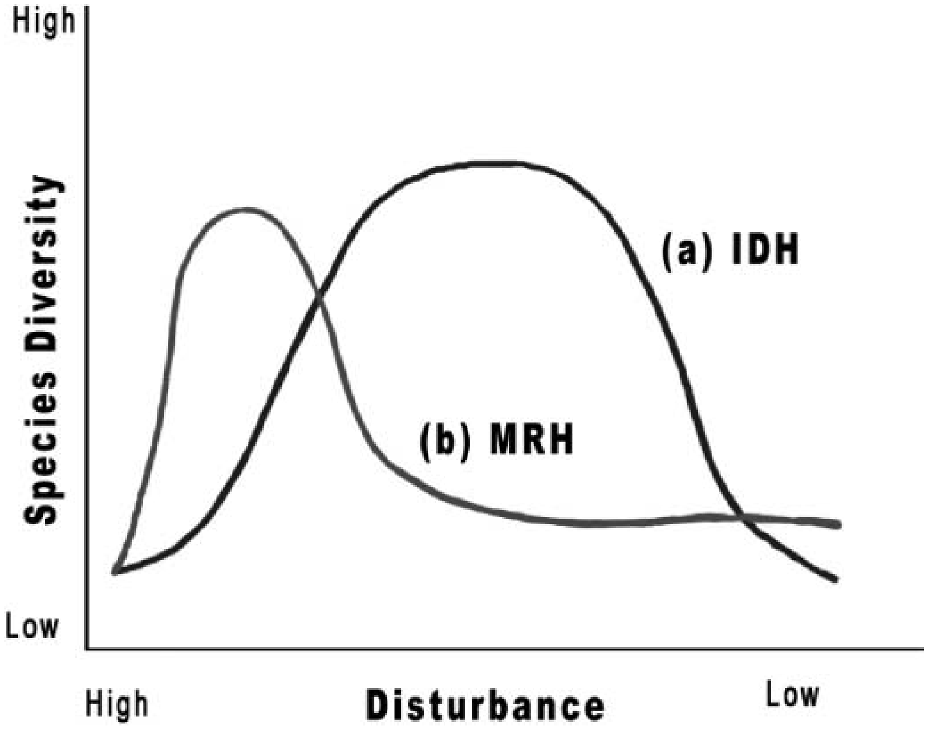


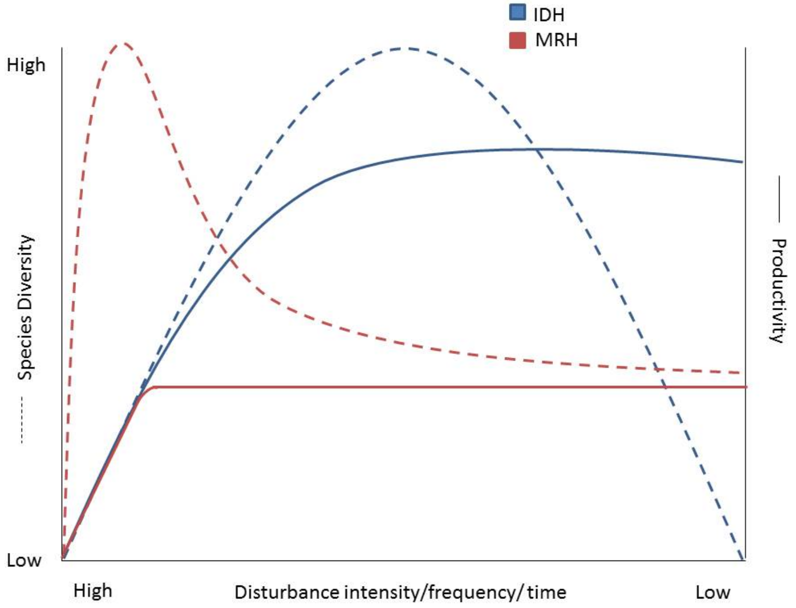
https://www.biodiverseperspectives.com/2013/08/14/idh-mrh-wtf/

INTERMEDIATE DISTURBANCE HYPOTHESIS (IDH)

The IDH (Connell, 1978) proposes that species diversity displays a humpshaped response curve to disturbance, peaking at intermediate disturbance levels.

IDH is portrayed as a cyclic pattern of disturbances in terms of intensity and frequency, describing communities that become less stable with time (as diversity decreases) and more vulnerable to disturbance. It is commonly associated with **fire-driven terrestrial ecosystems** (Mackey and Currie, 2001).





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BIODIVERZITA A PROCESY

CHARAKTERISTIKY DRUHŮ (SPECIES TRAITS)

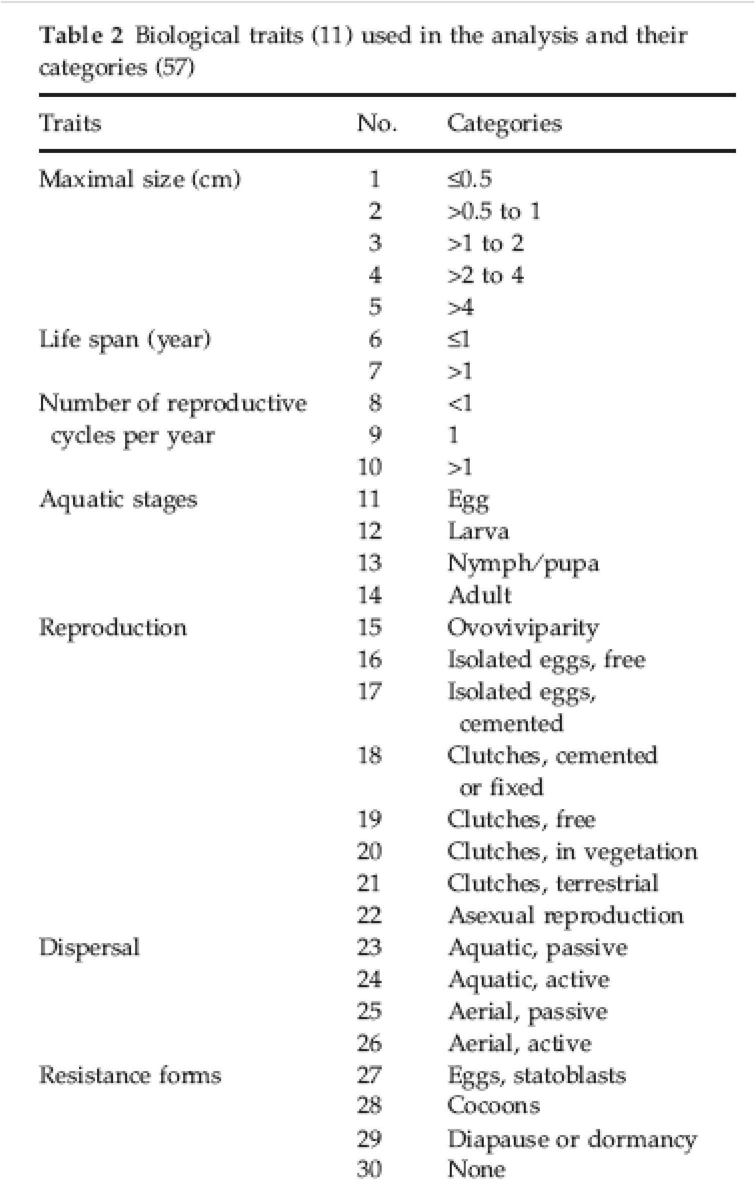
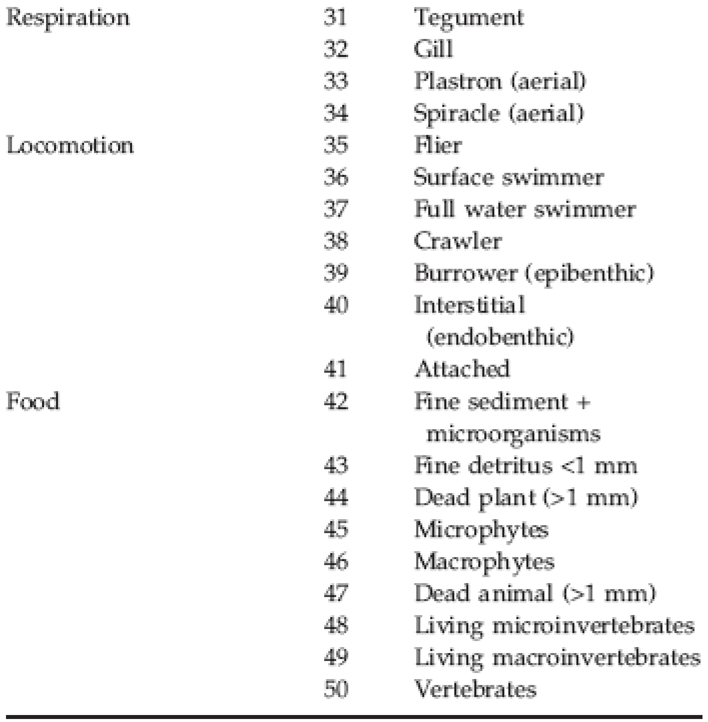
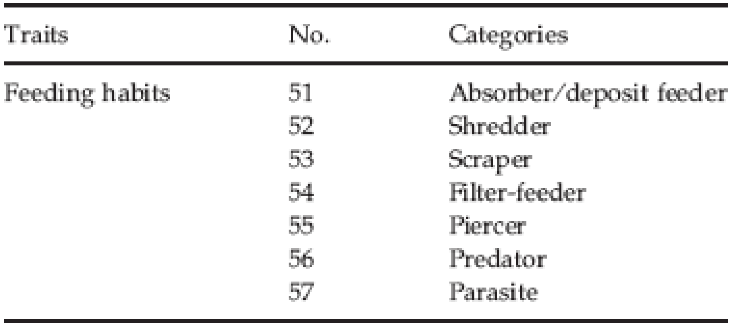



Table 2 Biological traits (11) used in the analysis and their categories (57)

Traits	No.	Categories
Maximal size (cm)	1	≤0.5
	2	>0.5 to 1
	3	>1 to 2
	4	>2 to 4
	5	>4
Life span (year)	6	≤1
	7	>1
Number of reproductive cycles per year	8	<1
	9	1
	10	>1
Aquatic stages	11	Egg
	12	Larva
	13	Nymph/pupa
	14	Adult
Reproduction	15	Ovoviviparity
	16	Isolated eggs, free
	17	Isolated eggs, cemented
	18	Clutches, cemented or fixed
	19	Clutches, free
	20	Clutches, in vegetation
	21	Clutches, terrestrial
	22	Asexual reproduction
Dispersal	23	Aquatic, passive
	24	Aquatic, active
	25	Aerial, passive
	26	Aerial, active
Resistance forms	27	Eggs, statoblasts
	28	Cocoons
	29	Diapause or dormancy
	30	None
Respiration	31	Tegument
	32	Gill
	33	Plastron (aerial)
	34	Spiracle (aerial)
Locomotion	35	Flier
	36	Surface swimmer
	37	Full water swimmer
	38	Crawler
	39	Burrower (epibenthic)
	40	Interstitial (endobenthic)
	41	Attached
Food	42	Fine sediment + microorganisms
	43	Fine detritus <1 mm
	44	Dead plant (>1 mm)
	45	Microphytes
	46	Macrophytes
	47	Dead animal (>1 mm)
	48	Living microinvertebrates
	49	Living macroinvertebrates
	50	Vertebrates



Traits	No.	Categories
Feeding habits	51	Absorber/deposit feeder
	52	Shredder
	53	Scraper
	54	Filter-feeder
	55	Piercer
	56	Predator
	57	Parasite

Archaimbault et al., 2010

BIODIVERZITA A PROCESY

CHARAKTERISTIKY DRUHŮ (SPECIES TRAITS)

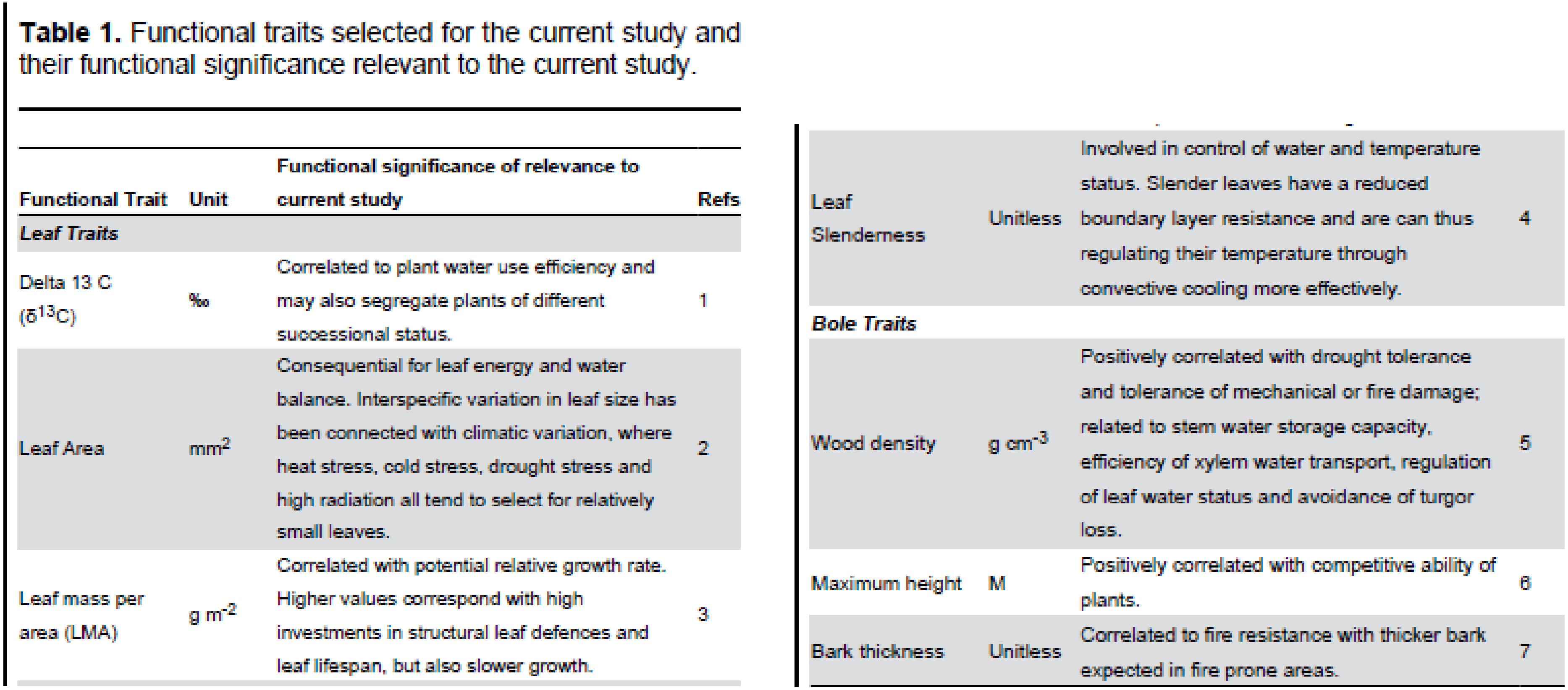
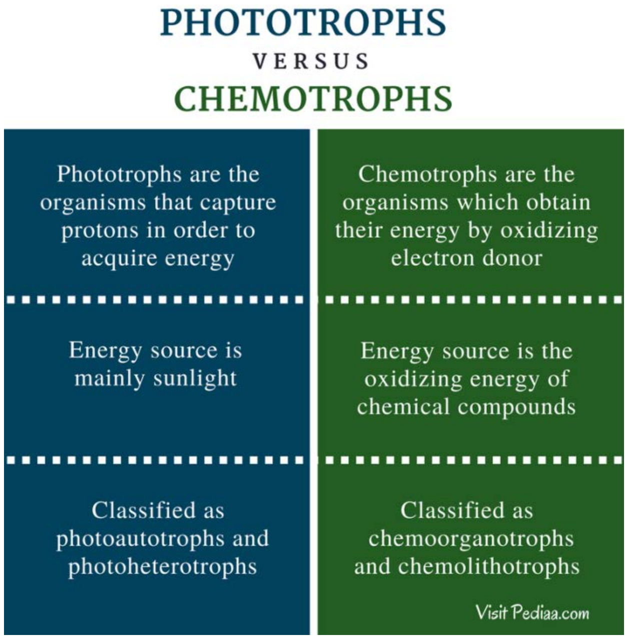


Table 1. Functional traits selected for the current study and their functional significance relevant to the current study.

Functional Trait	Unit	Functional significance of relevance to current study	Refs
Leaf Traits			
Delta 13 C ($\delta^{13}C$)	‰	Correlated to plant water use efficiency and may also segregate plants of different successional status.	1
Leaf Area	mm^2	Consequential for leaf energy and water balance. Interspecific variation in leaf size has been connected with climatic variation, where heat stress, cold stress, drought stress and high radiation all tend to select for relatively small leaves.	2
Leaf mass per area (LMA)	$g\ m^{-2}$	Correlated with potential relative growth rate. Higher values correspond with high investments in structural leaf defences and leaf lifespan, but also slower growth.	3
Leaf Slenderness	Unitless	Involved in control of water and temperature status. Slender leaves have a reduced boundary layer resistance and are can thus regulating their temperature through convective cooling more effectively.	4
Bole Traits			
Wood density	$g\ cm^{-3}$	Positively correlated with drought tolerance and tolerance of mechanical or fire damage; related to stem water storage capacity, efficiency of xylem water transport, regulation of leaf water status and avoidance of turgor loss.	5
Maximum height	M	Positively correlated with competitive ability of plants.	6
Bark thickness	Unitless	Correlated to fire resistance with thicker bark expected in fire prone areas.	7

PRIMÁRNÍ PRODUKCE

- vznik organické hmoty
- zdrojem energie sluneční záření (fotosyntéza) nebo chemotrofií
- ecosystém s větší diverzitou může ukládat více uhlíku jako výsledek zvýšených vstupů z fotosyntézy
- nejen organická hmota vzniklá aktivitou primárních producentů, ale i její rozklad a zapojení do dalších procesů ekosystému



PHOTOTROPHS
VERSUS
CHEMOTROPHS

PHOTOTROPHS	CHEMOTROPHS
Phototrophs are the organisms that capture protons in order to acquire energy	Chemotrophs are the organisms which obtain their energy by oxidizing electron donor
Energy source is mainly sunlight	Energy source is the oxidizing energy of chemical compounds
Classified as photoautotrophs and photoheterotrophs	Classified as chemoorganotrophs and chemolithotrophs

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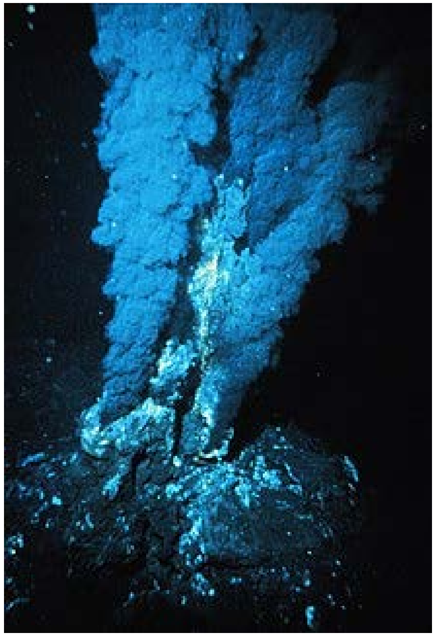
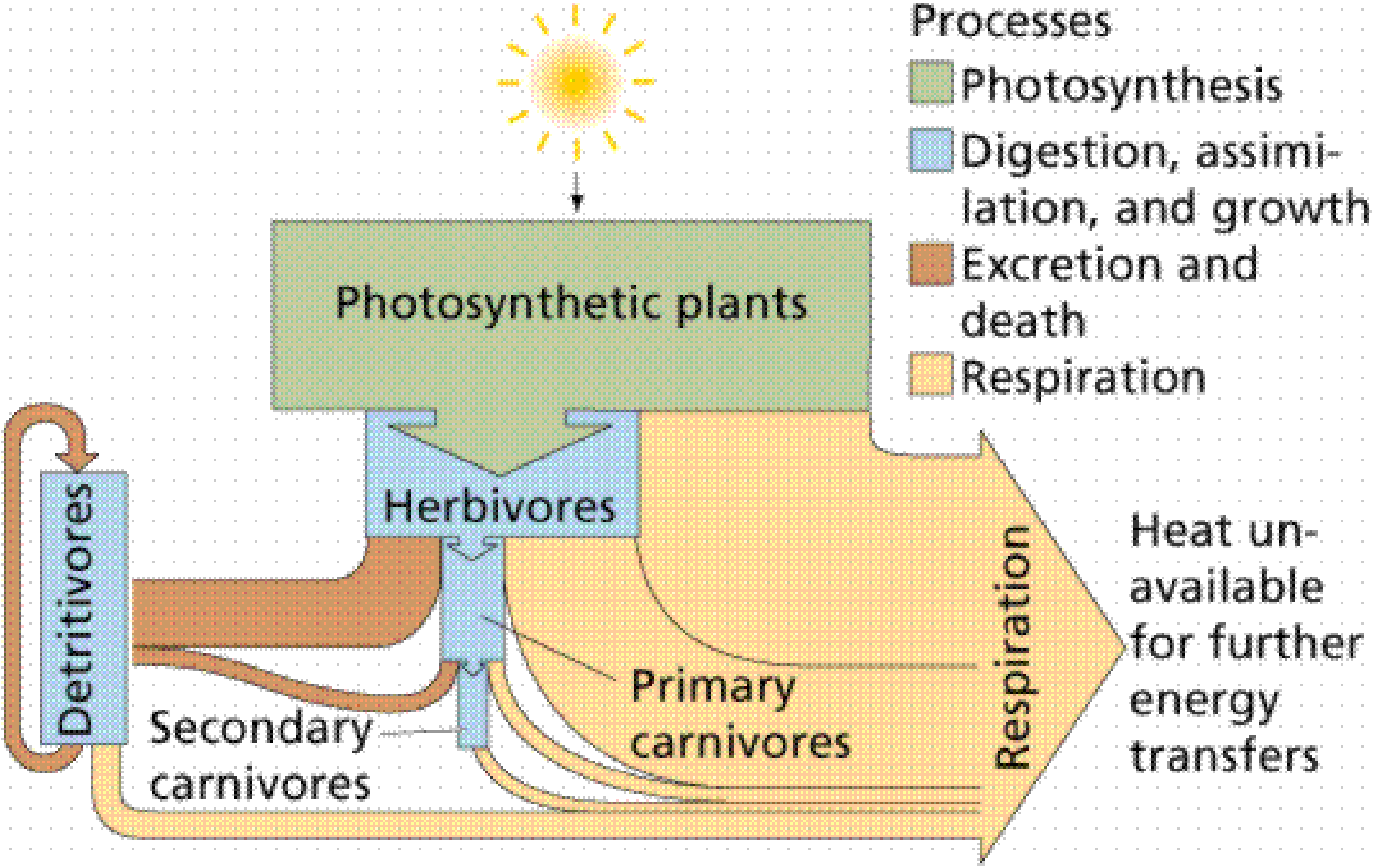


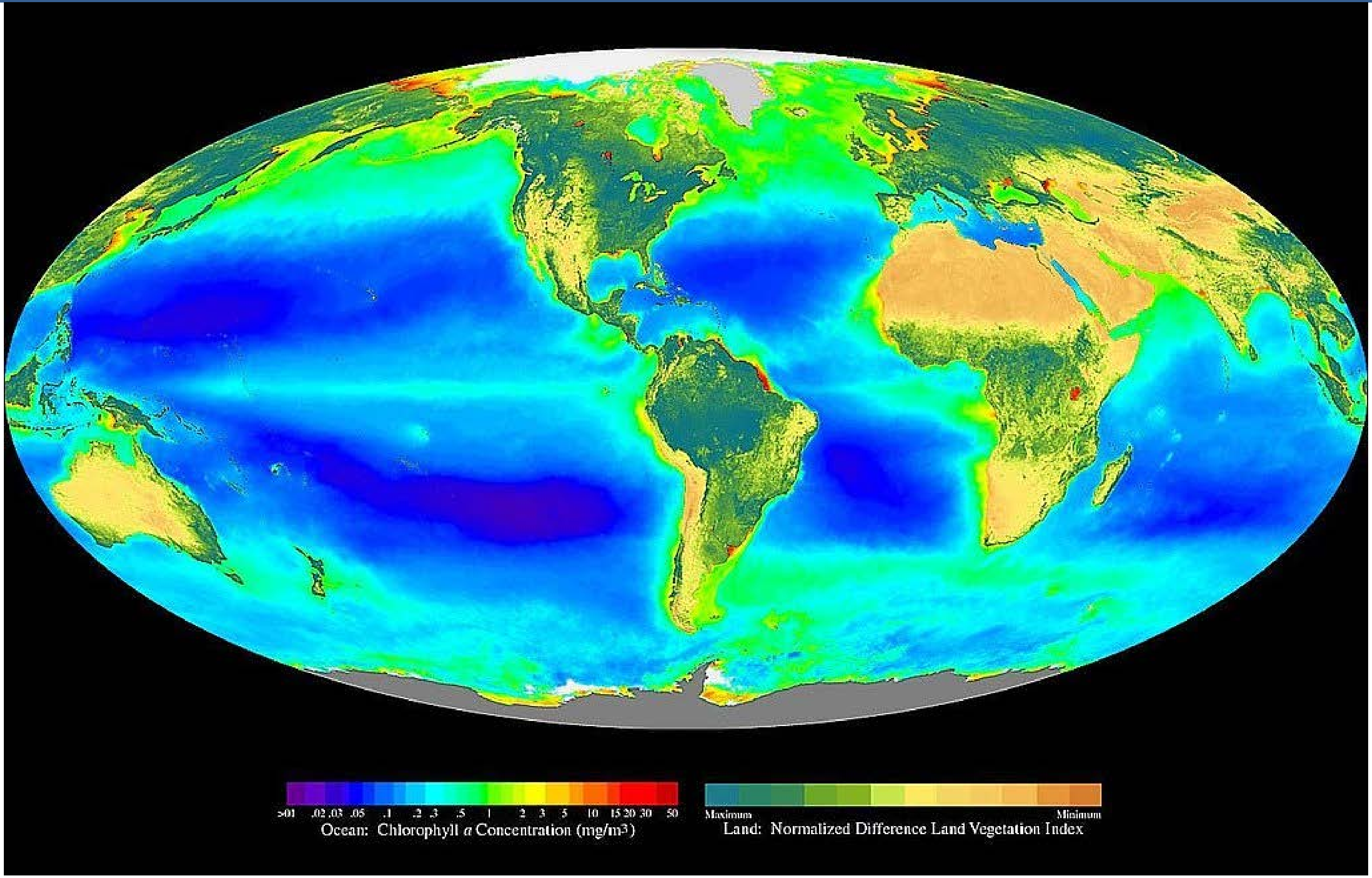
https://en.wikipedia.org/wiki/Chemotroph#/media/File:Blacksmoker_in_Atlantic_Ocean.jpg

PRIMÁRNÍ PRODUKCE



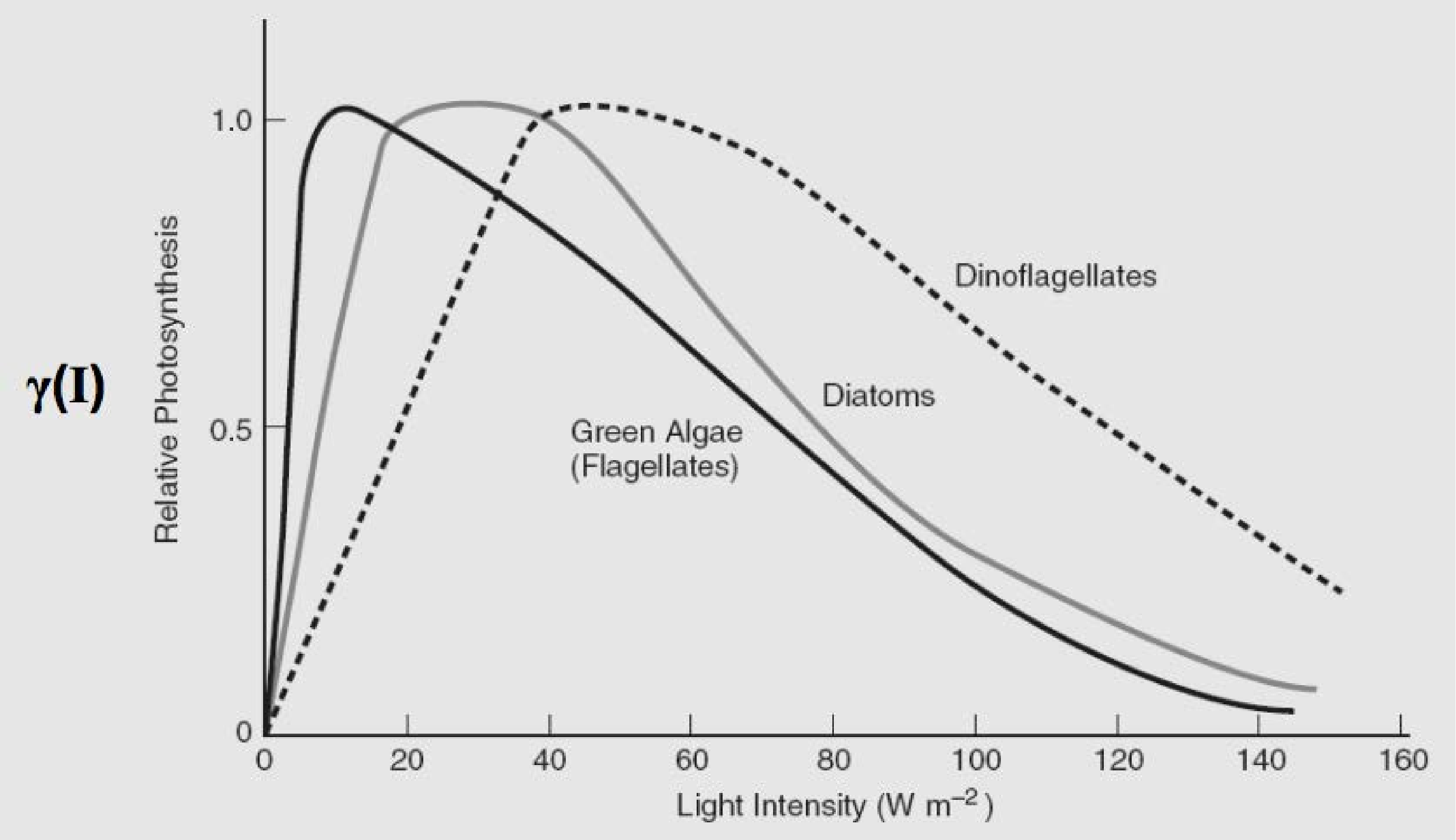
The flow of energy through an ecosystem. Image from Purves et al., Life: The Science of Biology, 4th Edition, by Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com)

PRIMÁRNÍ PRODUKCE



Global oceanic and terrestrial photoautotroph abundance, from September 1997 to August 2000. As an estimate of autotroph biomass, it is only a rough indicator of primary-production potential, and not an actual estimate of it. Provided by the SeaWiFS Project, NASA/Goddard Space Flight Center and ORBIMAGE.

PRIMÁRNÍ PRODUKCE



https://upload.wikimedia.org/wikipedia/commons/7/75/Phytoplankton_Intensity.png

ROZKLAD ORGANICKÉ HMOTY (DECOMPOSITION)

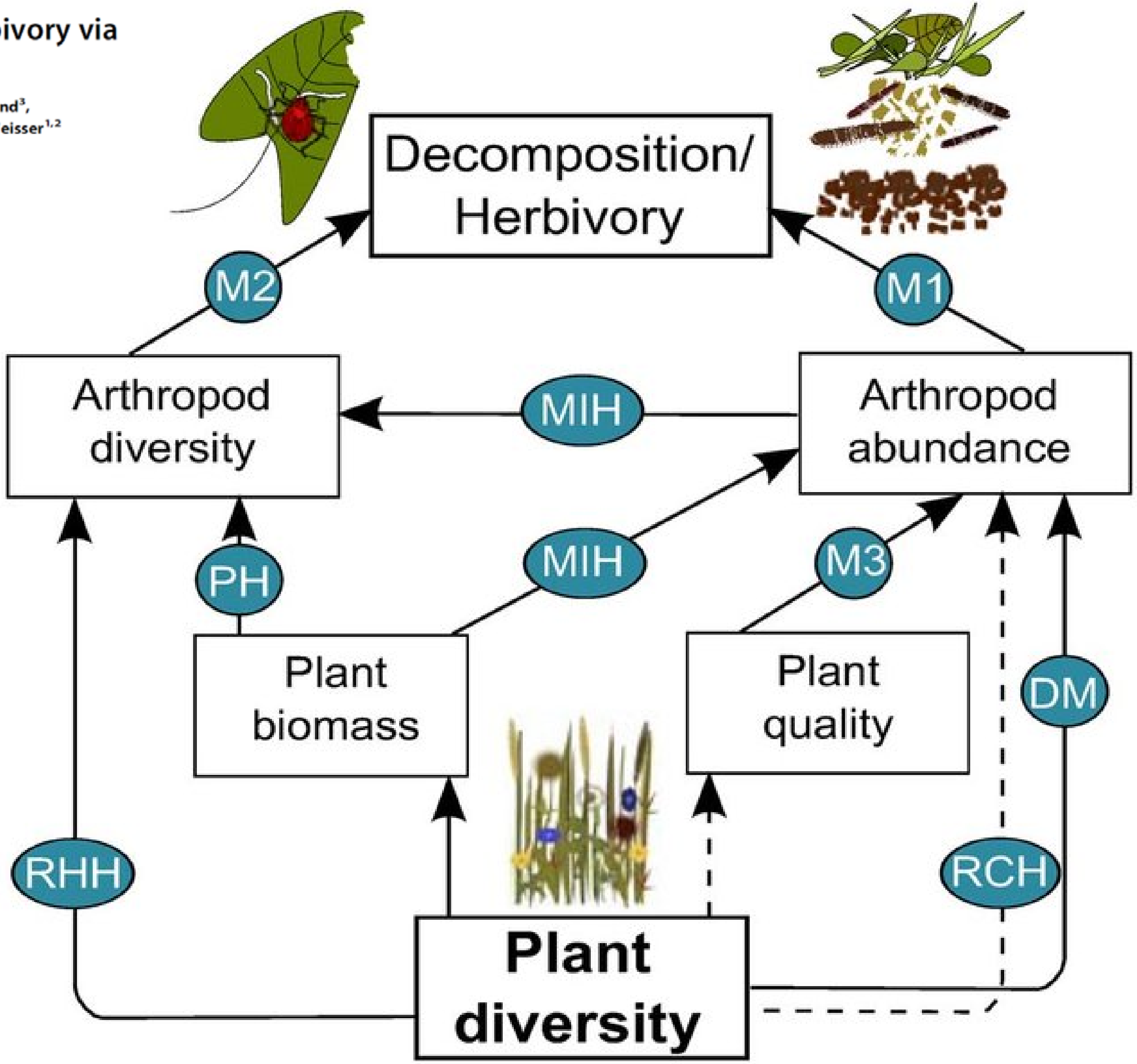
OPEN ACCESS Freely available online

PLOS | ONE

Plant Diversity Impacts Decomposition and Herbivory via Changes in Aboveground Arthropods

Anne Ebeling[1*], Sebastian T. Meyer[2], Maike Abbas[3], Nico Eisenhauer[1], Helmut Hillebrand[3], Markus Lange[4], Christoph Scherber[5], Anja Vogel[1], Alexandra Weigelt[6], Wolfgang W. Weisser[1,2]

DM=Dietary Mixing
RCH=Resource Concentration Hypothesis
RHH=Resource Heterogeneity Hypothesis
MIH=More Individuals Hypothesis
PH=Productivity Hypothesis



Decomposition/ Herbivory

M2

M1

Arthropod diversity

MIH

Arthropod abundance

PH

MIH

M3

Plant biomass

Plant quality

DM

RHH

RCH

Plant diversity

ROZKLAD ORGANICKÉ HMOTY (DECOMPOSITION)

Resource concentration hypothesis (Root 1973)

- specialisté z řad herbivorního hmyzu by měli být početnější na větších ploškách hostitelských rostlin, protože hmyz má větší pravděpodobnost nálezu a delšího setrvání na těchto větších ploškách

ROZKLAD ORGANICKÉ HMOTY (DECOMPOSITION)

MIH and **PH** předpokládají pozitivní vztah mezi biomasou rostlin a diverzitou konzumentů, liší se ovšem mechanismy na kterých jsou založeny

More Individuals Hypothesis (MIH)

- se vztahuje ke společenstvům, která jsou limitována v produktivitě
- predikuje vyšší abundance konzumentů na produktivnějších místech, stejně jako zvyšující se diverzitu konzumentů v závislosti na abundanci

Productivity Hypothesis (PH)

- vyšší celková úroveň zdrojů ve formě různorodých rostlinných společenstev přímo přitahuje více druhů konzumentů-generalistů

Resource Concentration Hypothesis (RCH)

- předpokládá nižší abundance specializovaných herbivorních škůdců ve více různorodých habitatech, což souvisí s nižšími denzitami hostitelských rostlin

Dietary Mixing (DM)

- pro herbivorní generalisty (např. sarančata) schopnost kombinovat různé zdroje potravy k dosažení optimální kombinace živin nebo k naředění toxinů může zvýšit jejich zdatnost a následně i abundanci. Projeví se pozitivní vztah mezi diverzitou rostlin a abundanci členovců

Resource Heterogeneity Hypothesis (RHH)

- predikuje, že díky vyššímu počtu různých potravních zdrojů souvisejícímu s narůstající diverzitou rostlin, se zvyšuje druhová bohatost konzumentů-specialistů

ROZKLAD ORGANICKÉ HMOTY (DECOMPOSITION)

DECOMPOSITION

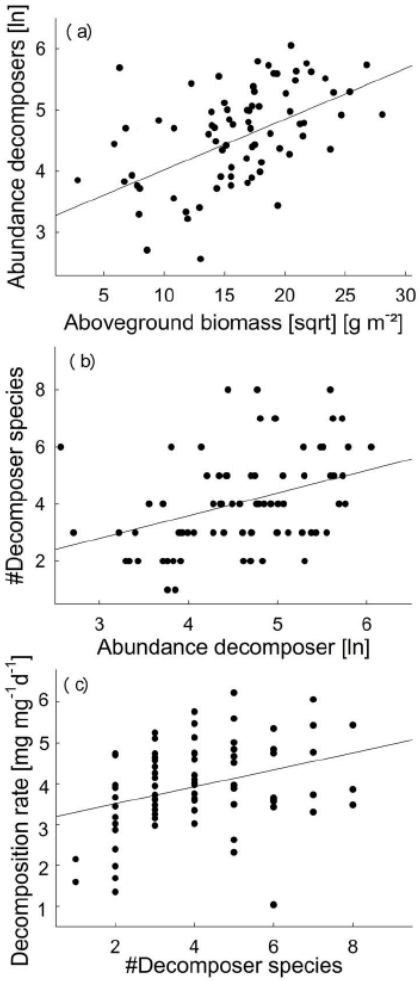


Figure 3. Pairwise correlations visualizing the significant links detected in the path analysis relating plants, decomposers and decomposition. We show the relationships between aboveground plant biomass and decomposer abundances (a), between decomposer abundances and their species richness (b) and decomposer species richness and decomposition (c). For statistics, see Table S2.
doi:10.1371/journal.pone.0106529.g003

HERBIVORY

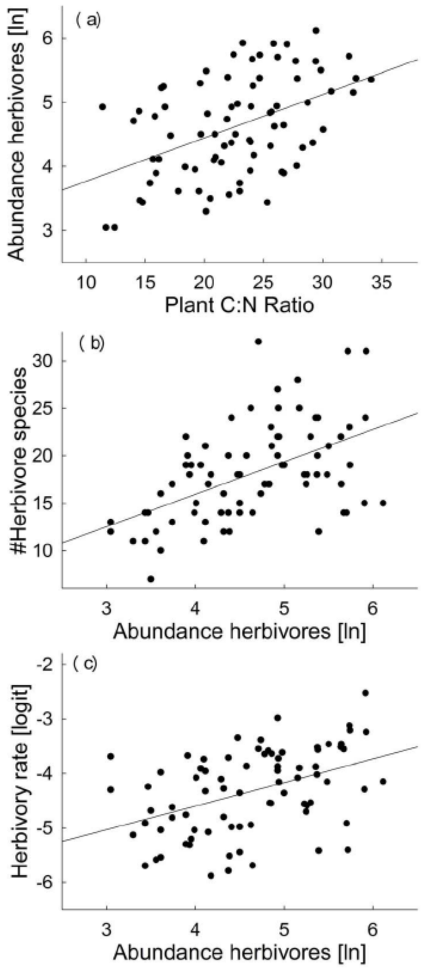


Figure 4. Pairwise correlations visualizing the significant links detected in the path analysis relating plants, herbivores and herbivory. We show the relationships between plant C:N ratio and herbivore abundance (a), herbivore species richness and their abundance (b), and between herbivore abundance and herbivory rate (c). For statistics, see Table S4.
doi:10.1371/journal.pone.0106529.g004

ROZKLAD ORGANICKÉ HMOTY (DECOMPOSITION)

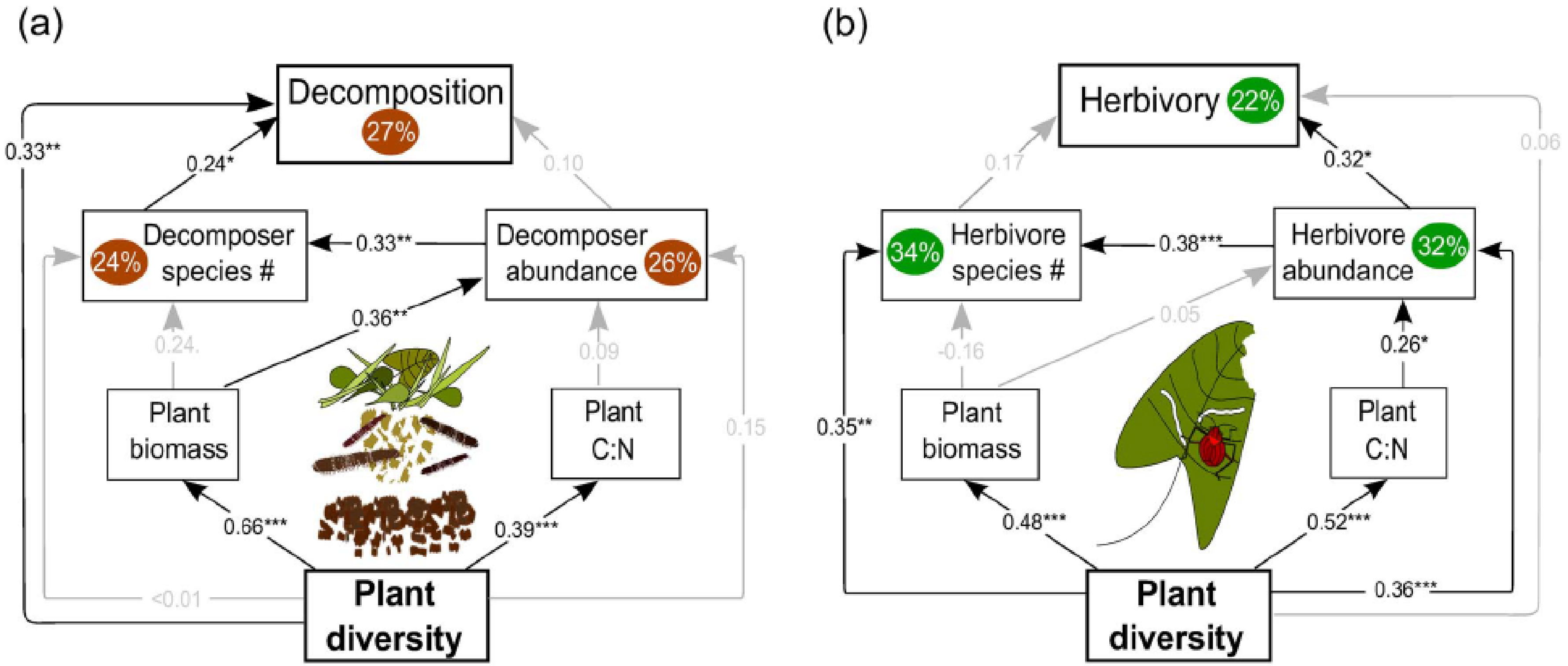


Figure 2. Path diagram explaining plant community effects on decomposition and herbivory. Models relate plant community variables (diversity, quantity and quality), species richness and abundance of (a) decomposer arthropods to decomposition, and (b) herbivorous insects to herbivory. Standardised path coefficients are given on top of the path arrows with significances indicated by *, $P<0.05$; **, $P<0.01$; ***, $P<0.001$. Non-significant paths are given in grey.

doi:10.1371/journal.pone.0106529.g002

ROZKLAD ORGANICKÉ HMOTY (DECOMPOSITION)

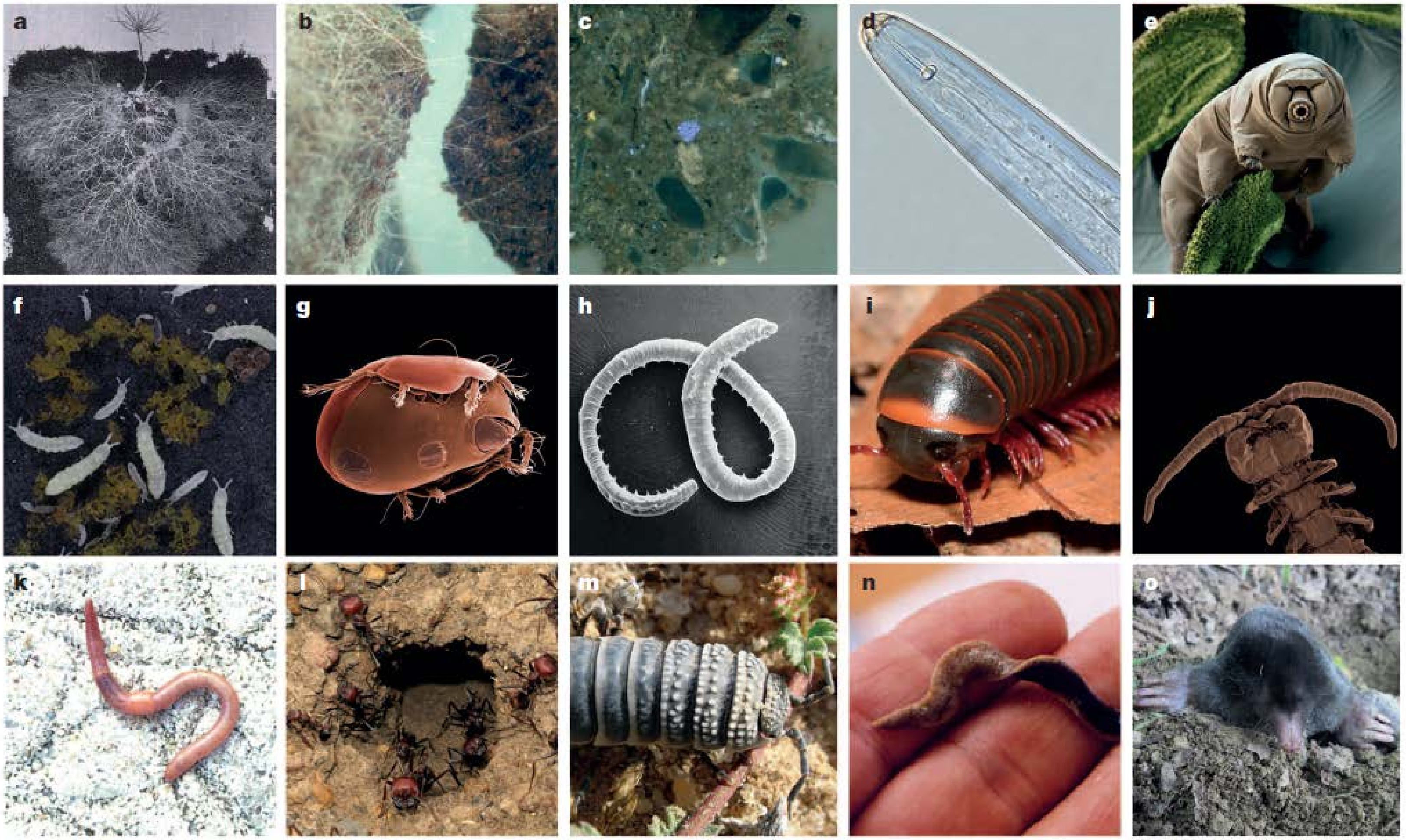
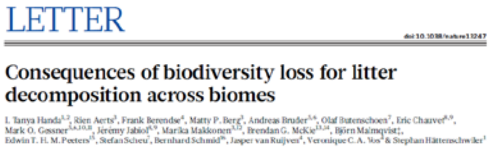


Figure 1 | A selection of organisms of the soil food web. a–o, The selection of organisms includes ectomycorrhizal (a) and decomposer fungi (b), bacteria (c), nematode (d), tardigrade (e), collembolan (f), mite (g), enchytraeid worm (h), millipede (i), centipede (j), earthworm (k), ants (l), woodlice (m), flatworm (n) and mole (o). All photographs are from the European Soil Biodiversity Atlas, courtesy of A. Jones; individual photo credits are: K. Ritz (b, c); H. van Wijnen (d); Water bear in moss, Eye of Science/Science Photo Library (e); P. Henning Krog (f); D. Walter (g); J. Rombke (h); J. Mourek (i, j); D. Cluzeau (k); European Soil Biodiversity Atlas, Joint Research Centre (l, n); S Taiti (m); and H. Atter (o).

ROZKLAD ORGANICKÉ HMOTY (DECOMPOSITION)



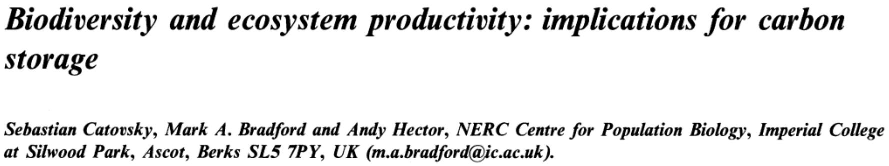
LETTER

doi:10.1038/nature13247

Consequences of biodiversity loss for litter decomposition across biomes

I. Tanya Handa[1,2], Rien Aerts[3], Frank Berendse[4], Matty P. Berg[3], Andreas Bruder[5,6], Olaf Butenschoen[7], Eric Chauvet[8,9], Mark O. Gessner[5,6,10,11], Jérémy Jabiol[8,9], Marika Makkonen[3,12], Brendan G. McKie[13,14], Björn Malmqvist†, Edwin T. H. M. Peeters[15], Stefan Scheu[7], Bernhard Schmid[16], Jasper van Ruijven[4], Veronique C. A. Vos[4] & Stephan Hättenschwiler[1]

- smíchání opadu z různých funkčních typů rostlin se projevilo ve zvýšené dynamice uhlíku a dusíku



Biodiversity and ecosystem productivity: implications for carbon storage

Sebastian Catovsky, Mark A. Bradford and Andy Hector, NERC Centre for Population Biology, Imperial College at Silwood Park, Ascot, Berks SL5 7PY, UK (m.a.bradford@ic.ac.uk).

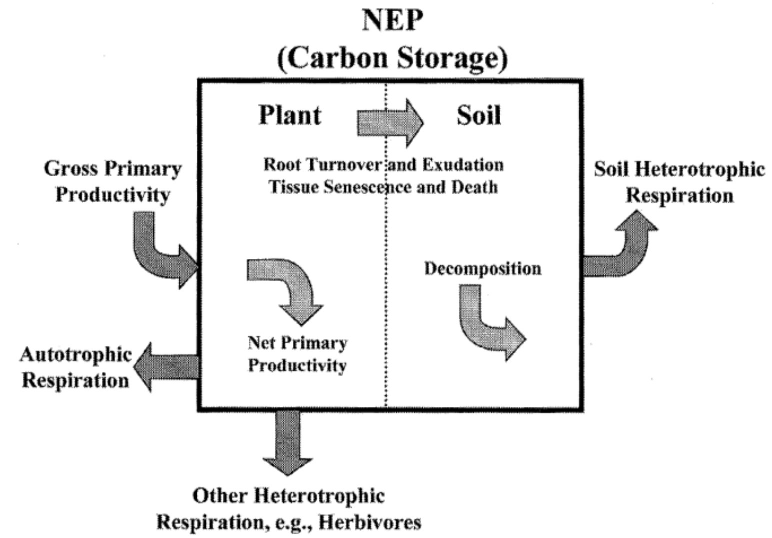


Fig. 1. Conceptual model showing the main biological components of ecosystem carbon budgets.

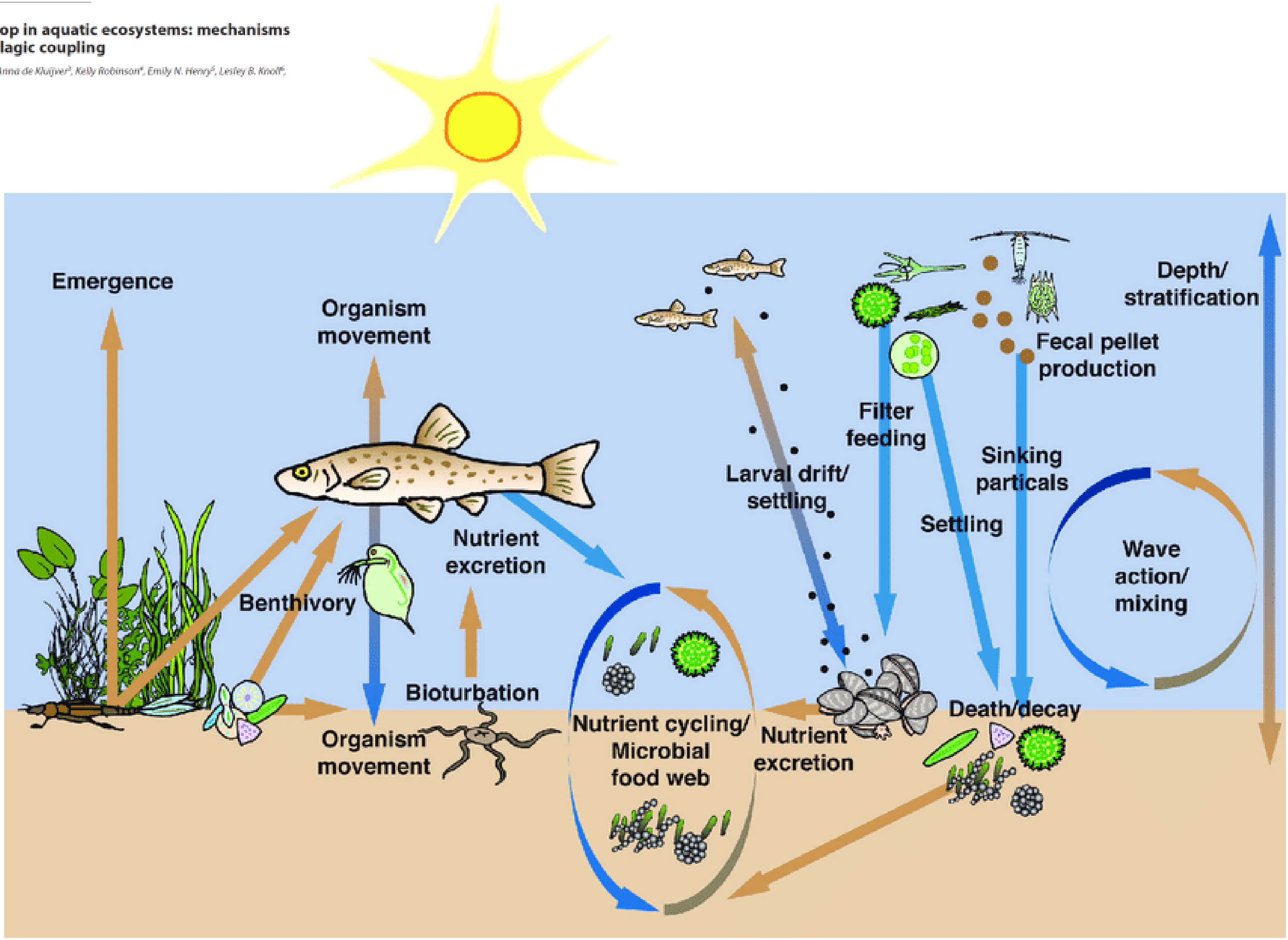
OIKOS 97:3 (2002)

KOLOBĚH ŽIVIN

Eco-DAS X
Symposium Proceedings

Linking the bottom to the top in aquatic ecosystems: mechanisms and stressors of benthic-pelagic coupling

Melissa M. Baustian[1], Gretchen J. A. Hansen[2], Anna de Kluijver[3], Kelly Robinson[4], Emily N. Henry[5], Lesley B. Knoll[6], Kevin C. Rose[7], and Cayelan C. Carey[8]*



KOLOBĚH ŽIVIN

Eco-DAS X
Symposium Proceedings

Eco-DAS X Chapter 4, 2014, 38–60
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Linking the bottom to the top in aquatic ecosystems: mechanisms and stressors of benthic-pelagic coupling

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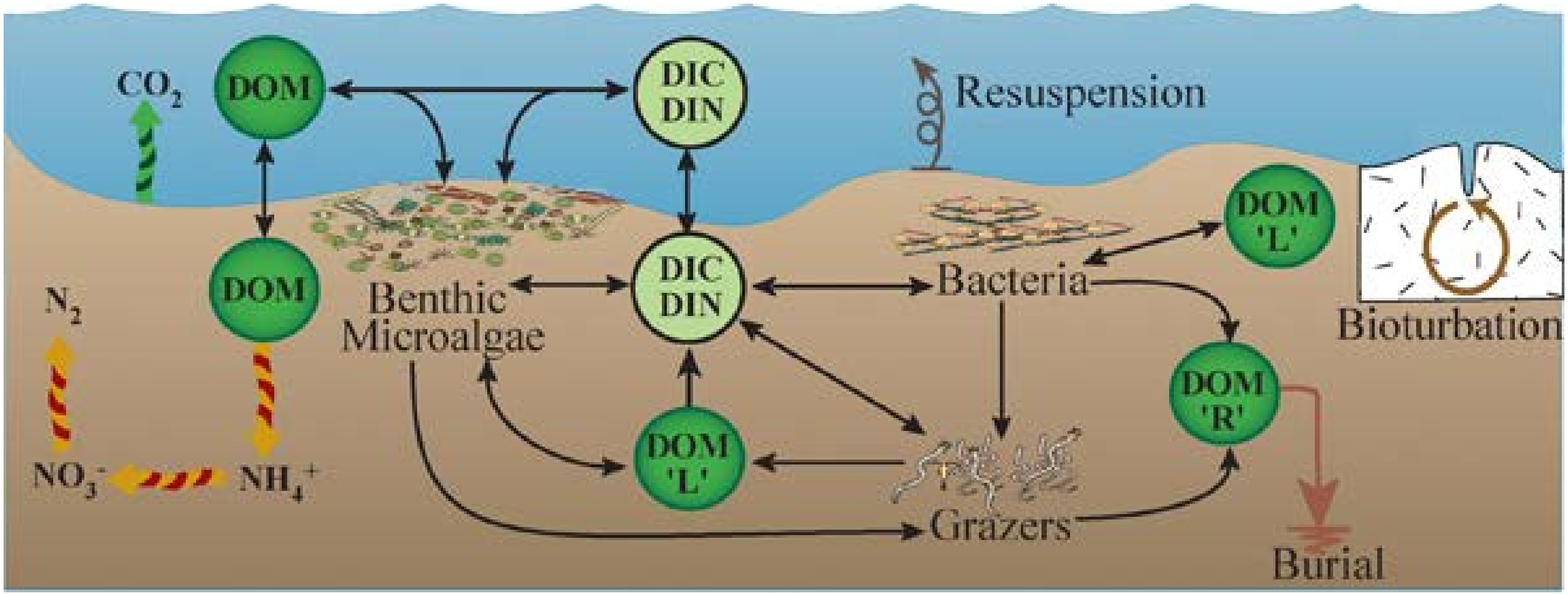
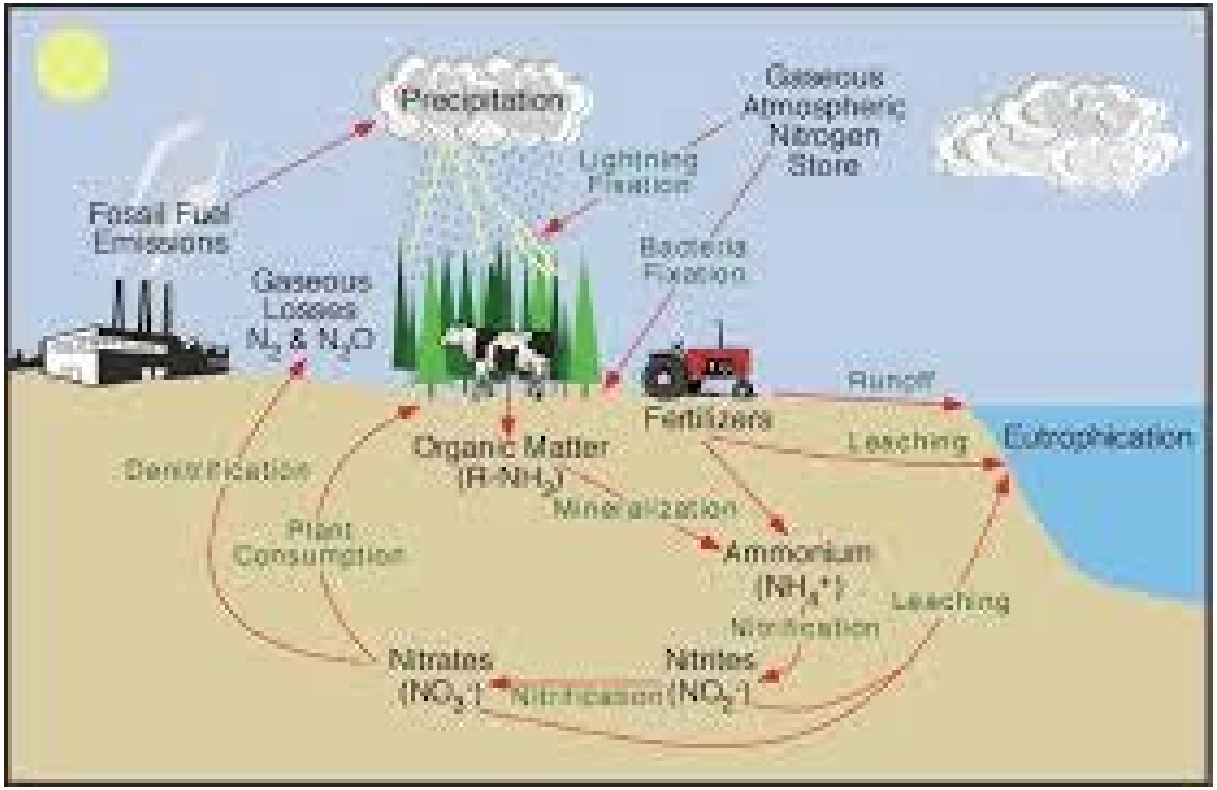


KOLOBĚH ŽIVIN

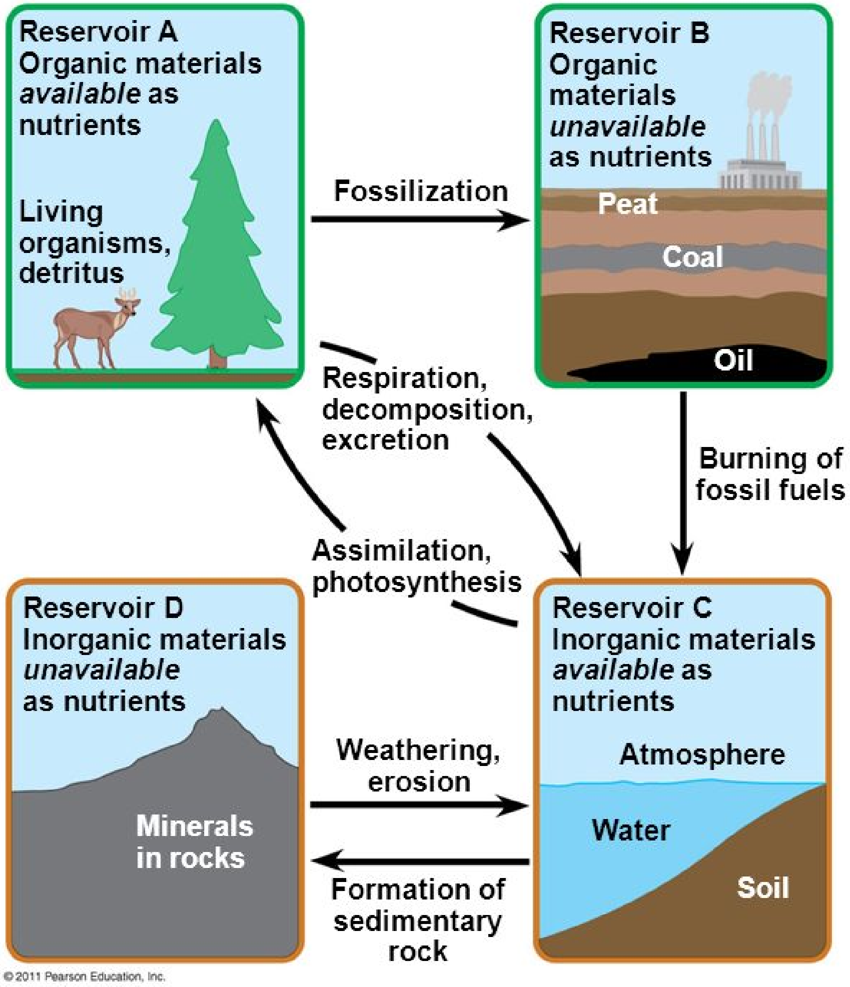


http://www.geocities.ws/jacklynn/website/pro.html

KOLOBĚH ŽIVIN

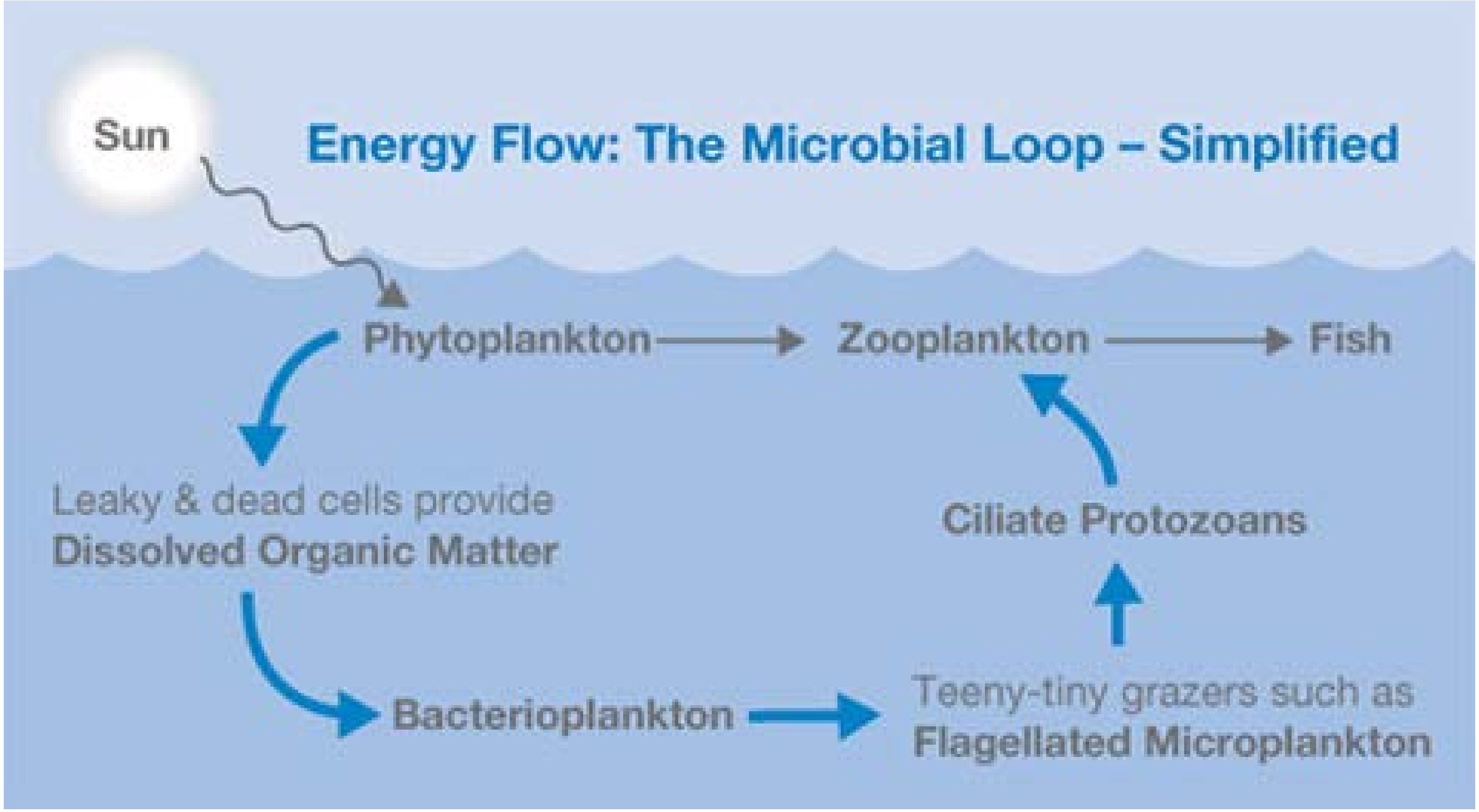
Figure 55.13

A general model of nutrient cycling.



KOLOBĚH ŽIVIN

EKOSYSTÉMY STOJATÝCH VOD



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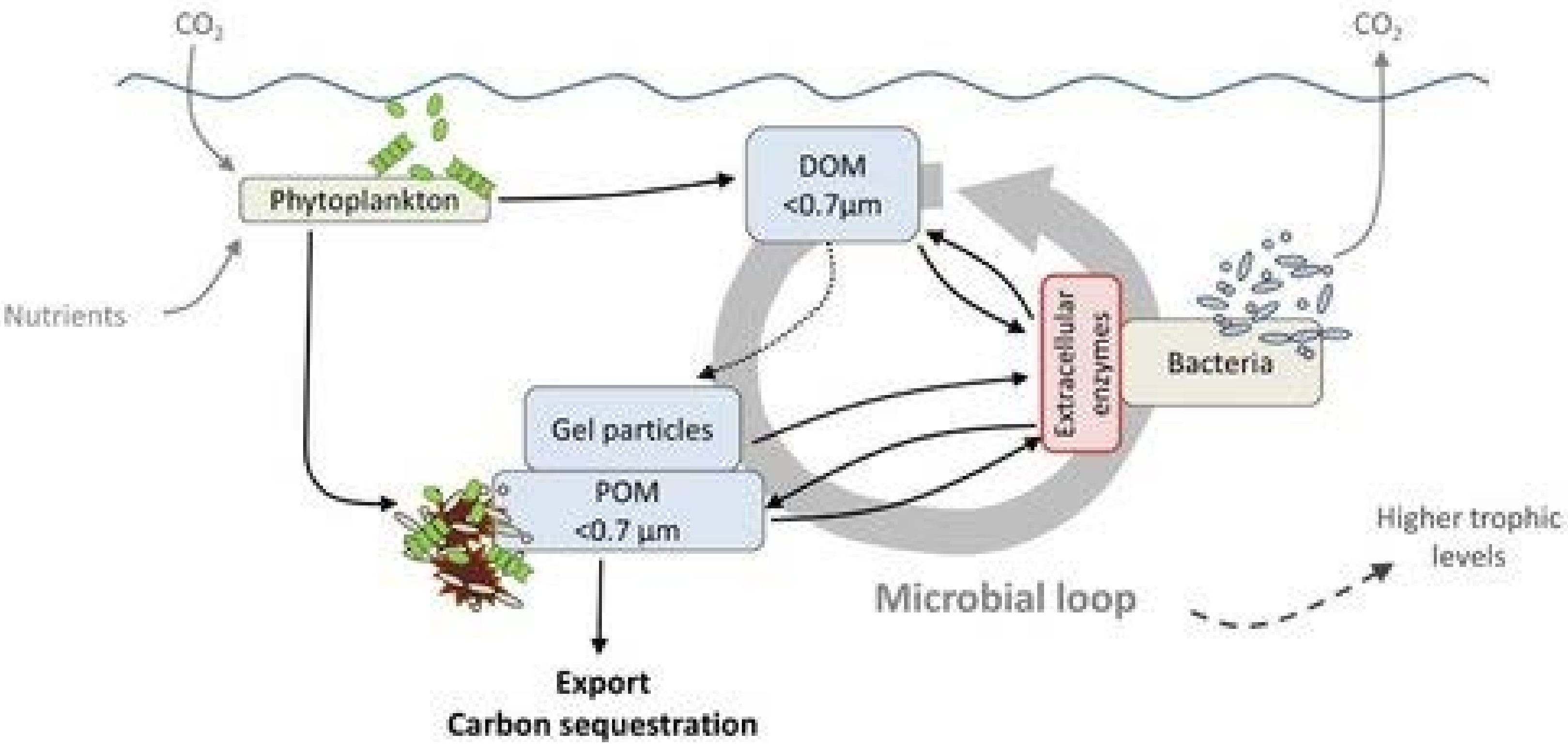
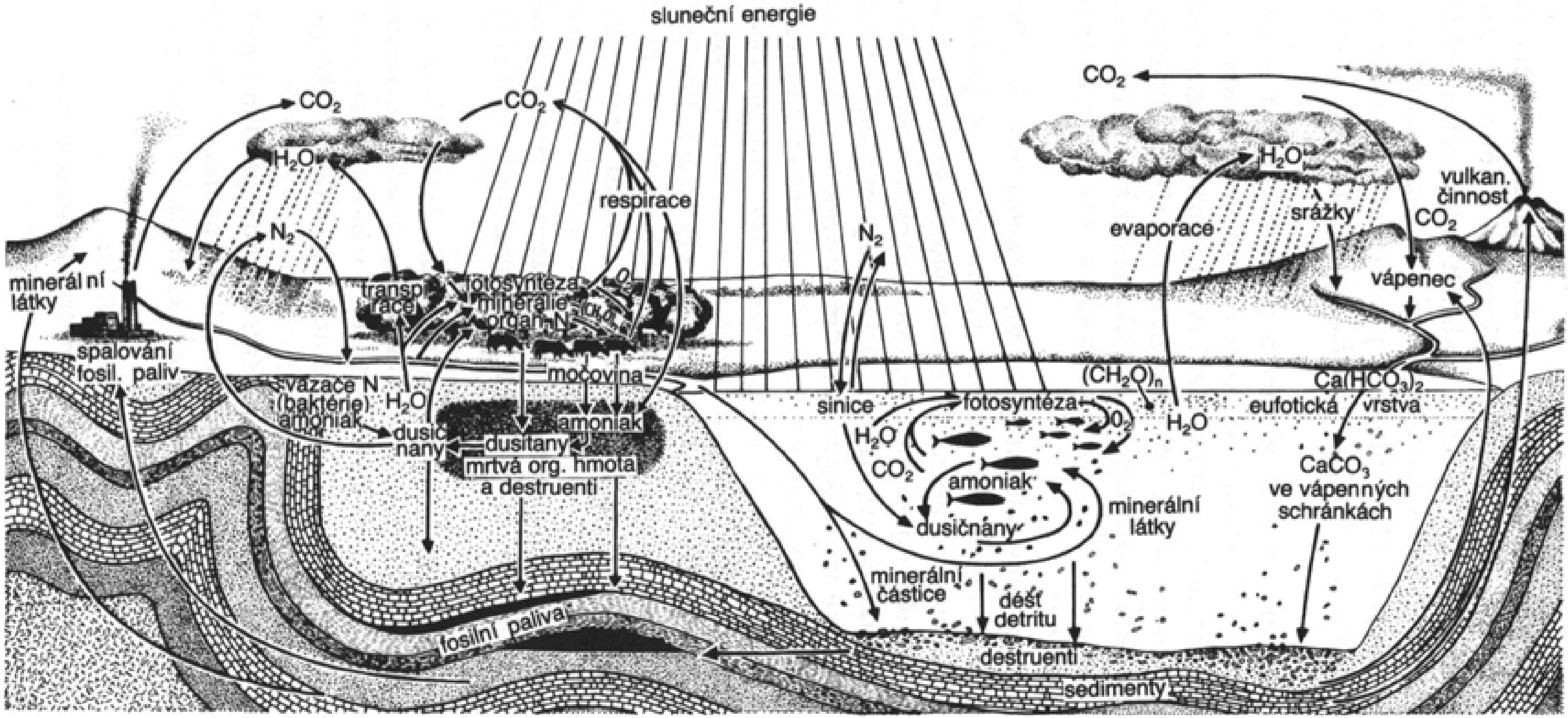
EKOSYSTÉMY STOJATÝCH VOD



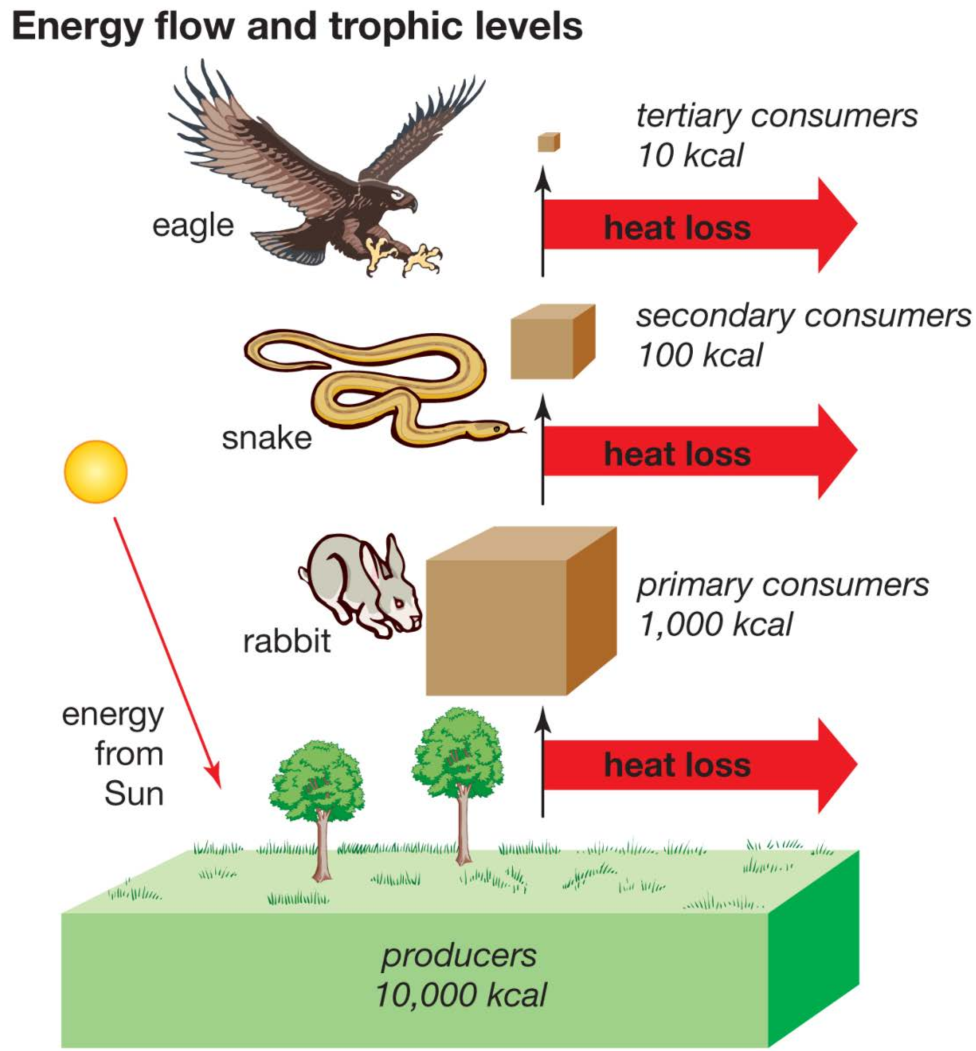
KOLOBĚH ŽIVIN

EKOSYSTÉMY STOJATÝCH VOD



55. Schéma zapojení vodního ekosystému do velkého koloběhu látek a biologické aktivity v biosféře. Jejich základem je utilizace sluneční energie pro fotosyntetickou redukci CO_2 na tvorbu organických sloučenin $(CH_2O)_n$, při současném uvolňování molekulárního O_2. Uvedeny jsou i některé další prvky (podle různých autorů)

TOKY ENERGIE A ŽIVIN



EKOSYSTÉMOVÉ SLUŽBY

Zásobovací služby

- potrava
- sladká voda
- dřevo a vláknina
- palivo
- suroviny (štěrk)

Regulační služby

- regulace podnebí
- regulace záplav
- čištění vody
- opylování
- regulace nemocí

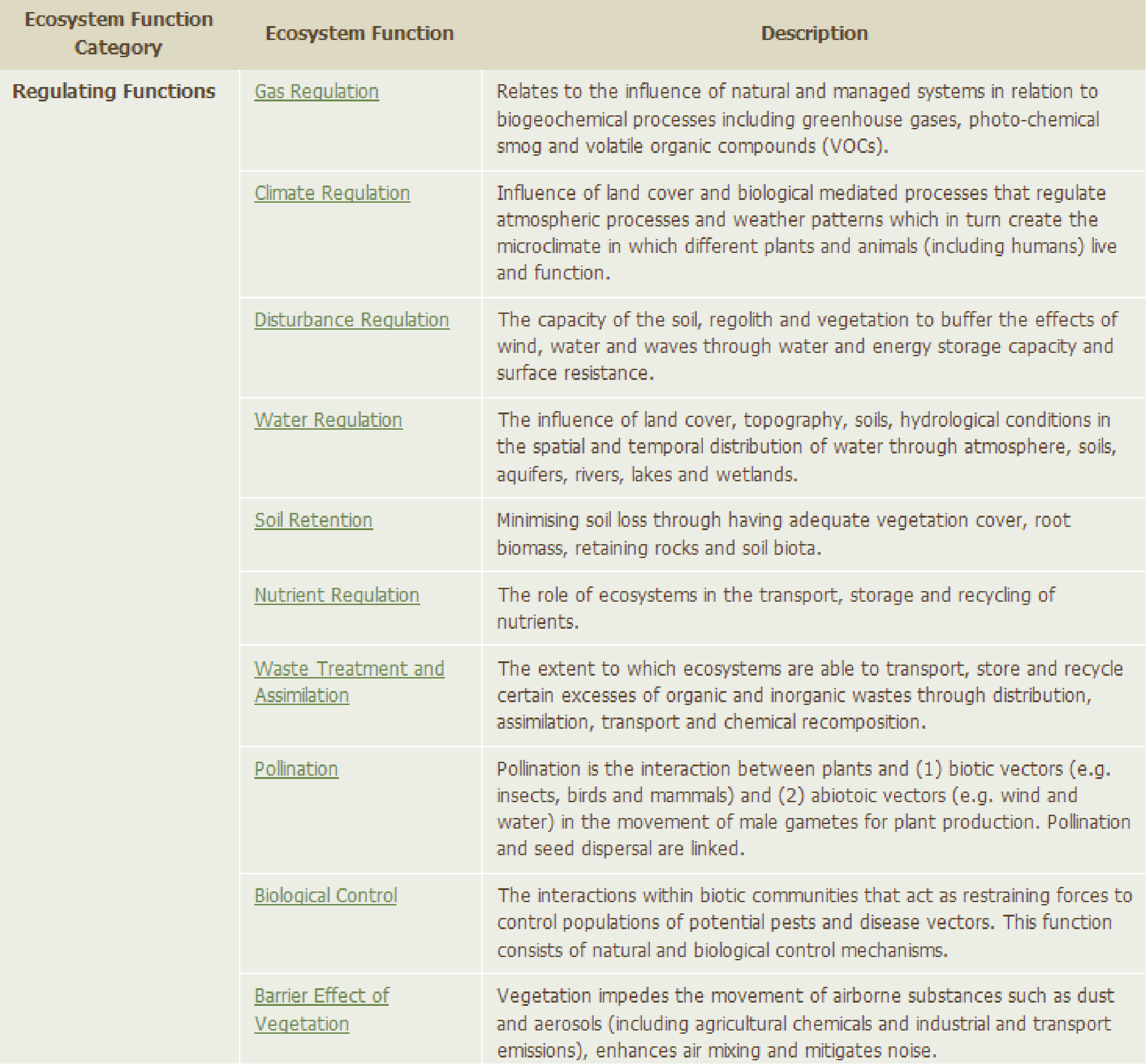
Kulturní služby

- estetické
- duchovní
- vzdělávácí
- rekreační

Podpůrné služby

- zachování biodiverzity
- oběh živin
- tvorba půdy
- primární produkce

EKOSYSTÉMOVÉ FUNKCE



Ecosystem Function Category	Ecosystem Function	Description
Regulating Functions	Gas Regulation	Relates to the influence of natural and managed systems in relation to biogeochemical processes including greenhouse gases, photo-chemical smog and volatile organic compounds (VOCs).
	Climate Regulation	Influence of land cover and biological mediated processes that regulate atmospheric processes and weather patterns which in turn create the microclimate in which different plants and animals (including humans) live and function.
	Disturbance Regulation	The capacity of the soil, regolith and vegetation to buffer the effects of wind, water and waves through water and energy storage capacity and surface resistance.
	Water Regulation	The influence of land cover, topography, soils, hydrological conditions in the spatial and temporal distribution of water through atmosphere, soils, aquifers, rivers, lakes and wetlands.
	Soil Retention	Minimising soil loss through having adequate vegetation cover, root biomass, retaining rocks and soil biota.
	Nutrient Regulation	The role of ecosystems in the transport, storage and recycling of nutrients.
	Waste Treatment and Assimilation	The extent to which ecosystems are able to transport, store and recycle certain excesses of organic and inorganic wastes through distribution, assimilation, transport and chemical recomposition.
	Pollination	Pollination is the interaction between plants and (1) biotic vectors (e.g. insects, birds and mammals) and (2) abiotoic vectors (e.g. wind and water) in the movement of male gametes for plant production. Pollination and seed dispersal are linked.
	Biological Control	The interactions within biotic communities that act as restraining forces to control populations of potential pests and disease vectors. This function consists of natural and biological control mechanisms.
	Barrier Effect of Vegetation	Vegetation impedes the movement of airborne substances such as dust and aerosols (including agricultural chemicals and industrial and transport emissions), enhances air mixing and mitigates noise.

EKOSYSTÉMOVÉ FUNKCE

Supporting Functions	Supporting Habitats	Preservation of natural and semi natural ecosystems as suitable living space for wild biotic communities and individual species. This function also includes the provision of suitable breeding, reproduction, nursery, refugia and corridors (connectivity) for species.
	Soil Formation	Soil formation is the facilitation of soil formation processes. Soil formation processes include the chemical weathering of rocks and the transportation and accumulation of inorganic and organic matter.
Provisioning Functions	Food	Biomass that sustains living organisms. Material that can be converted to provide energy and nutrition. Mostly initially derived from photosynthesis.
	Raw Materials	Biomass that is used by species for any purpose other than food.
	Water Supply	The role of ecosystems in providing water through sediment trapping, infiltration, dissolution, precipitation and diffusion.
	Genetic Resources	Self maintaining diversity of organisms developed over evolutionary time (capable of continuing to change). Measurable at species, molecular and sub molecular levels.
	Provision of Shade and Shelter	Relates to vegetation that ameliorates extremes in weather and climate at a local landscape scale. Shade or shelter is important for plants, animals and structures.
	Pharmacological Resources	Natural materials that are or can be used by organisms to maintain, restore or improve health (natural patterns can be copied by humans for synthetic products).
Cultural Functions	Landscape Opportunity	The extent and variety of natural features and landscapes.

BIODIVERZITA A REZILIENCE

Trends in Ecology & Evolution CellPress

Review

Biodiversity and Resilience of Ecosystem Functions

Tom H. Oliver,[1,2,*] Matthew S. Heard,[2] Nick J.B. Isaac,[2]
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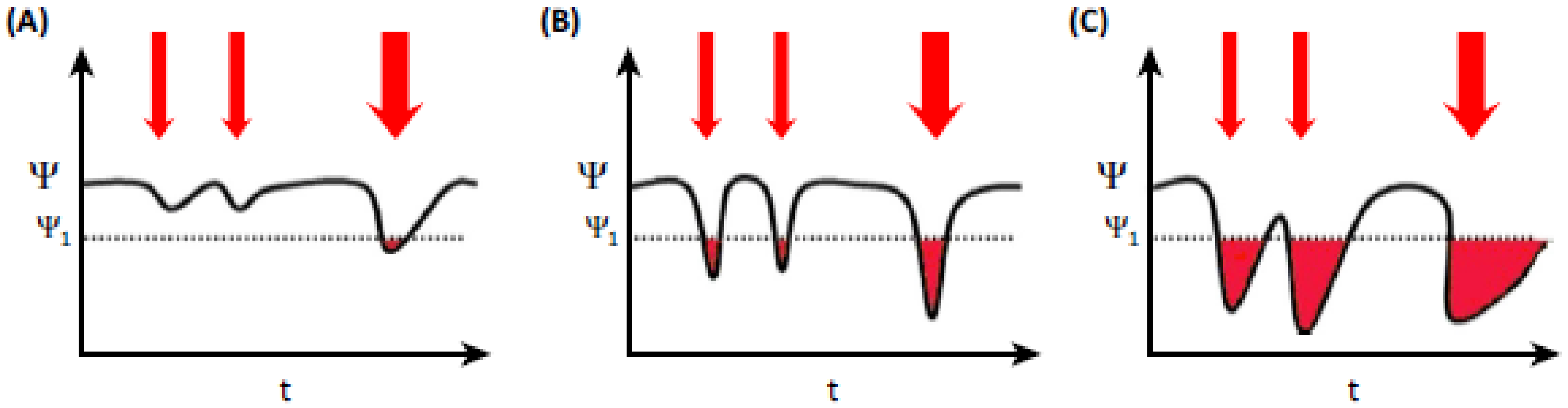
K. Blake Suttle,[11] Georgina M. Mace,[12]
Berta Martín-López,[13,14] Ben A. Woodcock,[2] and
James M. Bullock[2]

vysoká rezistence pomalá obnova	nízká rezistence rychlá obnova	nízká rezistence pomalá obnova



Trends in Ecology & Evolution

Figure 1. Schematic Showing Varying Resilience Levels of an Ecosystem Function (Ψ) to Environmental Perturbations (Red Arrows). Panel (A) shows a system with high resistance but slow recovery; panel (B) shows a system with low resistance but rapid recovery; panel (C) shows a system with both low resistance and slow recovery. Lack of resilience (vulnerability) could be quantified as the length of time that ecosystem functions are provided below some minimum threshold set by resource managers (this threshold shown with the symbol Ψ_1) or the total deficit of ecosystem function (i.e., the total shaded-red area). Note that, in the short term, mean function is similar in all systems but in the longer term mean function is lower and the extent of functional deficit is higher in the least resilient system (C).

BIODIVERZITA A REZILIENCE

Trends in Ecology & Evolution

CellPress

Review

Biodiversity and Resilience of Ecosystem Functions

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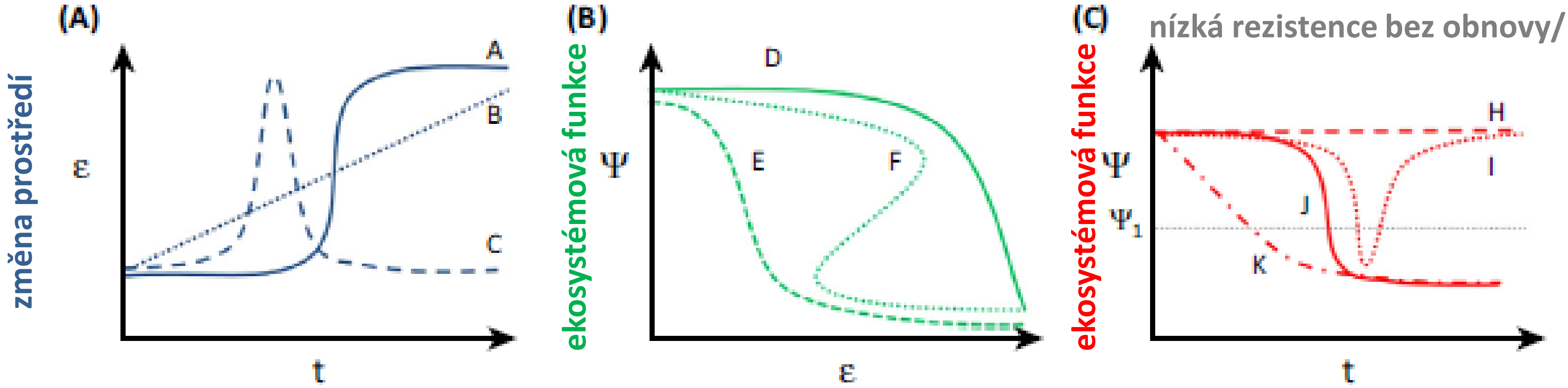
rychlý nástup /A/
chronický /B/
přechodné narušení /C/

vysoká rezistence /D/
nižší rezistence /E/
management /F/

úplná rezistence /H/
omezená rezistence a plná obnova /I/
omezená rezistence bez obnovy/J/
nízká rezistence bez obnovy/K/



Trends in Ecology & Evolution

Figure 2. Different Possible Relationships between Environmental Change (ε), time (t), and level of ecosystem function provided (Ψ). Panel (A) shows three types of environmental change: rapid onset (A), chronic (B), and transitory perturbation (C). Panel (B) shows that ecosystem function might be relatively resistant to increasing levels of environmental change (D), less resistant (E), or demonstrate hysteresis (F). Panel (C) shows the four qualitatively different outcomes for how ecosystem function varies over time, whether the system is fully resistant to an environmental change (H), shows limited resistance but full recovery (I), or shows limited (J) or low resistance (K) with no recovery of function. The horizontal line at Ψ_1 indicates some minimum threshold for ecosystem function that is set by resource managers. In both panels (A) and (C), short-term stochasticity about trends is omitted for clarity.

BIODIVERZITA A REZILIENCE

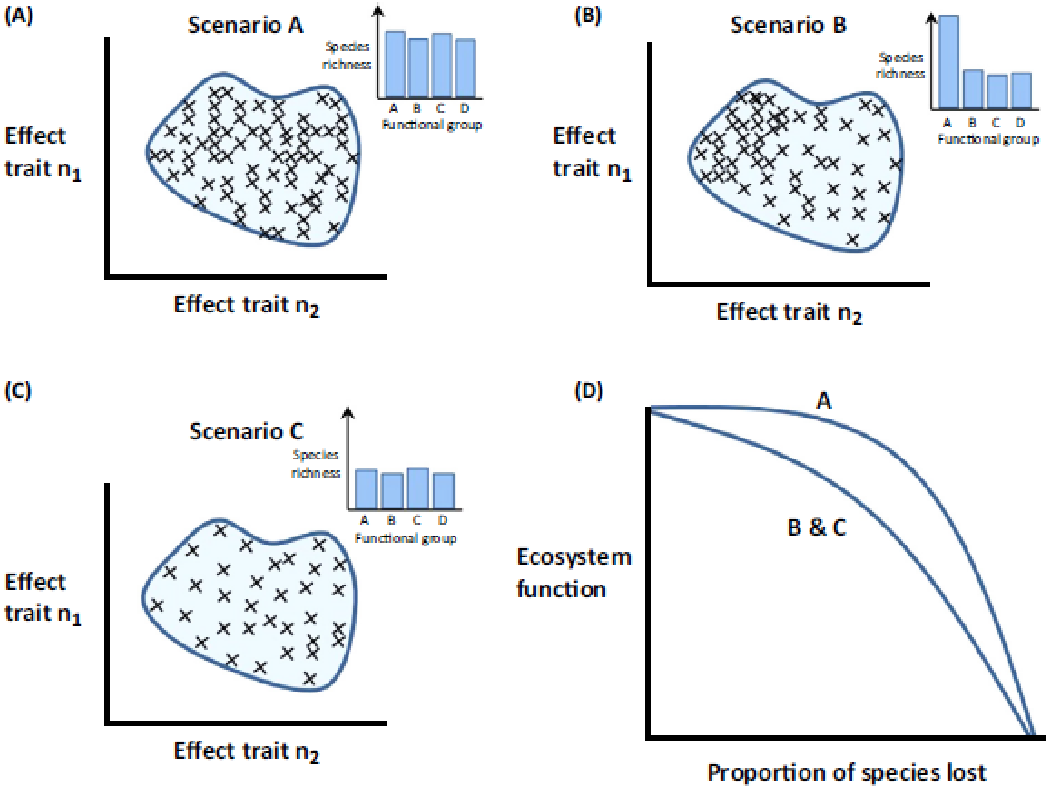
Trends in Ecology & Evolution

CellPress

Review

Biodiversity and Resilience of Ecosystem Functions

Tom H. Oliver,[1,2,*] Matthew S. Heard,[2] Nick J.B. Isaac,[2] David B. Roy,[2] Deborah Procter,[3] Felix Eigenbrod,[4] Rob Freckleton,[5] Andy Hector,[6] C. David L. Orme,[7] Owen L. Petchey,[8] Vânia Proença,[9] David Raffaelli,[10] K. Blake Suttle,[11] Georgina M. Mace,[12] Berta Martín-López,[13,14] Ben A. Woodcock,[2] and James M. Bullock[2]



Trends in Ecology & Evolution

Figure 3. Functional Redundancy and Effects on Resilience of Ecosystem Functions. Complementary effect-trait space occupied by all species in a community can be characterized by an *n*-dimensional hypervolume for continuous traits [main panels (A–C)] or as discrete functional groups for categorical traits (inset panels A–C). A high density of species spread evenly across complementary trait space [(A), shown for two of *n* possible traits] leads to higher resistance of ecosystem functions. This is shown in panel (D) (scenario A), which shows the hypothetical average impact on ecosystem function as species are lost from a community under increasing environmental perturbation. The same number of species less evenly dispersed across complementary effect-trait space [i.e., a more 'clumped' distribution, (B)] leads to less resistant ecosystem functions [(D), scenario B]. Similarly, fewer species that are evenly but thinly spread across complementary effect-trait space (C), also lead to less resistant ecosystem functions. In both cases, the communities are said to have lower 'functional redundancy'. The exact rate of loss of ecosystem function will be context dependent (e.g., depending on initial number of species, ordering of species extinctions, and degree of species clustering in trait space).

BIODIVERZITA A REZILIENCE

Trends in Ecology & Evolution

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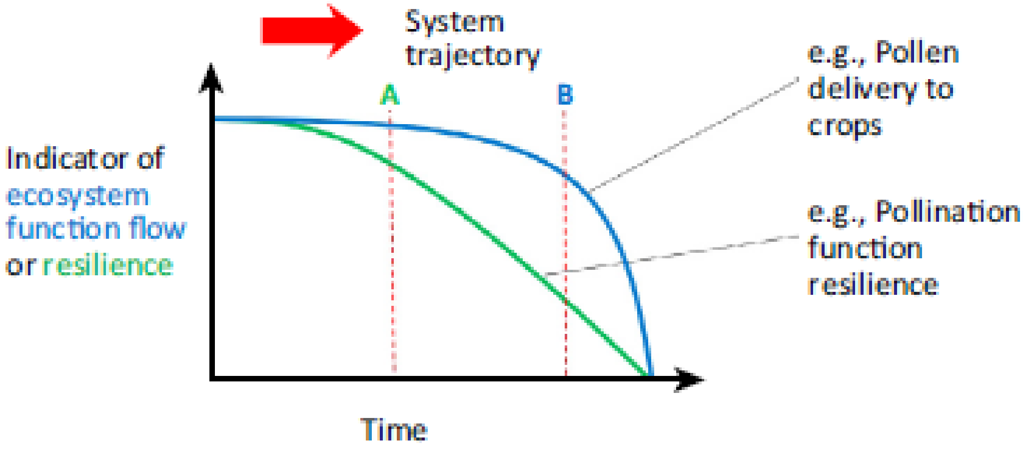
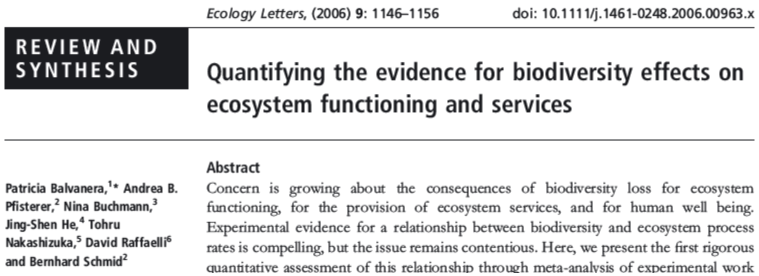


Trends in Ecology & Evolution

Figure 4. Hypothetical Example of Indicator Values for an Ecosystem Function Flow (e.g., Estimates of Pollen Delivery to Crops) or Resilience of that Function (e.g., Pollination under Environmental Perturbations as Measured by Some Combination of the Mechanisms Highlighted in this Review) as an Ecosystem is Degraded over Time. The thresholds to initiate management action (red dotted lines) differ depending on which indicator is used (A for the resilience indicator, B for the ecosystem function flow indicator). Given that remedial management takes time to put in place and become effective, unacceptable losses of ecosystem function might occur if ecosystem function flow indicators are solely relied on. These losses can be costly for society and difficult to reverse.

BIODIVERSITY AND ECOSYSTEM FUNCTION

OBECNÉ VZTAHY



Ecology Letters, (2006) 9: 1146–1156 doi: 10.1111/j.1461-0248.2006.00963.x

REVIEW AND SYNTHESIS

Quantifying the evidence for biodiversity effects on ecosystem functioning and services

Patricia Balvanera,[1]* Andrea B. Pfisterer,[2] Nina Buchmann,[3] Jing-Shen He,[4] Tohru Nakashizuka,[5] David Raffaelli[6] and Bernhard Schmid[2]

Abstract

Concern is growing about the consequences of biodiversity loss for ecosystem functioning, for the provision of ecosystem services, and for human well being. Experimental evidence for a relationship between biodiversity and ecosystem process rates is compelling, but the issue remains contentious. Here, we present the first rigorous quantitative assessment of this relationship through meta-analysis of experimental work

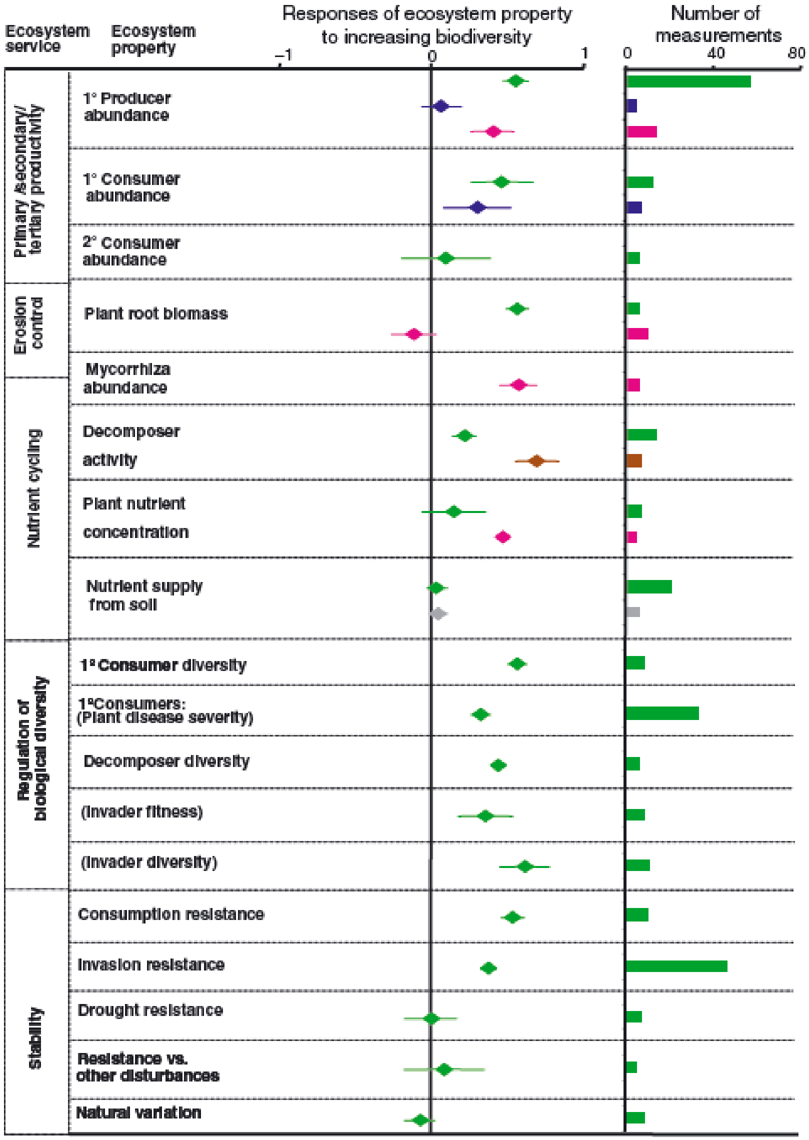


Figure 3 Magnitude and direction of biodiversity effects (shown are mean values and SE of normalized effect sizes Z_r, weighted by the reciprocal of the variance of the individual Z_r-values) and number of measurements available for ecosystem properties organized into ecosystem services. Coloured bars show differential effects of trophic level manipulated: green, primary producers; blue, primary consumers; pink, mycorrhiza; brown, decomposer; grey, multitrophic (multiple levels simultaneously manipulated). Ecosystem properties shown in parentheses were considered of negative value for human well being, and thus opposite of effect sizes are shown.

FUNKČNÍ DIVERZITA
A EKOSYSTÉMOVÉ SLUŽBY

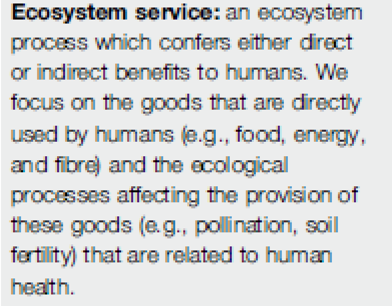
Trends in Plant Science

CellPress

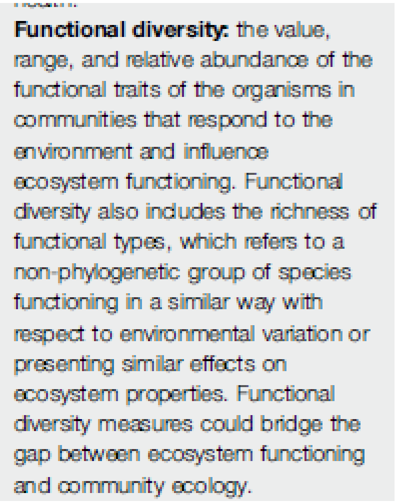
Opinion

Plant Functional Traits: Soil and Ecosystem Services

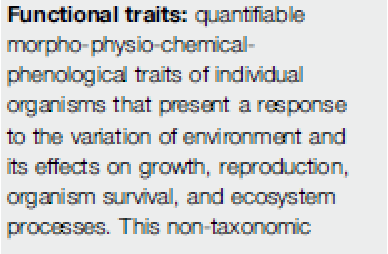
Michel-Pierre Faucon,[1,*] David Houben,[1] and Hans Lambers[2,*]



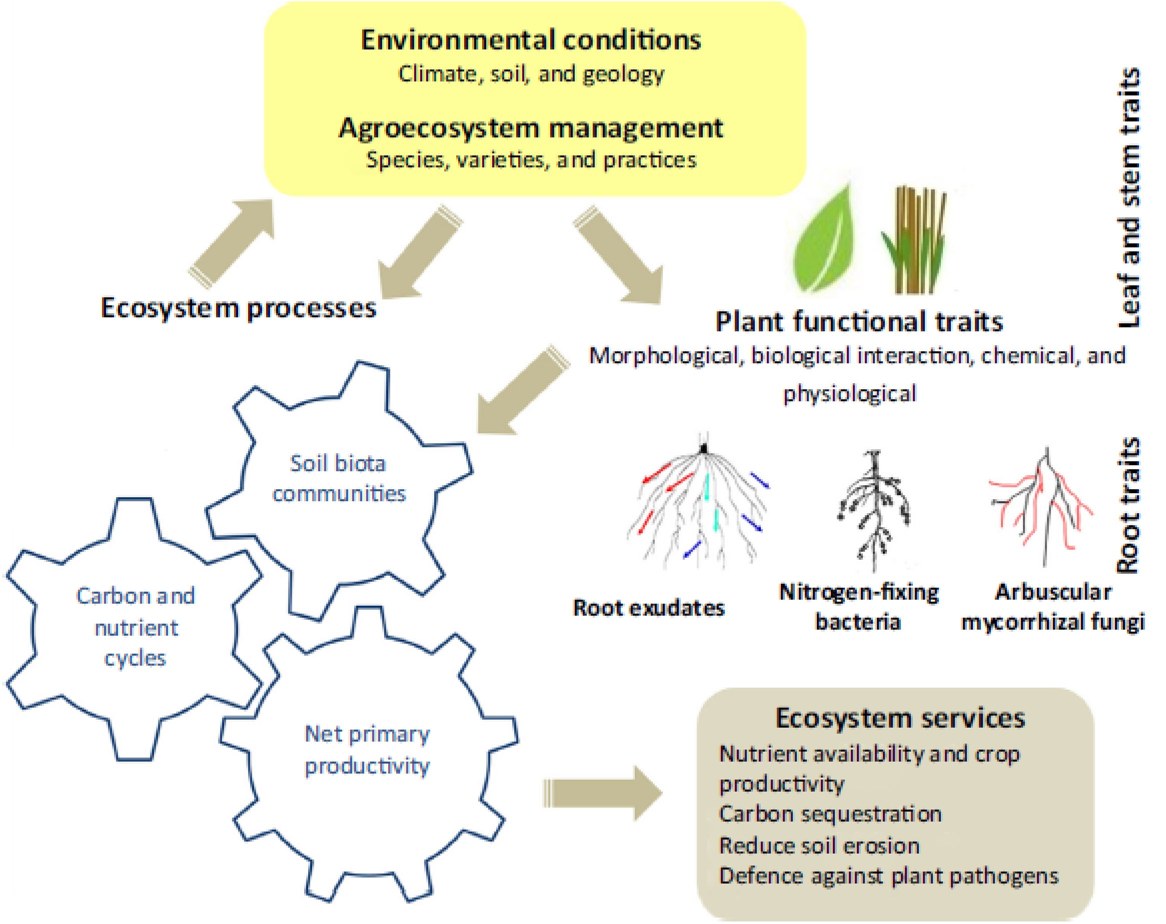
Ecosystem service: an ecosystem process which confers either direct or indirect benefits to humans. We focus on the goods that are directly used by humans (e.g., food, energy, and fibre) and the ecological processes affecting the provision of these goods (e.g., pollination, soil fertility) that are related to human health.



Functional diversity: the value, range, and relative abundance of the functional traits of the organisms in communities that respond to the environment and influence ecosystem functioning. Functional diversity also includes the richness of functional types, which refers to a non-phylogenetic group of species functioning in a similar way with respect to environmental variation or presenting similar effects on ecosystem properties. Functional diversity measures could bridge the gap between ecosystem functioning and community ecology.



Functional traits: quantifiable morpho-physio-chemical-phenological traits of individual organisms that present a response to the variation of environment and its effects on growth, reproduction, organism survival, and ecosystem processes. This non-taxonomic



Trends in Plant Science

Figure 1. Relationships between Plant Functional Traits, Ecosystem Processes, and Services in Agroecosystems. Plant functional traits are selected by climate, geology, soil conditions, and practices of agroecosystem management.

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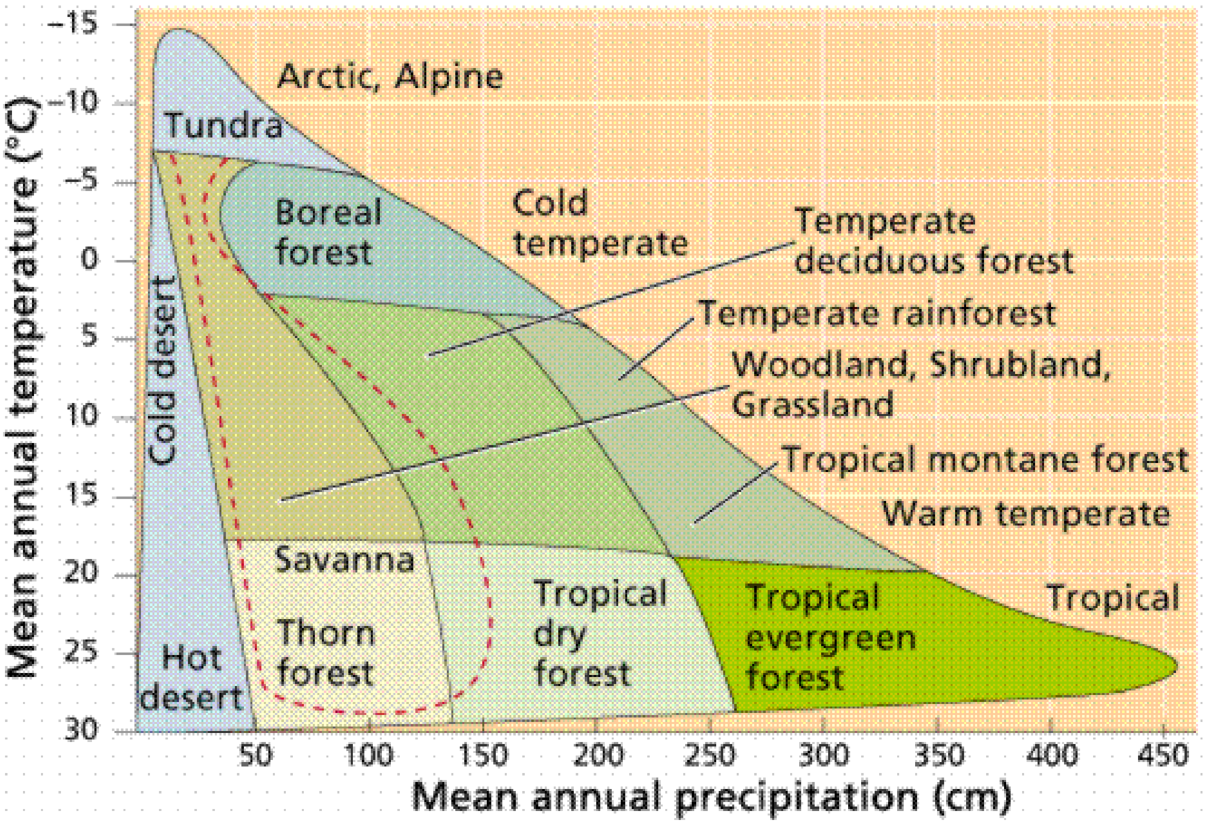

Effect of temperature on precipitation. Image from Purves et al., Life: The Science of Biology, 4th Edition, by Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com).

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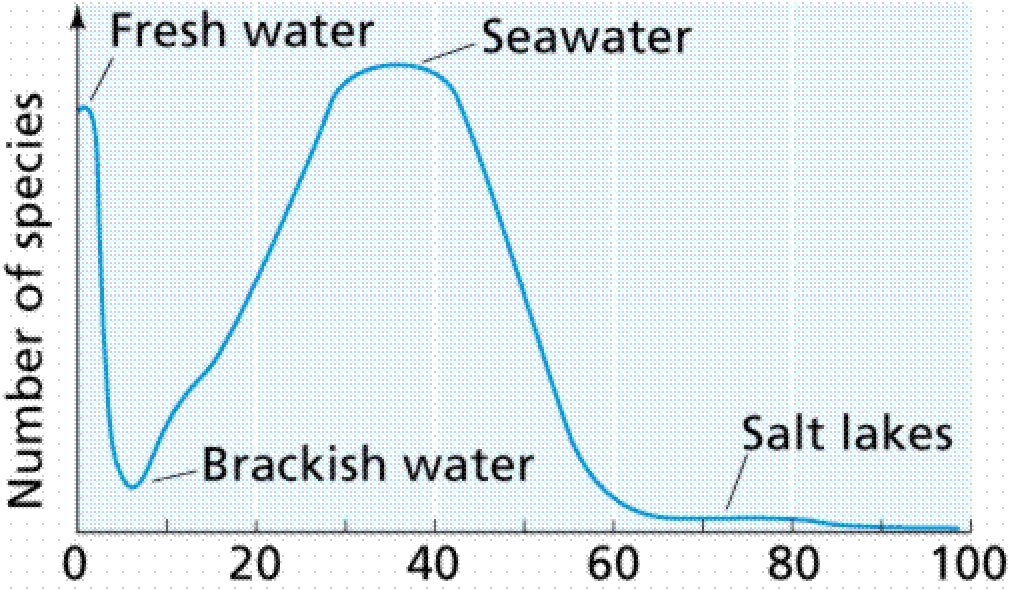

Species diversity and salt concentration. Image from Purves et al., Life: The Science of Biology, 4th Edition, by Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com).

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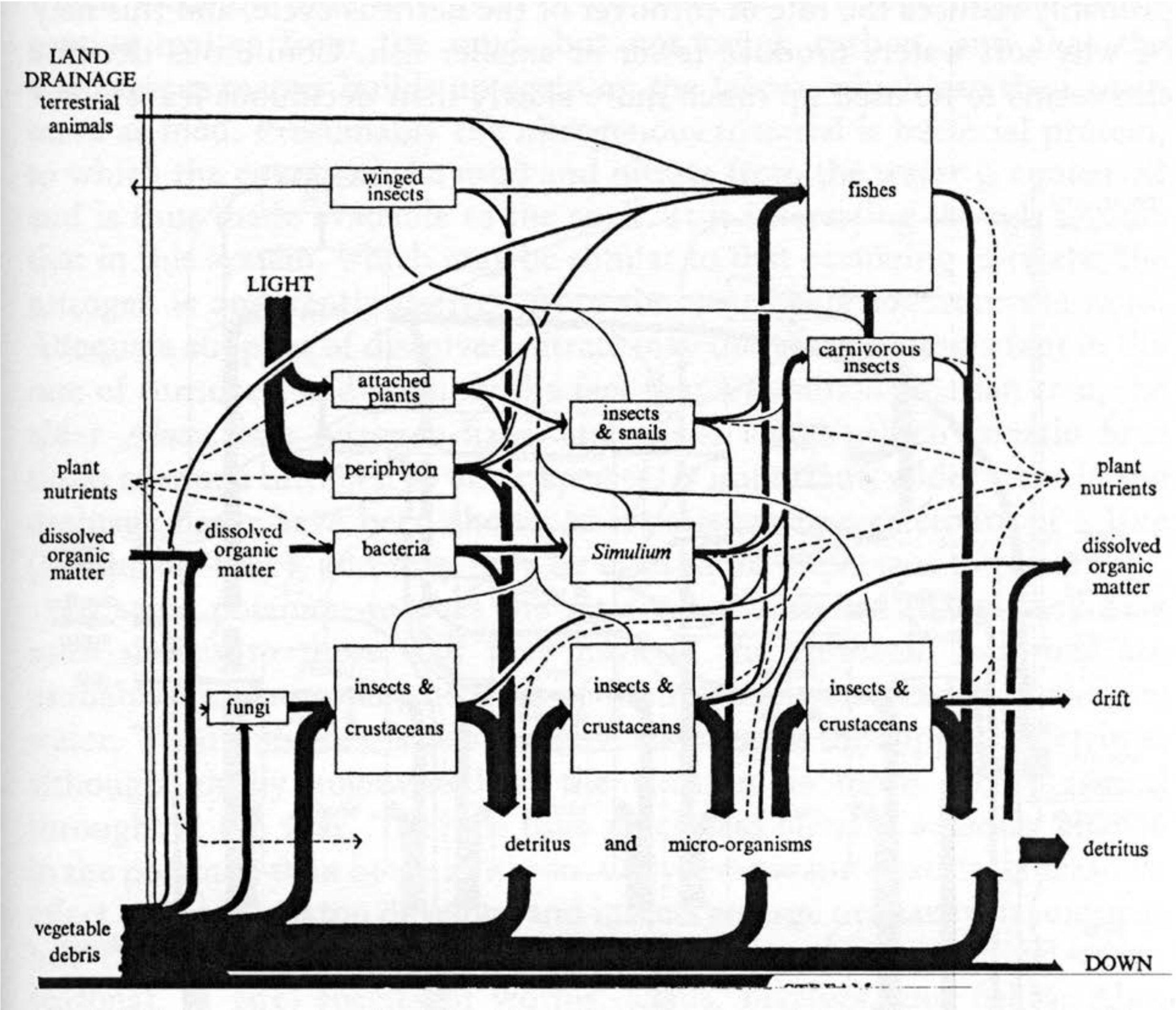
Rhithron – podhorské potoky



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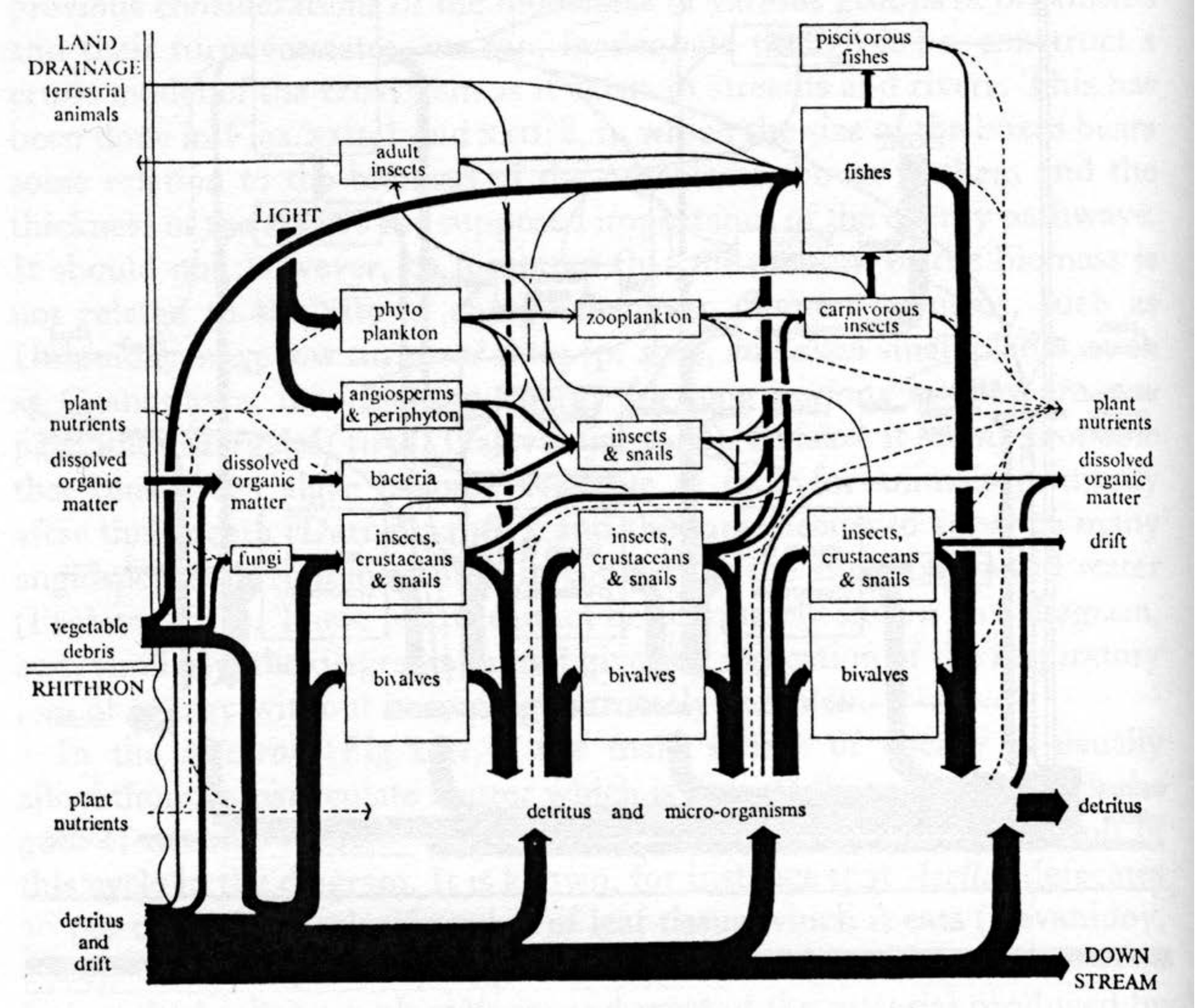
Potamon – nížinné řeky



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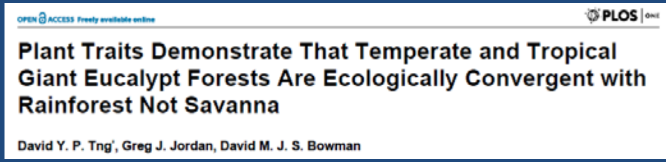

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PLOS | ONE

Plant Traits Demonstrate That Temperate and Tropical Giant Eucalypt Forests Are Ecologically Convergent with Rainforest Not Savanna

David Y. P. Tng*, Greg J. Jordan, David M. J. S. Bowman

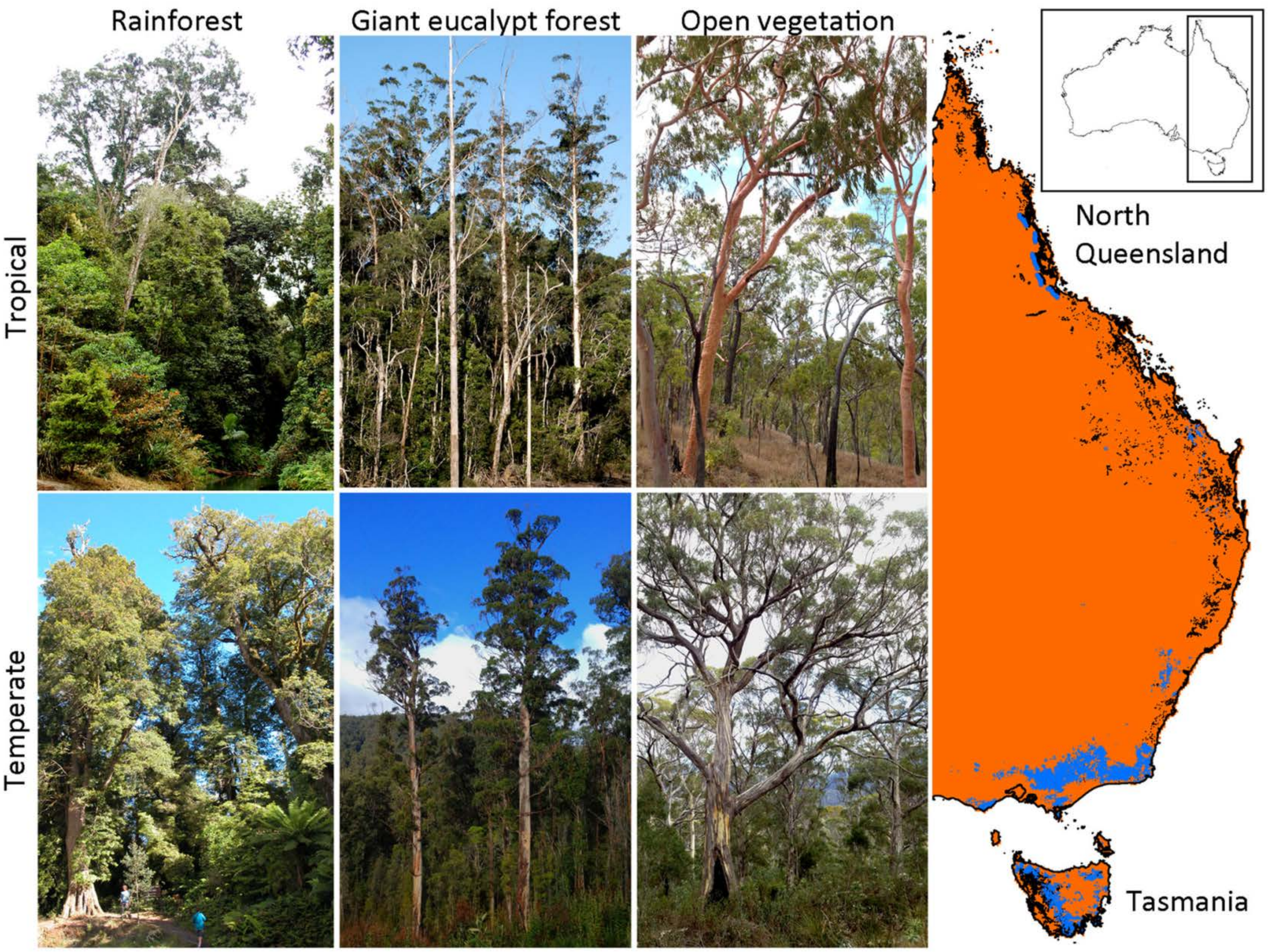

Figure 2. The distribution of rainforest (black) and giant eucalypt forest (blue) along the east coast of the Australian continent. The orange-coloured regions are open vegetation (including savanna and open eucalypt woodland). The ecotonal nature of giant eucalypt forest is most pronounced in tropical north Queensland, where giant eucalypt forests form narrow bands between rainforest and savanna (spatial extent exaggerated for clarity), and in cool temperate Tasmania, where giant eucalypt forests form a broad transition between the west and the eastern parts of the island. The inset images feature representative rainforests, giant eucalypt forests and open vegetation of the tropical and temperate zones. Note the taller stature and open canopy of giant eucalypts relative to rainforest in the understoreys.

doi: 10.1371/journal.pone.0084378.g002

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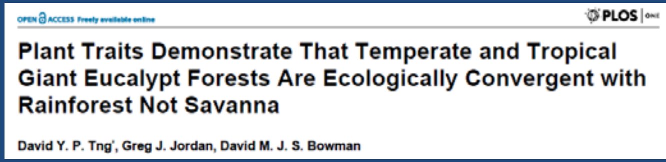

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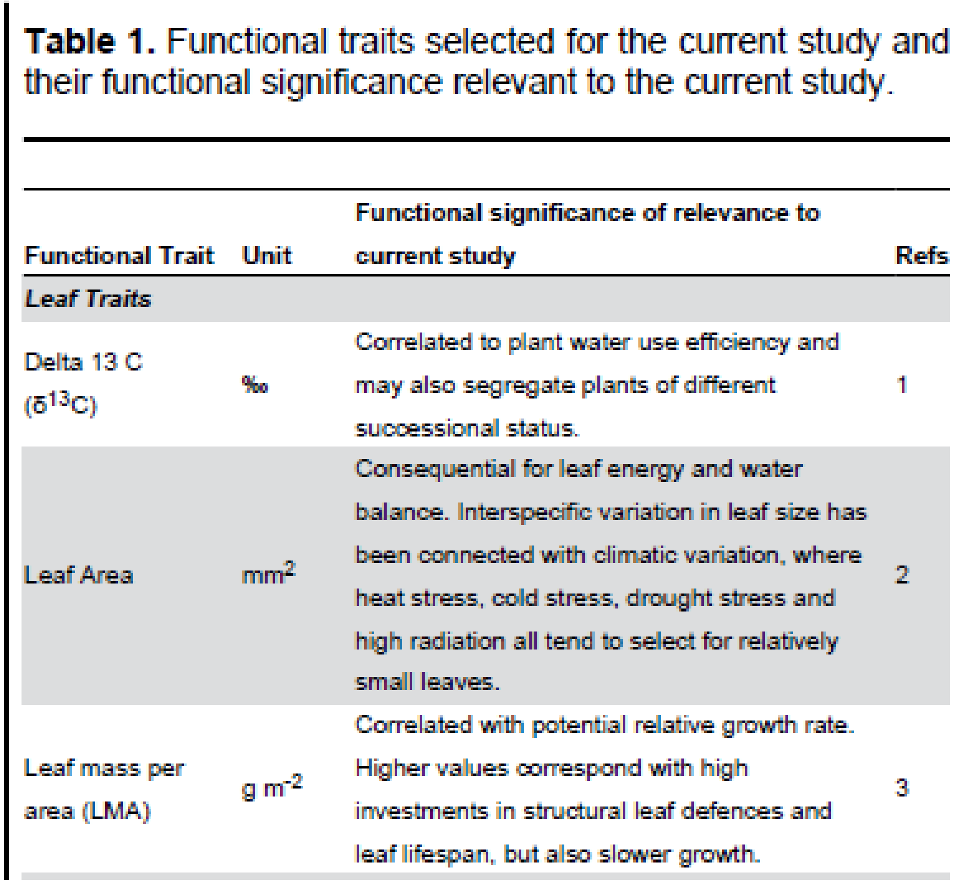
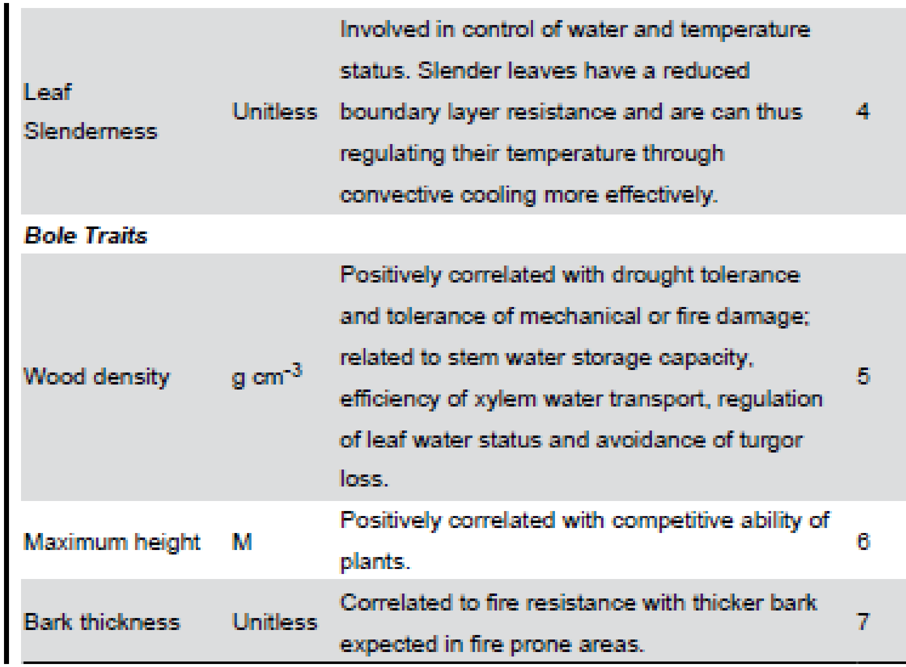

Table 1. Functional traits selected for the current study and their functional significance relevant to the current study.

Functional Trait	Unit	Functional significance of relevance to current study	Refs
Leaf Traits			
Delta 13 C ($\delta^{13}C$)	‰	Correlated to plant water use efficiency and may also segregate plants of different successional status.	1
Leaf Area	mm^2	Consequential for leaf energy and water balance. Interspecific variation in leaf size has been connected with climatic variation, where heat stress, cold stress, drought stress and high radiation all tend to select for relatively small leaves.	2
Leaf mass per area (LMA)	$g\ m^{-2}$	Correlated with potential relative growth rate. Higher values correspond with high investments in structural leaf defences and leaf lifespan, but also slower growth.	3
Leaf Slenderness	Unitless	Involved in control of water and temperature status. Slender leaves have a reduced boundary layer resistance and are can thus regulating their temperature through convective cooling more effectively.	4
Bole Traits			
Wood density	$g\ cm^{-3}$	Positively correlated with drought tolerance and tolerance of mechanical or fire damage; related to stem water storage capacity, efficiency of xylem water transport, regulation of leaf water status and avoidance of turgor loss.	5
Maximum height	M	Positively correlated with competitive ability of plants.	6
Bark thickness	Unitless	Correlated to fire resistance with thicker bark expected in fire prone areas.	7

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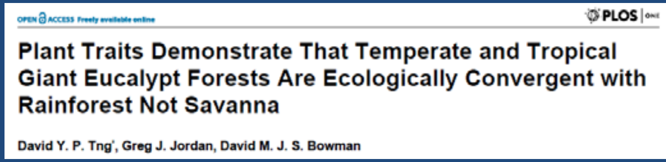
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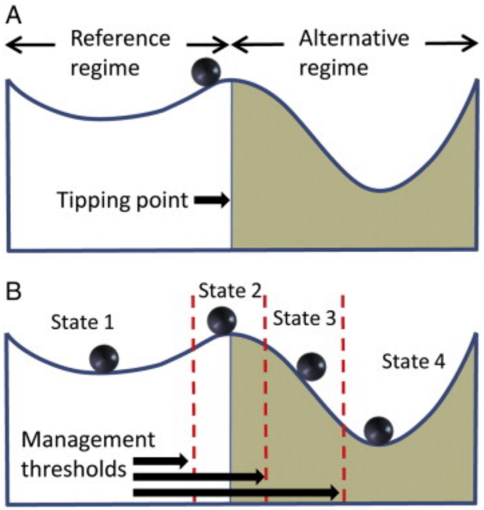

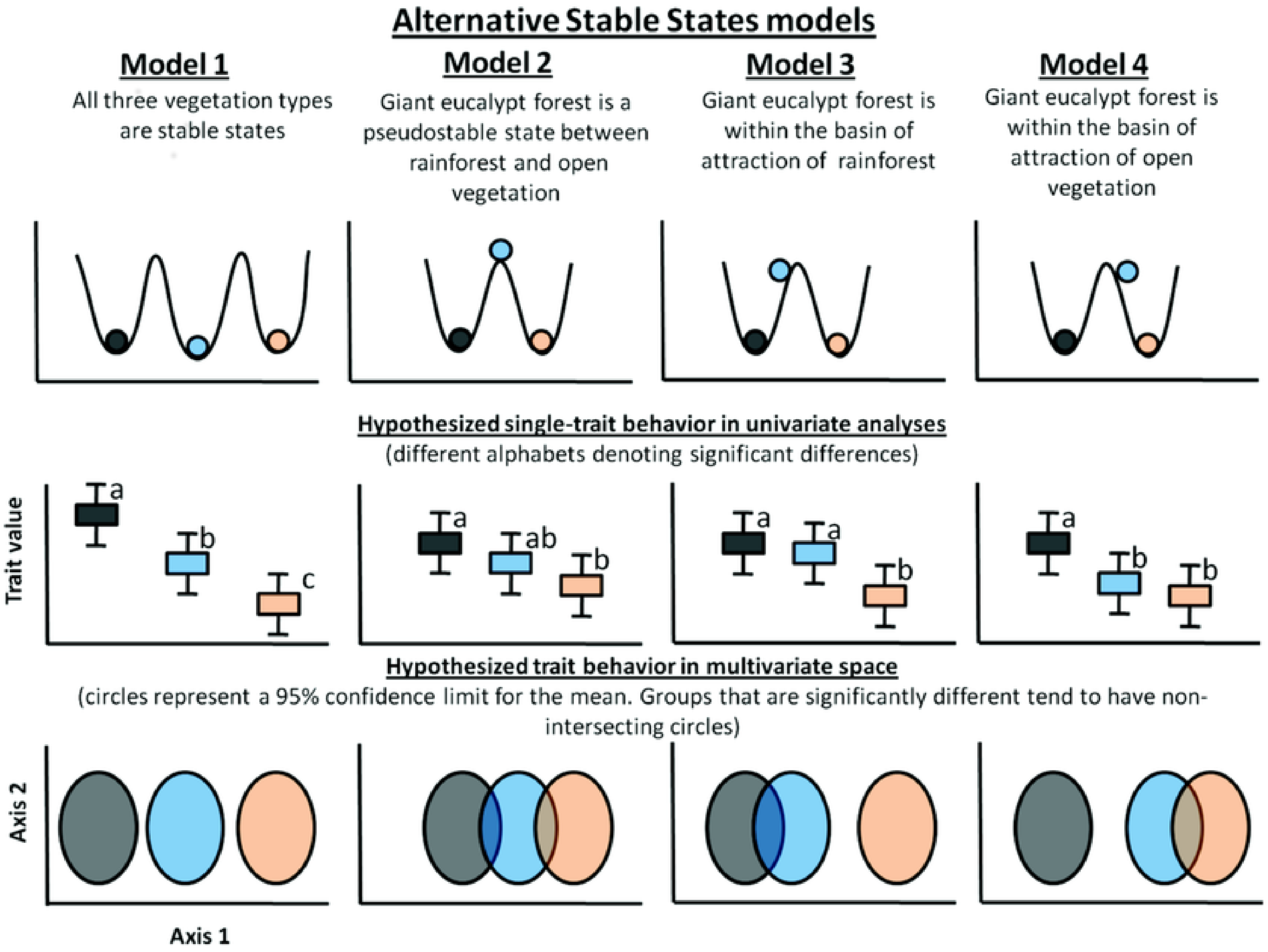

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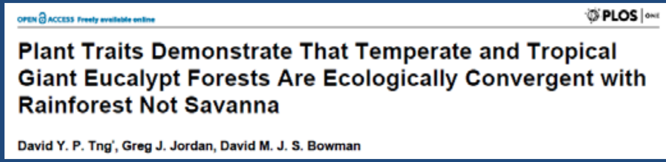

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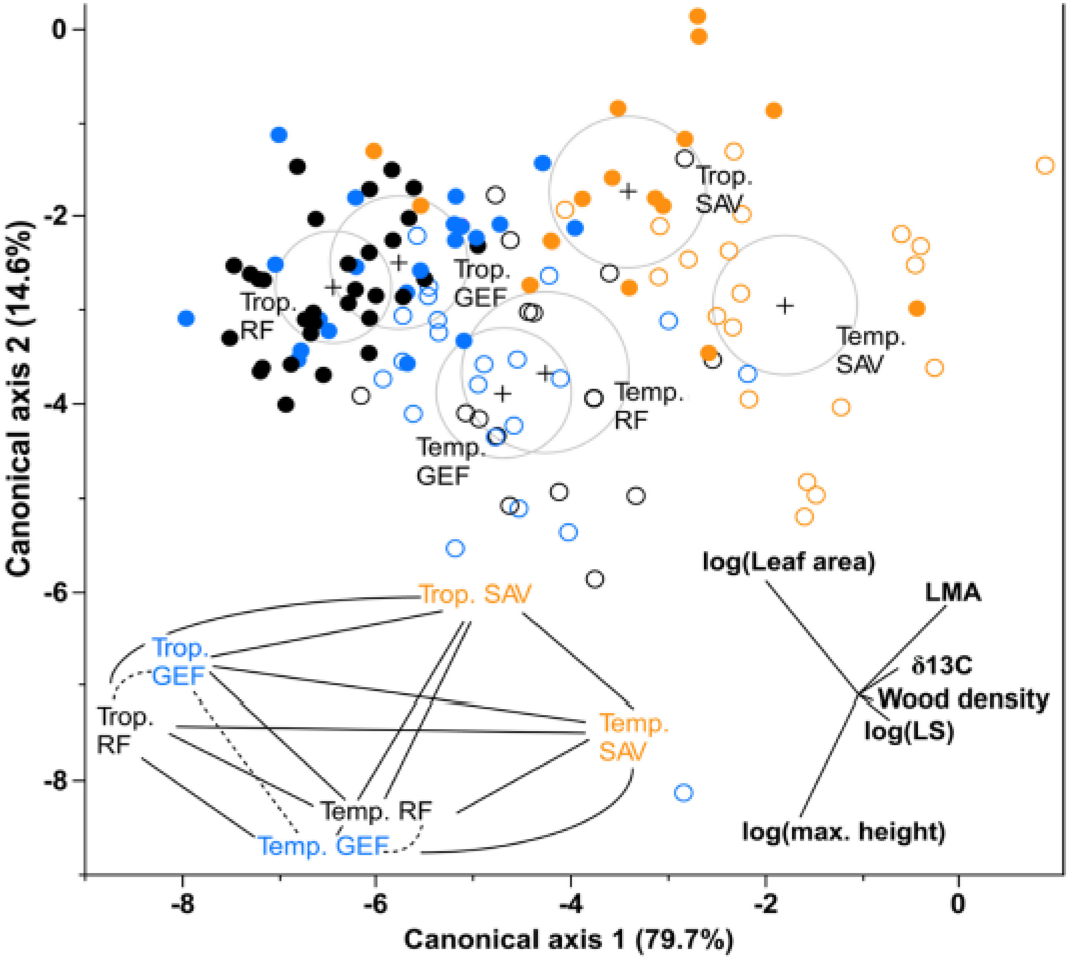

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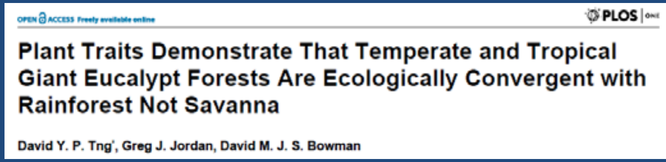

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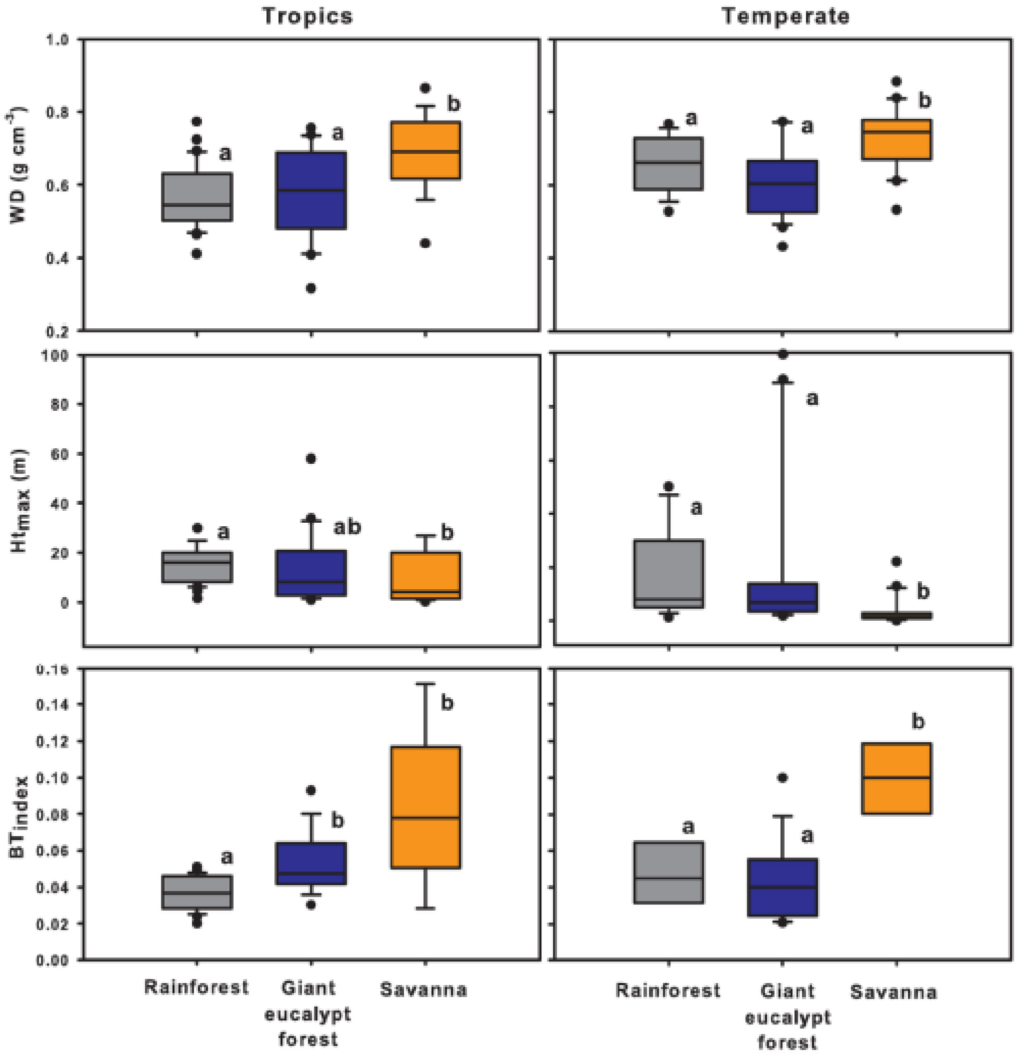

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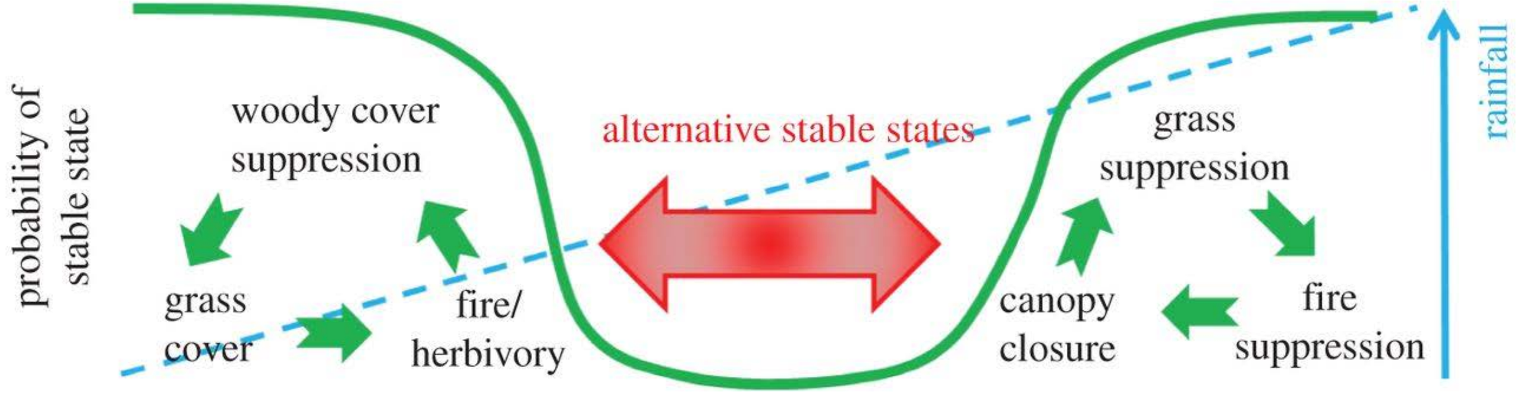
Oliveras I, Malhi Y. 2016: Many shades of green: the dynamic tropical forest–savannah transition zones. Phil. Trans. R. Soc. B 371: 20150308.



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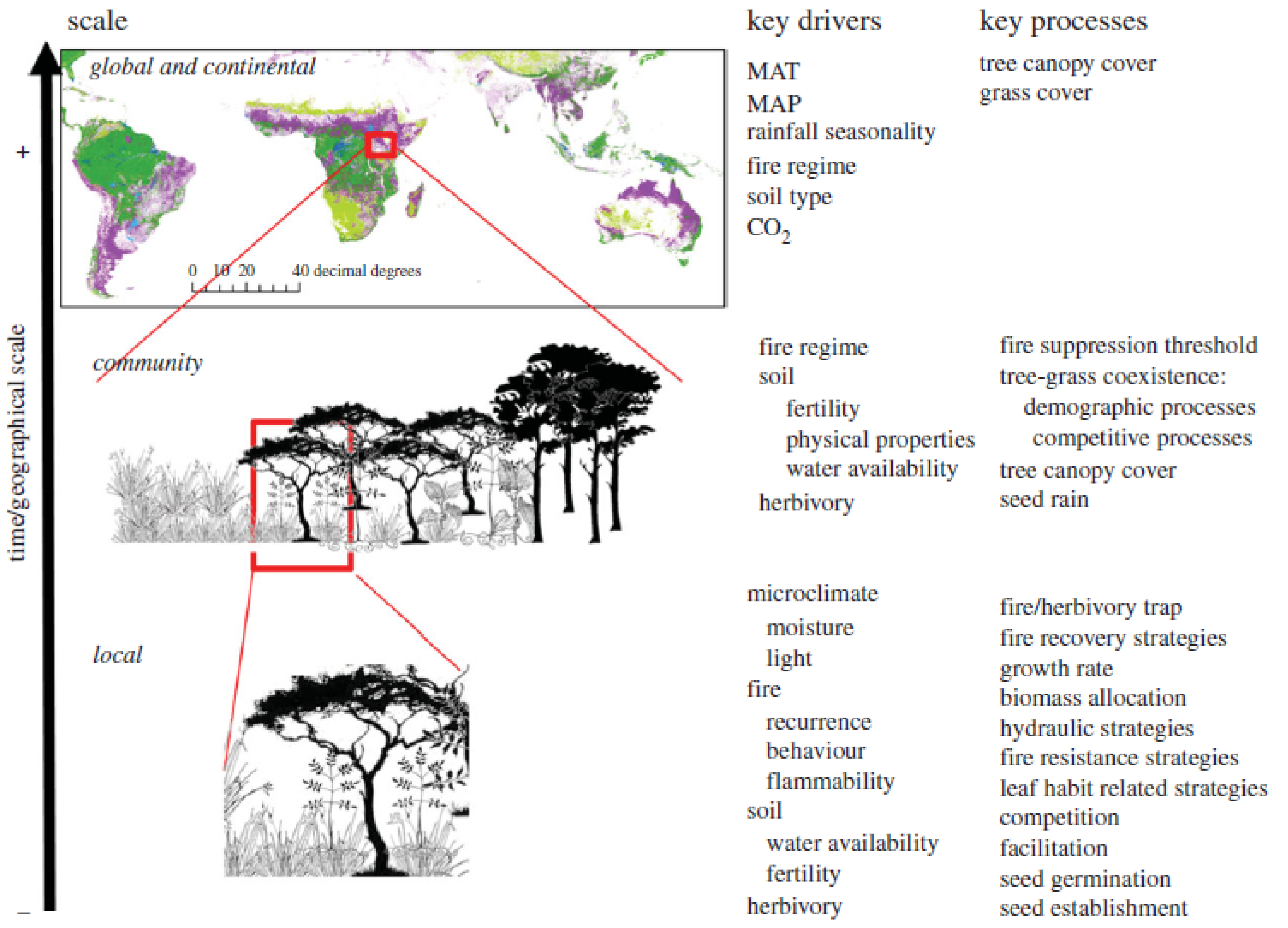

scale	key drivers	key processes
global and continental	MAT MAP rainfall seasonality fire regime soil type CO_2	tree canopy cover grass cover
community	fire regime soil fertility physical properties water availability herbivory	fire suppression threshold tree-grass coexistence: demographic processes competitive processes tree canopy cover seed rain
local	microclimate moisture light fire recurrence behaviour flammability soil water availability fertility herbivory	fire/herbivory trap fire recovery strategies growth rate biomass allocation hydraulic strategies fire resistance strategies leaf habit related strategies competition facilitation seed germination seed establishment

Figure 3. Different drivers and processes operate at different spatial and temporal scales in determining tropical forest–grassy vegetation transitions. At the global scale, and at large time scales, climate (mean annual temperature [MAT], precipitation MAP, seasonality and dry season length), fire regimes (frequency and intensity of fires) and soil types determine distribution between the forest (dark green), grassy vegetation (dark purple as natural, light purple has human-modified) and grassland biomes (reproduced with permission from GlobCover 2009, http://due.esrin.esa.int/page_globcover.php). At the community scale, fire regimes, soil properties and herbivory are the main drivers, and ecological processes are mostly reflected in tree–grass coexistence. At the local scale, many drivers and ecological processes affect the given vegetation existing at that precise point in space and time.

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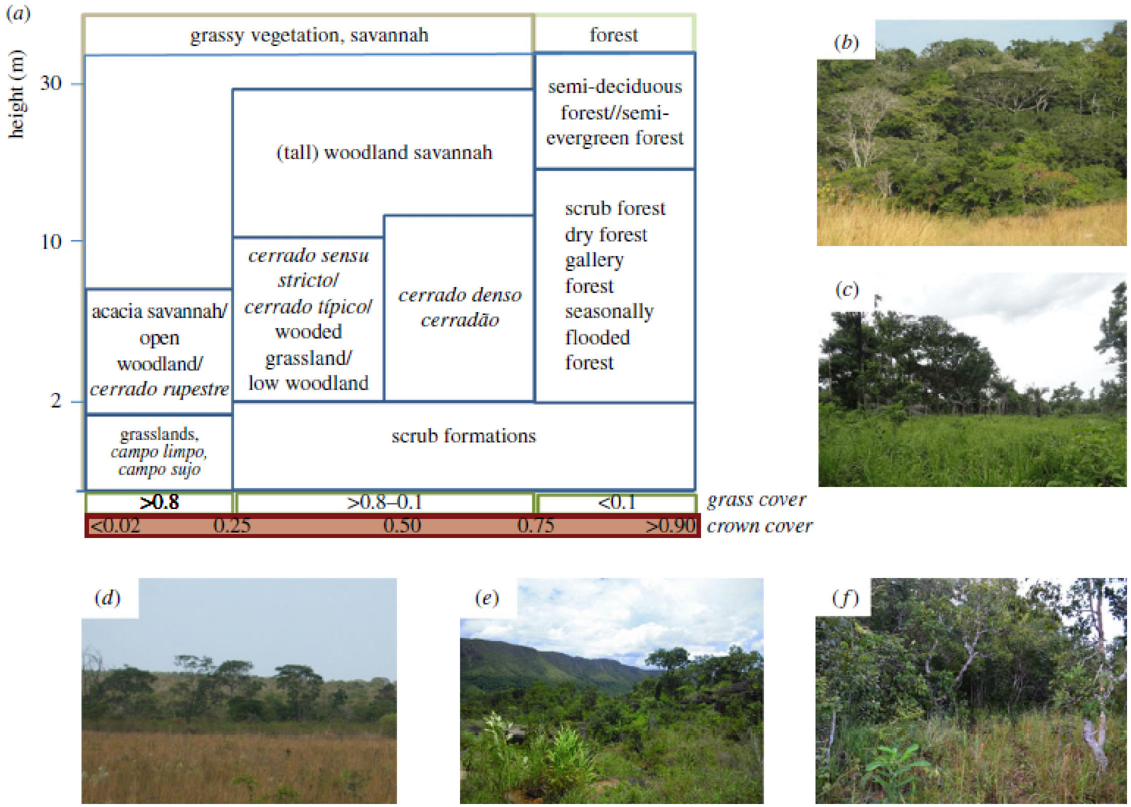

Figure 1. (*a*) Schematic of the main vegetation types between grassy vegetation and forests (adapted from [5]) and examples of forest–savannah transitions (*b*–*f*). (*a*) Crown cover and grass cover are inversely related. The most herbaceous formations are characterized by the absence or the marginal presence of woody vegetation, such as grasslands (*b*), open woodlands in West Africa (*c*), *campo sujo* (*d*) and *cerrado rupestre* (*e*) in Brazil. In the mid-range of grass and crown cover, one finds a wide variety of vegetation formations ranging from more open (e.g. a *cerrado típico* in Brazil (*e*,*f*)) to more closed formations like *cerradão* (*f*). Forests are characterized by tall vegetation and high crown cover, and the absence or the marginal presence of grasses, e.g. the tropical forests of Central Africa (*b*), gallery forests in Brazil (*d*–*f*). (*b*) Grassland–forest transition in Lope National Park, Gabon; (*c*) typical open–tall woodland transition in Ghana; (*d*) *campo sujo*–gallery forest transition near Brasilia (Brazil); (*e*) transition from *cerrado rupestre* to *cerrado denso*, with patches of gallery forests scattered on the landscape (Chapada dos Veadeiros, Brazil) and (*f*) transition from *cerrado típico* to *cerradão* (Serra das Araras, Mato Grosso, Brazil). Photo credits: (*b*) Sam Moore; (*c*–*f*) Imma Oliveras.

EKOSYSTÉMOVÉ FUNKCE

Megafauna and ecosystem function from the Pleistocene to the Anthropocene

Yadvinder Malhi[a,1], Christopher E. Doughty[a], Mauro Galetti[b], Felisa A. Smith[c], Jens-Christian Svenning[d], and John W. Terborgh[e]

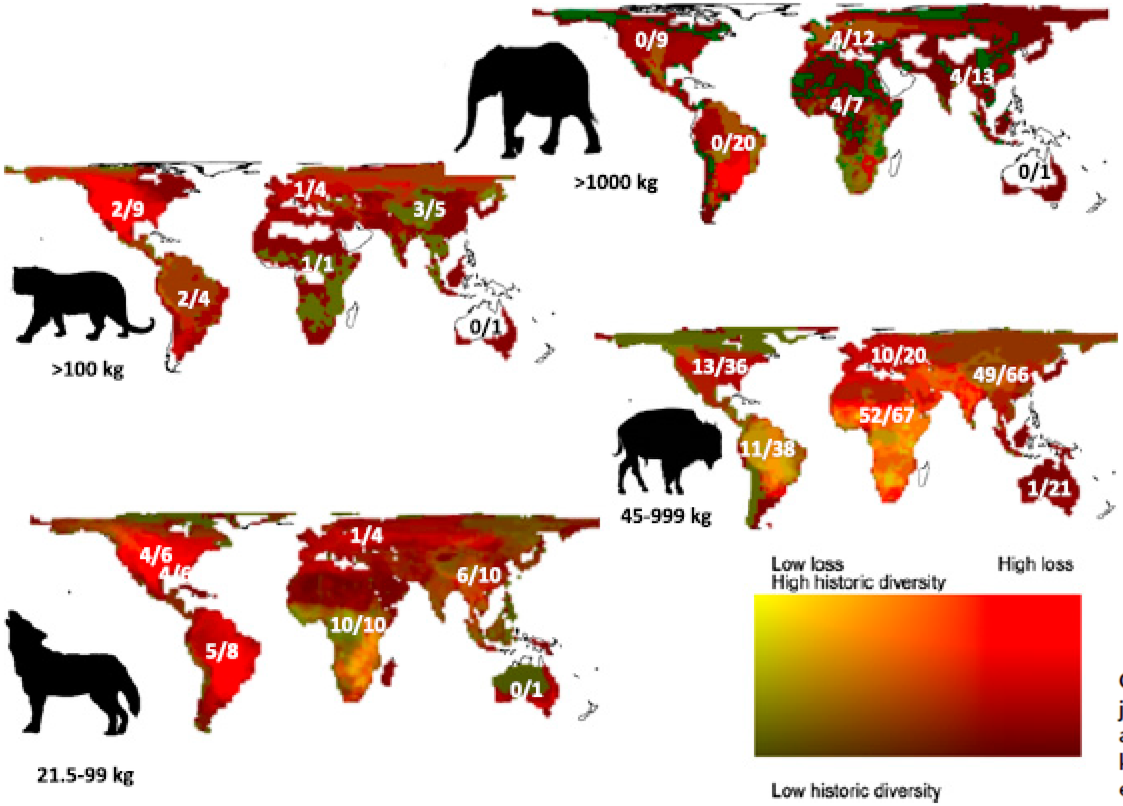

Fig. 1. Extant and lost megafauna, divided by continent and into megaherbivores (≥1,000 kg), megacarnivores (≥100 kg), large herbivores (45–999 kg), and large carnivores (21.5–999 kg).

Carnivores prey on the guilds below them, and to some extent on juveniles of herbivores above them. Megacarnivores can also limit the activity and abundance of the next-size class of carnivores (21.5–99 kg) by excluding them from prime habitat or killing them outright In each continent. The first number indicates the number of species remaining (often in greatly reduced abundance and restricted range), and the second number indicates how many would have existed in a Late Pleistocene baseline. Data from ref. 44. Background colors indicate prehistoric diversity and relative loss rate in each guild. Yellow/light green shows areas of high intrinsic megafaunal diversity and low loss (e.g., large herbivores in Africa), dark green indicates low historic diversity and low loss (e.g., large herbivores in high latitude North America), red indicates high diversity and high loss (e.g., Americas), and dark brown indicates low diversity and high loss (e.g., high latitude Eurasia).

EKOSYSTÉMOVÉ FUNKCE

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- large herbivores and carnivores (the megafauna) have been in a state of decline and **extinction** since the Late Pleistocene, both on land and more recently in the oceans
- consequences of these declines for ecosystem function
- understanding of how megafauna affect ecosystem physical and trophic structure, species composition, biogeochemistry, and climate
- understanding of changes in biosphere function since the Late Pleistocene and of the functioning of contemporary ecosystems
- offering a rationale and frame work for scientifically informed restoration of megafaunal function where possible and appropriate

EKOSYSTÉMOVÉ FUNKCE

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Yadvinder Malhi[a,1], Christopher E. Doughty[a], Mauro Galetti[b], Felisa A. Smith[c], Jens-Christian Svenning[d], and John W. Terborgh[e]

Ecosystem Physical Structure

- odstraňování stromové vegetace chobotnatci
- vyvrácení 1500 vzrostlých stomů na 1 sloního jedince a rok (Kruger National Park)
- 3 potenciální stavy ekosystému:
    - ”green world” of tree cover dominated by a bottom-up resource constraint (water or nutrients), and two consumer-controlled states
    - “a black world” controlled by fire dynamics
    - “brown world” controlled by herbivores
- loss of megafauna cascades through the trophic structure of terrestrial ecosystems, converting plant communities from topdown to bottom-up-regulation
- the exact direction of transition depends on the ecological roles of lost megafauna and also on rainfall seasonality and frequency of fire ignition
- in drier systems, or where human activity has greatly increased fire ignition frequency,
- the loss of grazers can increase grass fuel loads and lead to a shift to a fire-dominated ecosystem (a brown-to-black transition)
- in wetter systems, loss of browsing and grazing can lead to closed canopy forests (a brown-to-green transition)

EKOSYSTÉMOVÉ FUNKCE

Megafauna and ecosystem function from the Pleistocene to the Anthropocene

Yadvinder Malhi[a,1], Christopher E. Doughty[a], Mauro Galetti[b], Felisa A. Smith[c], Jens-Christian Svenning[d], and John W. Terborgh[e]

Ecosystem Physical Structure

- during Pleistocene glacials, the relationship between megafauna and vegetation cover may have been exacerbated through low atmospheric CO_2 concentrations, which further inhibited woody vegetation growth and made it more susceptible to browsing pressure
- megafaunal control of ecosystem state may exist in high northern latitudes (northern Eurasia and Beringia), determining the distribution of water-logged vegetation vs. a dry "mammoth steppe" that once supported a high biomass of megafauna, including mammoths, horses, and bison
- heavy grazing maintained these steppes by suppressing woody growth, stimulating production by deeprooted, grazing-resistant grasses, and accelerating nutrient cycling in this cold climate through consumption and egestion

EKOSYSTÉMOVÉ FUNKCE


Megafauna and ecosystem function from the Pleistocene to the Anthropocene

Yadvinder Malhi[a,1], Christopher E. Doughty[a], Mauro Galetti[b], Felisa A. Smith[c], Jens-Christian Svenning[d], and John W. Terborgh[e]

Ecosystem Trophic Structure

- large herbivores and carnivores both play an important role in shaping the abundance and composition of the whole animal community
- large herbivores have effects through habitat as outlined above but can also suppress smaller herbivore species through competition
- top carnivores play an important role in ecosystem stability by regulating the abundance and behaviors of lesser herbivores (such as deer) and mesopredators
- much of the effect of top carnivores comes from behavior change in herbivores because they avoid vulnerable parts of the “landscapes of fear” that carnivores create
- for example: reintroductionof wolves into Yellowstone National Park, which seems to have decreased browsing pressure by American elk (Cervus elaphus) on exposed alluvial floodplains, resulting in regrowth of willow tree cover and reduced erosion and river sediment content
- the loss of keystone species can induce trophic cascades that lead to habitat change, shifting the abundance of other species, and can lead to further extinction

- the **loss of megafauna** can result in an increased abundance of **smaller herbivores** and **predators** and can lead to **simpler ecosystems** with **few interspecific interactions**, **shorter food chains**, and **less functional redundancy and resilience**

EKOSYSTÉMOVÉ FUNKCE

Megafauna and ecosystem function from the Pleistocene to the Anthropocene

Yadvinder Malhi[a,1], Christopher E. Doughty[a], Mauro Galetti[b], Felisa A. Smith[c], Jens-Christian Svenning[d], and John W. Terborgh[e]

Vegetation Community Composition and Diversity

- correlations between seed dispersal syndrome and tree stature and wood density would lead to changes in ecosystem biomass and carbon stocks as a consequence of the loss of megafaunal seed dispersal
- megafaunal herbivory can affect woody species composition by promoting browsing-tolerant vegetation
- in African savannas, browsers shift the species composition toward dominance by thorny acacias and chemically defended species
- several apparent “fire adaptations” on plants, such as sclerophyllous leaves and thick bark, could also be used to deter large herbivores

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Ecosystem Biogeochemistry

- large animals play a disproportionately important role in accelerating ecosystem biogeochemical cycling
- nutrients that would be locked for years in leaves and stems are liberated for use through animal consumption, digestion, defecation, and urination
- on nutrientpoor soils and in low-productivity dry or cold climates, where megafaunal guts can act as giant warm and moist incubating vats that accelerate otherwise slow nutrient cycling
- because of their high food consumption rates, long gut residence times, and large diurnal movement ranges, megafauna can also play a disproportionate role in the **lateral movement** of nutrients across landscapes through their feces and urine
- in the **oceans**, a similar megafaunal nutrient transfer occurs, with whales and other marine mammals consuming nutrients in the deep ocean and transferring them to the surface through feces and physical mixing
- global megafaunal **nutrient pump** that works against the abiotic entropic flow of nutrients from weathering continents to oceanic sediments, an interlinked system recycling nutrients, with whales moving nutrients from the deep sea to surface waters, anadromous fish and seabirds moving nutrients from the ocean to land, and terrestrial megafauna moving nutrients away from hotspots, such as river floodplains, into the continental interior

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Ecosystem Biogeochemistry

- magnitudes of nutrient fluxes and estimate that the vertical ocean pump has declined by 77%, the sea-to-land pump has reduced by 94%, and the terrestrial diffusion of these nutrients has decreased by 92%
- in these studies, **phosphorus** has been used as the metric for nutrient transfer. However, a very similar framework could be applied to many other potentially limiting micronutrients, such as **sodium** on land (87) and **iron** in the oceans

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Regional and Global Climate

- through consumption and digestion, megafauna can have impacts on biogeochemical cycling, including the release of greenhouse gases
- massive size can alter vegetation and soil structures and composition through trampling or browsing which can affect soil biogeochemical processes, alter water tables and soil methane emissions, and also affect land surface albedo and evapotranspiration
- potent impact on climate after the extinctions may have been through the modification of albedo at high latitudes through effects on tree cover
- assessment of the net impact of tree cover on climate requires consideration of carbon, evapotranspiration, and albedo impacts
- in regions with abundant winter snow cover, trees tend to warm the surface (92) because they are dark features that peek above highly reflective snow
- at lower latitudes and local scales, if increased tree cover increases evapotranspiration, surface evaporative cooling, and the formation of reflective clouds, the loss of megafauna may lead to a net cooling
- increased reflectivity cools the surface, helping to keep large reserves of soil carbon from decomposing (methane emissions)

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Practical Insights and Applications for the Anthropocene

- ecological role of megafauna, notably via habitat structure and trophic cascades, is increasingly discussed in a conservation context
- overhunting of seed dispersers, such as large monkeys and tapirs, will lead to a long-term decline in high biomass tree species, and thereby a decline in the carbon stock even in structurally intact forests
- beyond a pure focus on animal loss, however, an opportunity exists to explore how to rebuild the ecosystem functions provided by large animals /megafauna comebacks: e.g., brown bear (Ursus arctos) and wolf (Canis lupus)/
- restoring native top predators helps suppress invasive mesopredators or invasive herbivores to the benefit of native species
- exotic top predators may provide similar effects, by replacing lost native species
- e.g. dingo (Canis lupus dingo), which, by suppressing invasive mesopredators and herbivores, is reported to have positive effects on a range of native species in Australia

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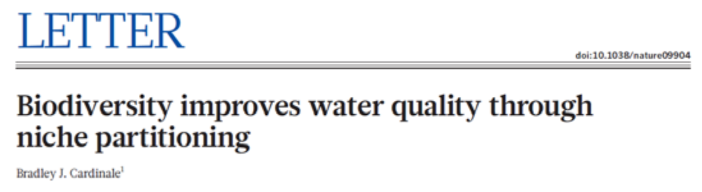

LETTER

doi:10.1038/nature09904

Biodiversity improves water quality through niche partitioning

Bradley J. Cardinale[1]

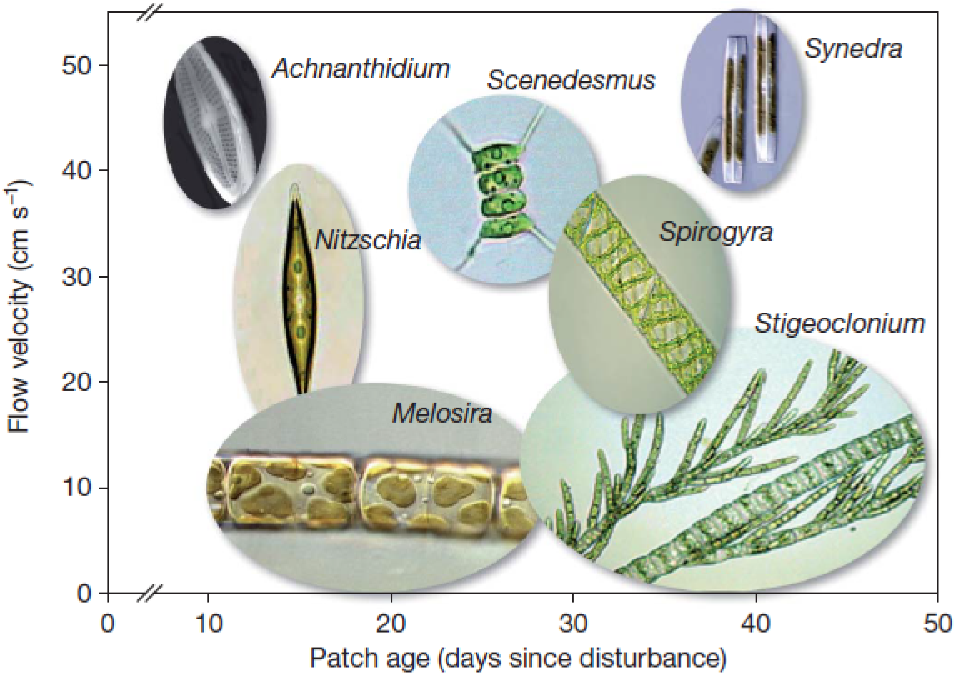

Figure 2 | Niche partitioning by algae. The ovals show the mean (centre of image) ± 95% confidence interval (boundary of image) of cell densities along two axes of a species niche (successional age of habitat and near-bed velocity). Filamentous algae that are susceptible to shear (*Melosira* and *Stigeoclonium*) were abundant in low-velocity habitats. Single-celled diatoms that grow prostrate to a surface (*Achnanthidium* and *Synedra*) achieved the highest densities in high-velocity habitats. Early successional habitats were dominated by small diatoms with fast rates of growth (*Achnanthidium* and *Nitzschia*), whereas late successional habitats were dominated by slow-growing cells, colonies or filaments (*Stigeoclonium*, *Spirogyra* and *Synedra*). *Navicula* is not plotted, because it failed to establish itself in polyculture despite growing in monoculture.

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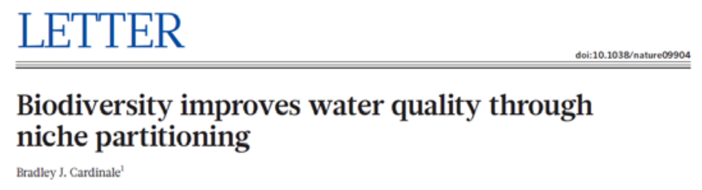

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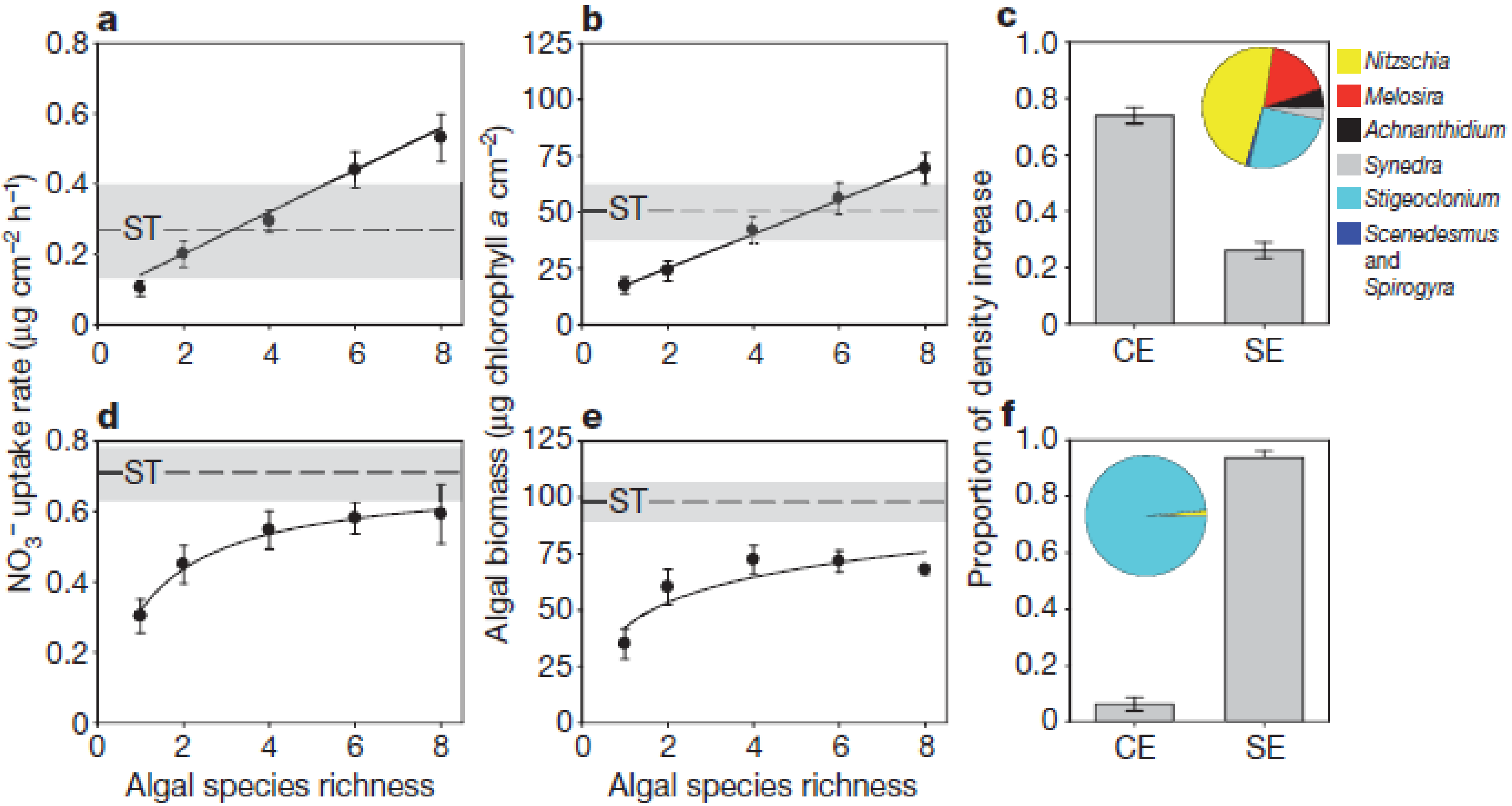

Figure 1 | Algal diversity effects on NO_3^-, algal biomass and final population sizes. **a–c**, Heterogeneous streams, with flow varying spatially and habitats varying in successional age. **d–f**, Homogeneous streams, in which niche opportunities had been removed. Data are presented as mean ± s.e.m. of 24 replicates for monocultures, 15 replicates for 2–6 species polycultures and 6 replicates for 8-species polycultures. Best fitting functions (Table 1) are plotted as solid lines. The horizontal line and the grey shaded area show mean ± s.e.m. for *Stigeoclonium*, which achieved the highest values of all of the monocultures. **c**, **f**, The proportion of increased polyculture cell densities driven by niche complementarity (CE) or selection effects (SE; that is, the influence of dominant species).

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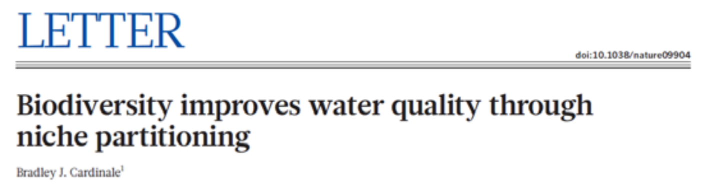

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- diverzita neovlivnila absorbci NO_3 vztaženou na jednotku biomasy
- however, a significant proportion of the variation in NO_3 uptake could be explained by differences in the total algal biomass among streams
- algal biomass was a linear function of diversity across the range of richness used in the study, increasing by 7.67 mg chlorophyll a cm^{-2} for each additional species
- increased algal biomass, and consequently the higher rate of NO_3 uptake, led to a strong relationship between algal species richness and the total amount of nitrogen stored in the biofilm at the end of the experiment

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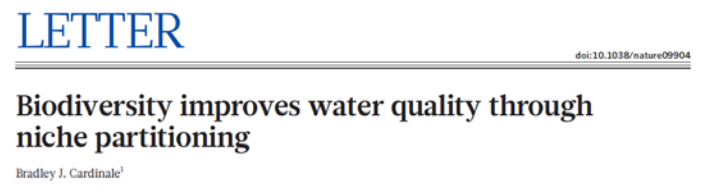

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- ecosystems with more species are more efficient at removing nutrients from soil and water than are ecosystems with fewer species
- niche partitioning among species of algae can increase the uptake and storage of nitrate
- manipulated the number of species of algae growing in the biofilms of 150 stream mesocosms that had been set up to mimic the variety of flow habitats and disturbance regimes that are typical of natural streams

- nitrogen uptake rates, as measured by using ^{15}N-labelled nitrate, increased linearly with species richness and were driven by niche differencesamong species
- as different forms of algae came to dominate each unique habitat in a stream, the more diverse communities achieved a higher biomass and greater ^{15}N uptake
- when these niche opportunities were experimentally removed by making all of the habitats in a stream uniform, diversity did not influence nitrogen uptake, and biofilms collapsed to a single dominant species
- these results provide direct evidence that communities with more species take greater advantage of the niche opportunities in an environment, and this allows diverse systems to capture a greater proportion of biologically available resources such as nitrogen
- **one implication is that biodiversity mayhelp to buffer natural ecosystems against the ecological impacts of nutrient pollution**

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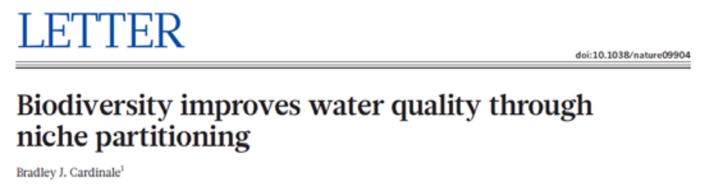

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- Buffering against nutrient pollution will require not only the conservation of biodiversity, but also conservation of the forms of environmental heterogeneity that create niche opportunities and allow species to coexist.