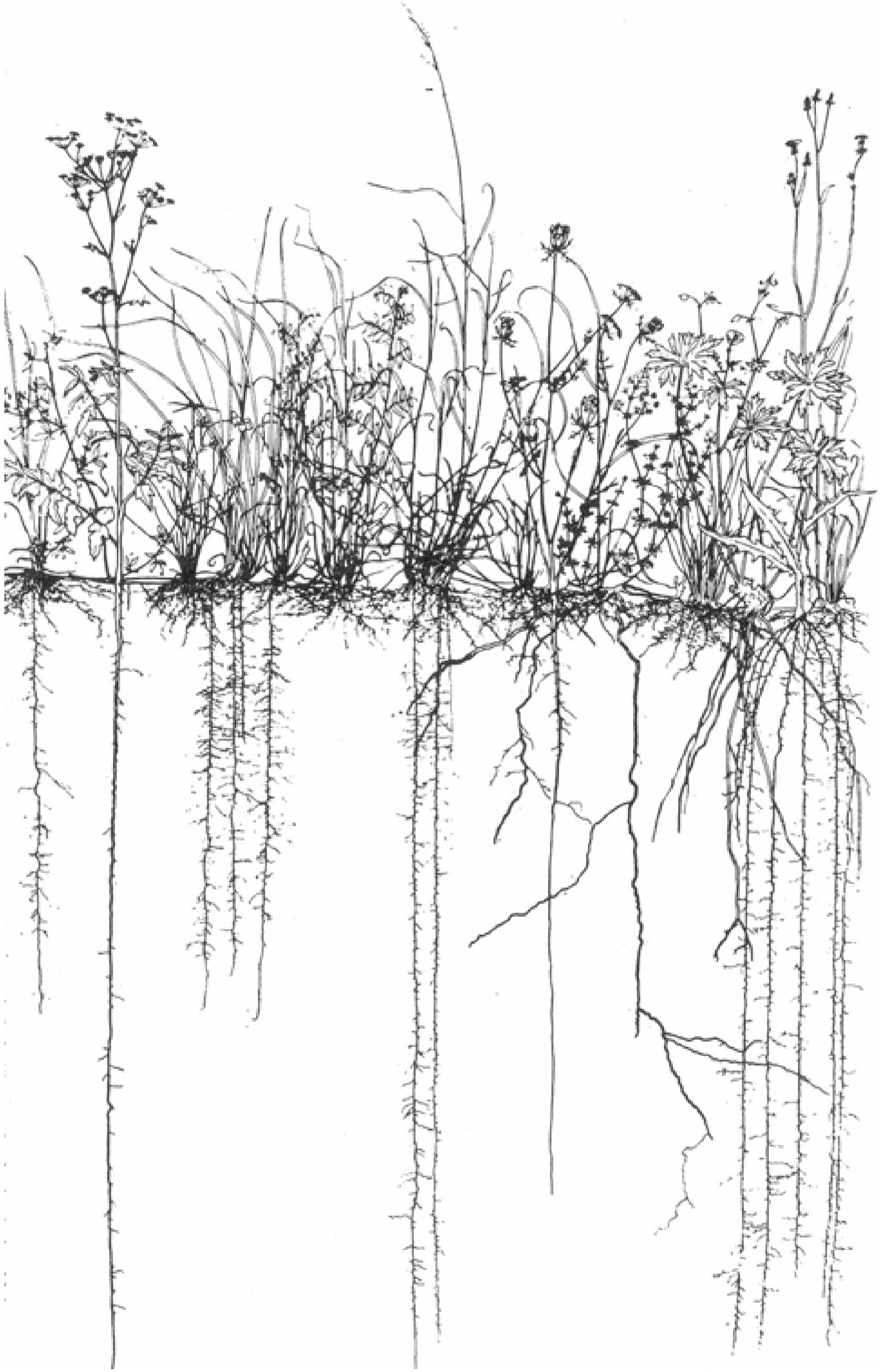
Sekundärstoffe

und

Biodiversität



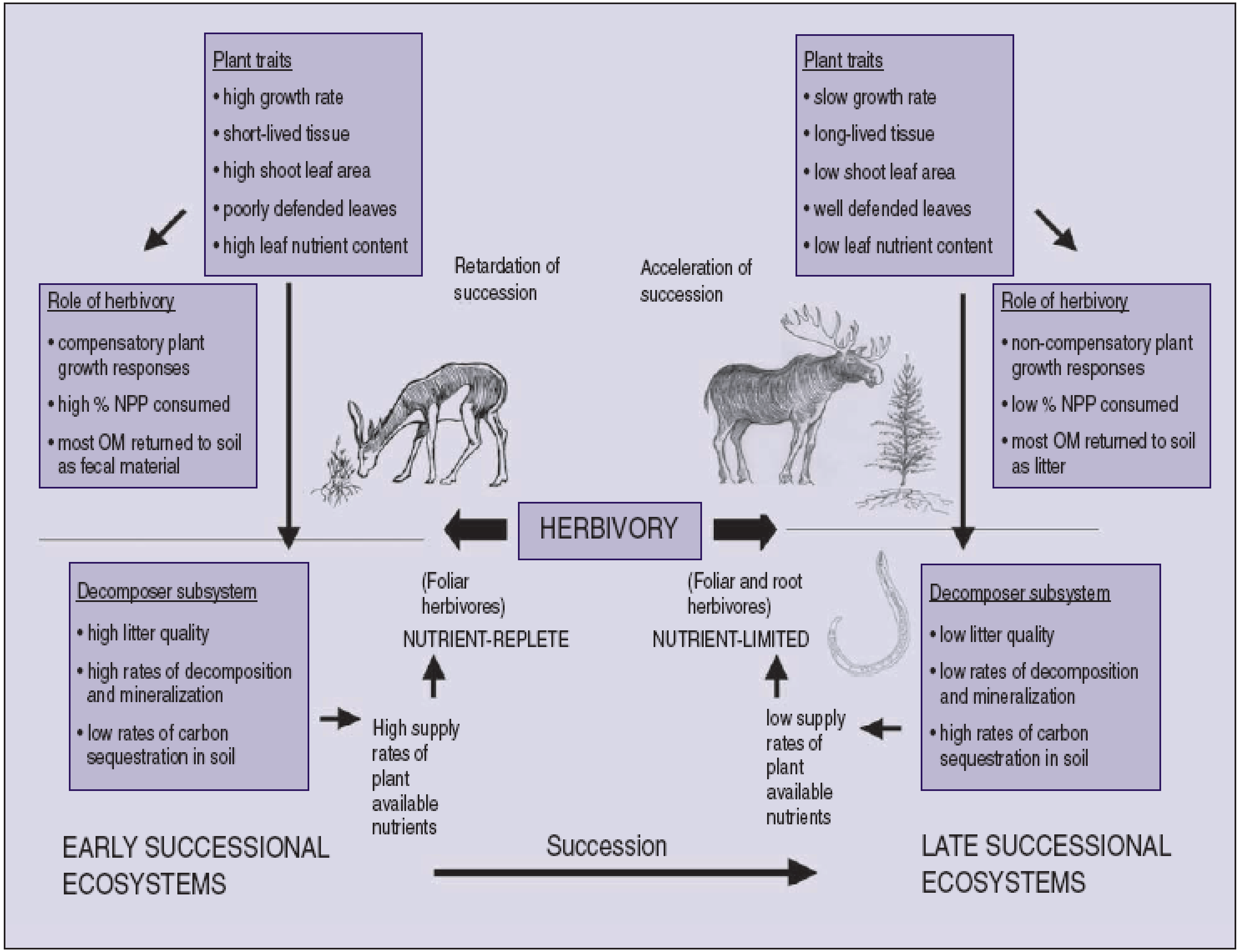


Figure 2. *How browsing mammals can alter vegetation succession (Bardgett and Wardle 2003).*

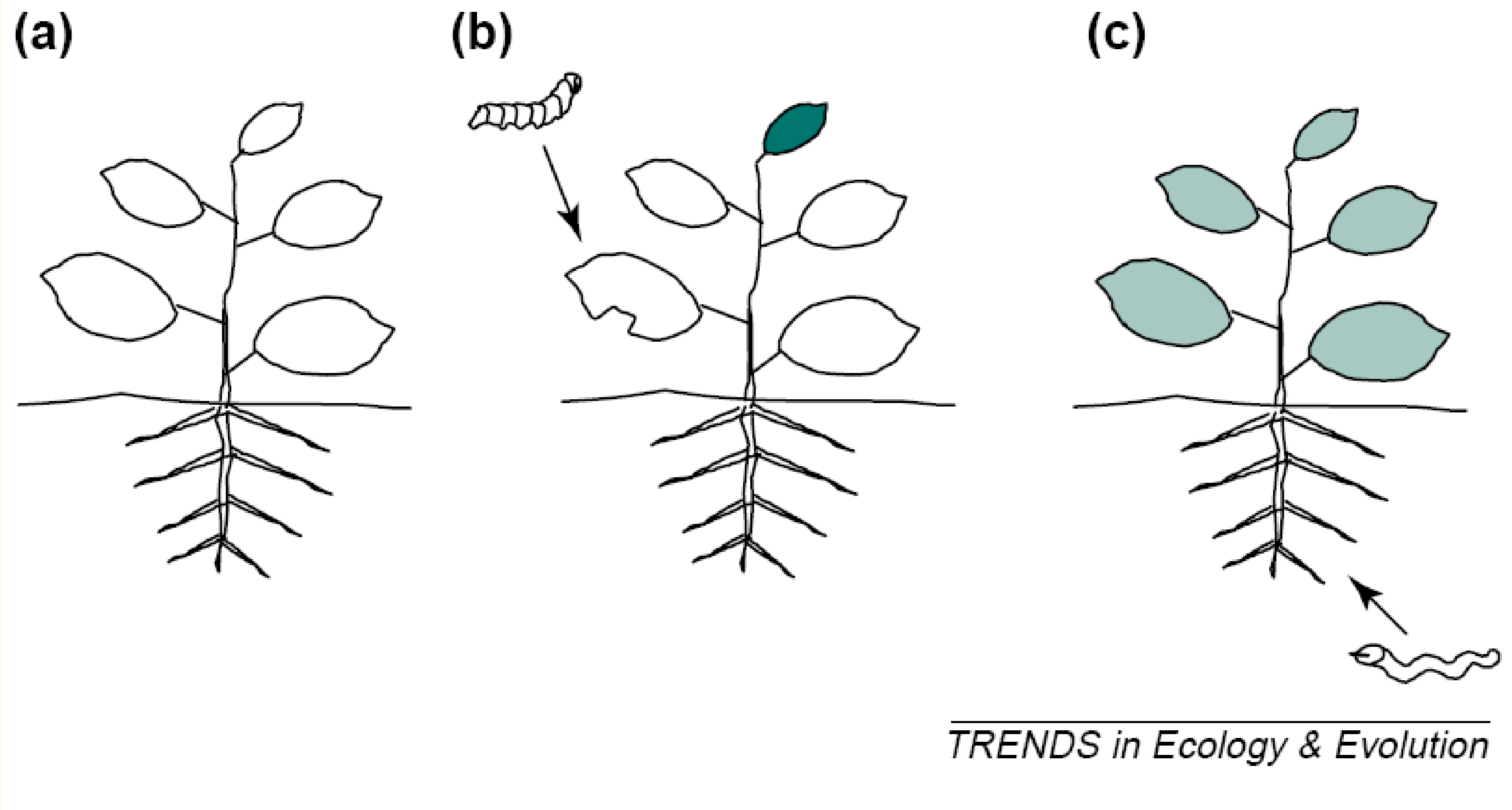
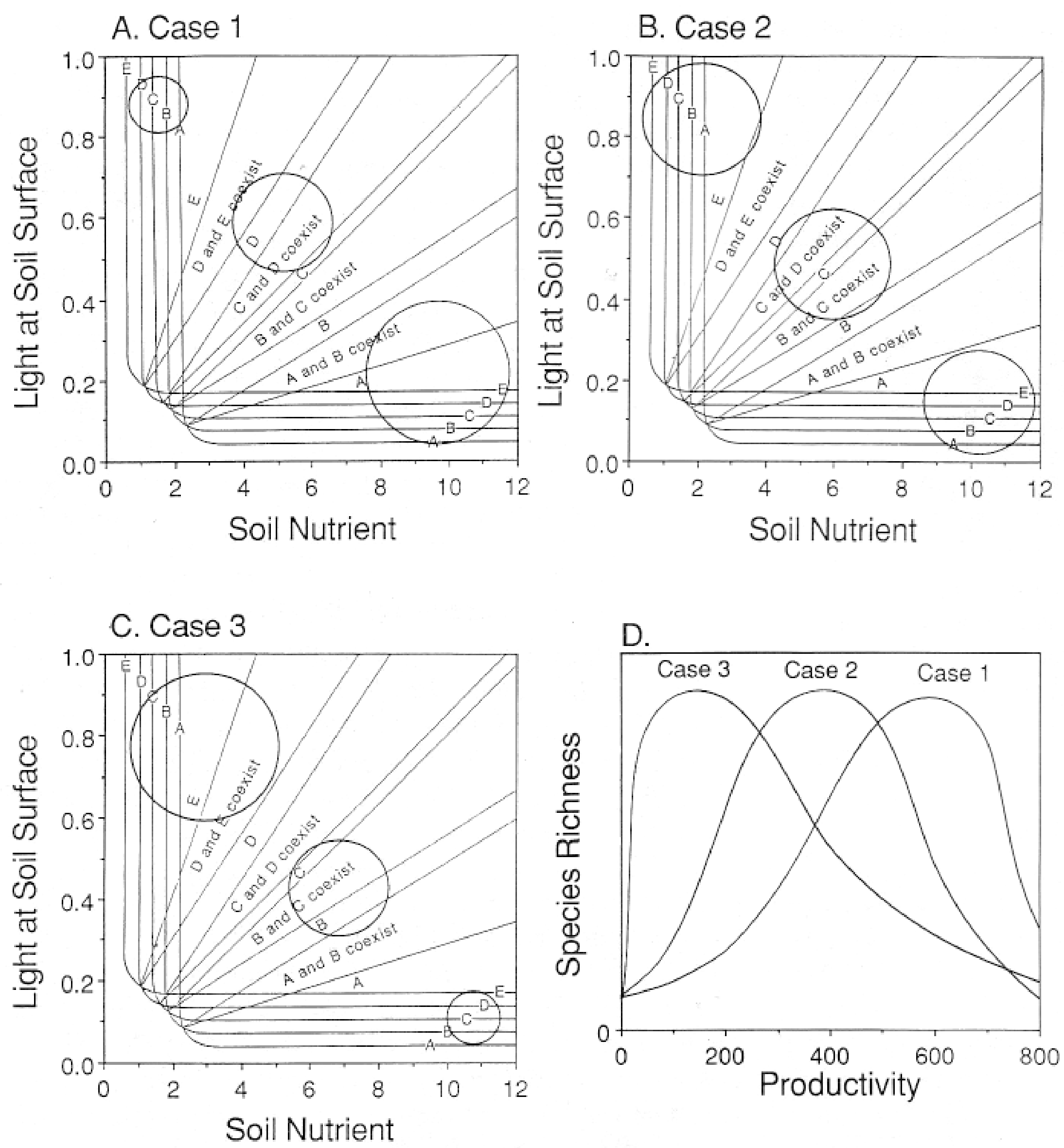


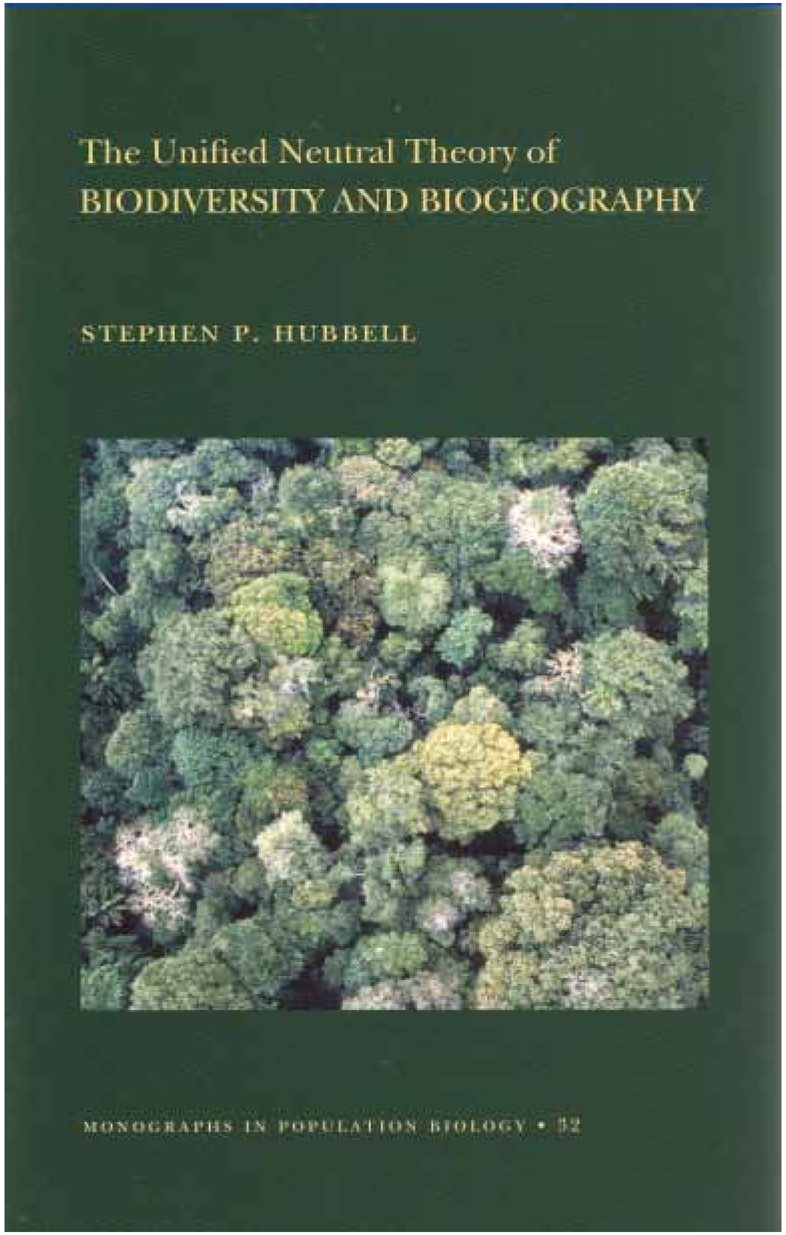
Figure I. Spatial differences in the induction of aboveground direct defense in cotton plants experiencing no herbivory **(a)**, and after aboveground **(b)** and belowground **(c)** herbivory. Shading of leaves indicates the level of induction (white, no induction; light green, low induction; dark green, high induction).

1993



Nischendifferenzierung durch Resourcengradienten

2001


The Unified Neutral Theory of
BIODIVERSITY AND BIOGEOGRAPHY
STEPHEN P. HUBBELL
MONOGRAPHS IN POPULATION BIOLOGY • 32

Biotische Interaktionen

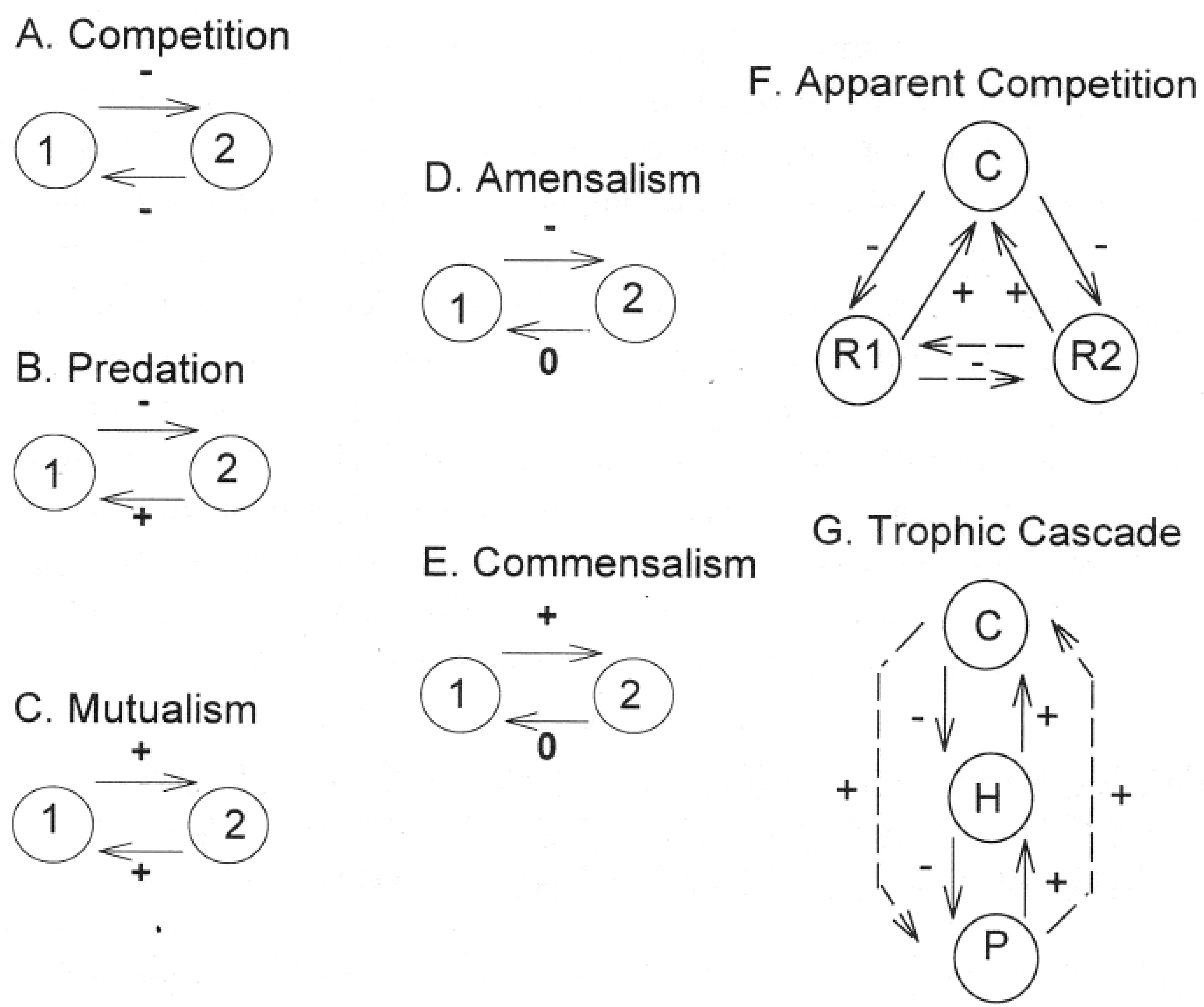


FIGURE 1.7. *Examples of direct and indirect interactions among species in communities. Direct effects are indicated by solid lines, with signs corresponding to the signs of interactions between the species. Net indirect effects are indicated by broken lines. C, consumer; R1, resource 1; R2, resource 2; P, primary producer, H, herbivore.*

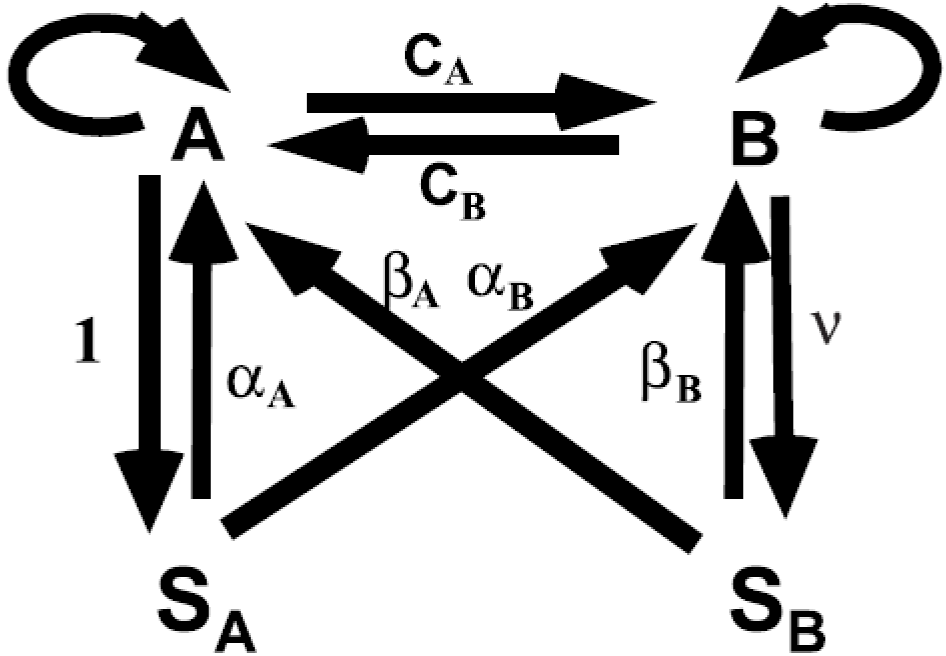
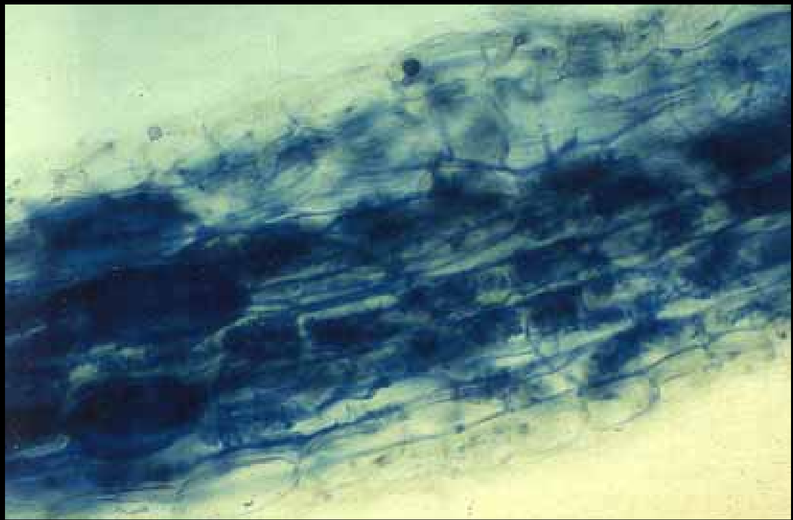


Fig. 1 In this figure, we present the potential interactions between two plant species, *A* and *B*, and their soil communities, represented by S_A and S_B, respectively. The presence of plant A causes a change in its associated soil community (i.e. an increase in S_A) that can then directly alter the growth of plant *A*, represented by the parameters α_A, or alter the growth of plant *B*, represented by the parameter α_B. Similarly, plant *B* can have direct feedback on its own growth, represented by β_B, as well as indirect feedback through changes in the growth of plant *A*, represented by the parameter β_A. The two plant species can also have direct density dependence on their own growth and competitive effects on each other's growth.

Mutualismus

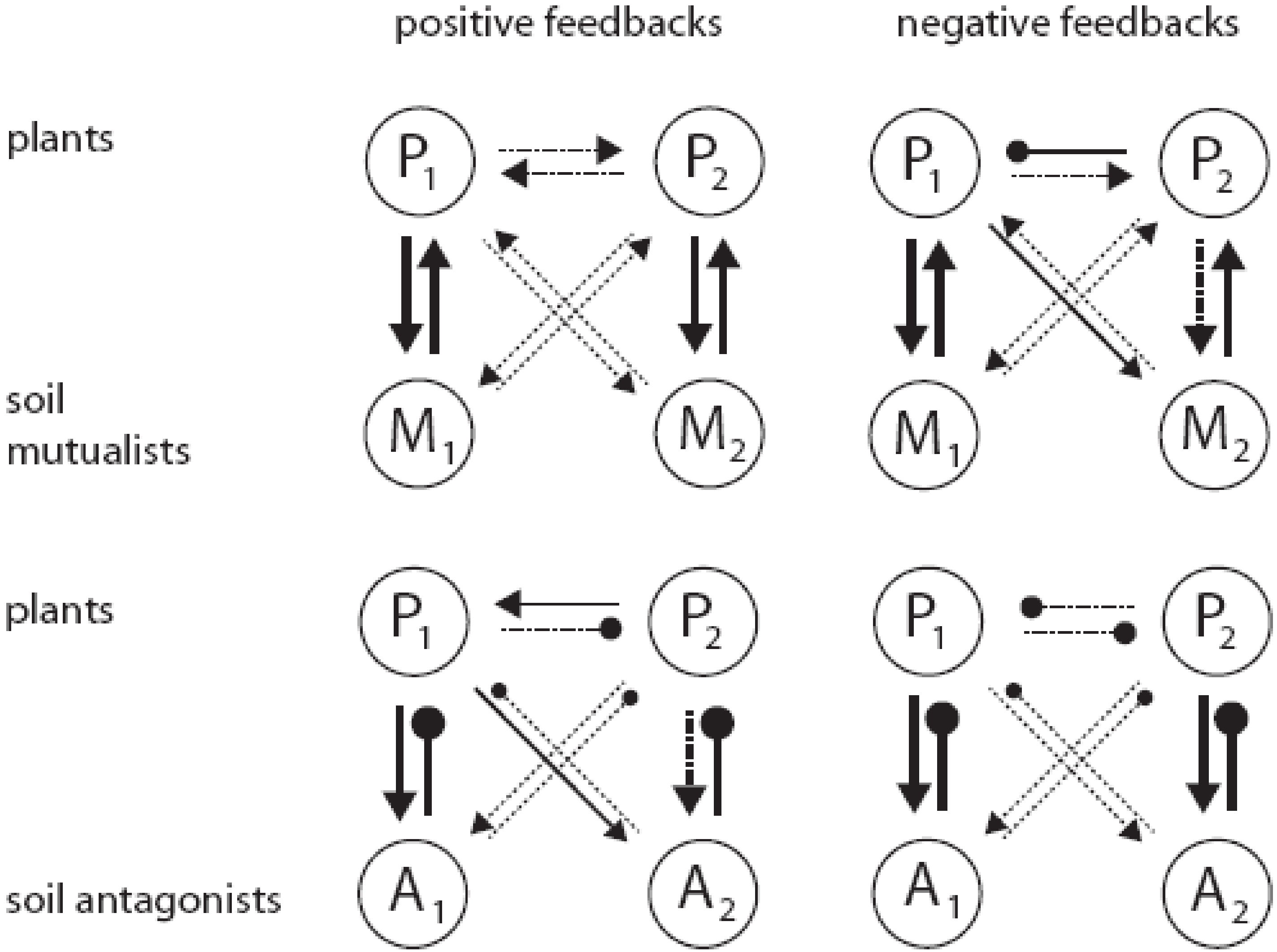


arbuskuläre Mykorrhiza
Symbiose eines Zygomyceten
mit höheren Pflanzen

Antagonismus

Wurzelfäule

Bever (2003):


positive feedbacks
negative feedbacks
plants
soil mutualists
plants
soil antagonists
P1
P2
M1
M2
A1
A2

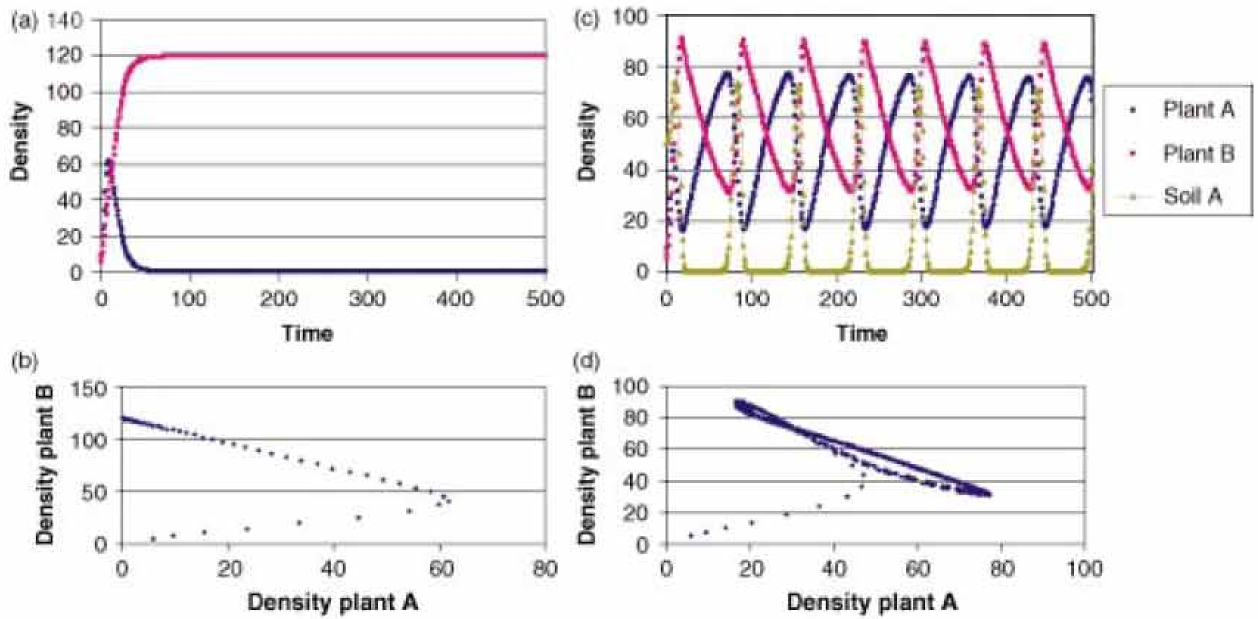
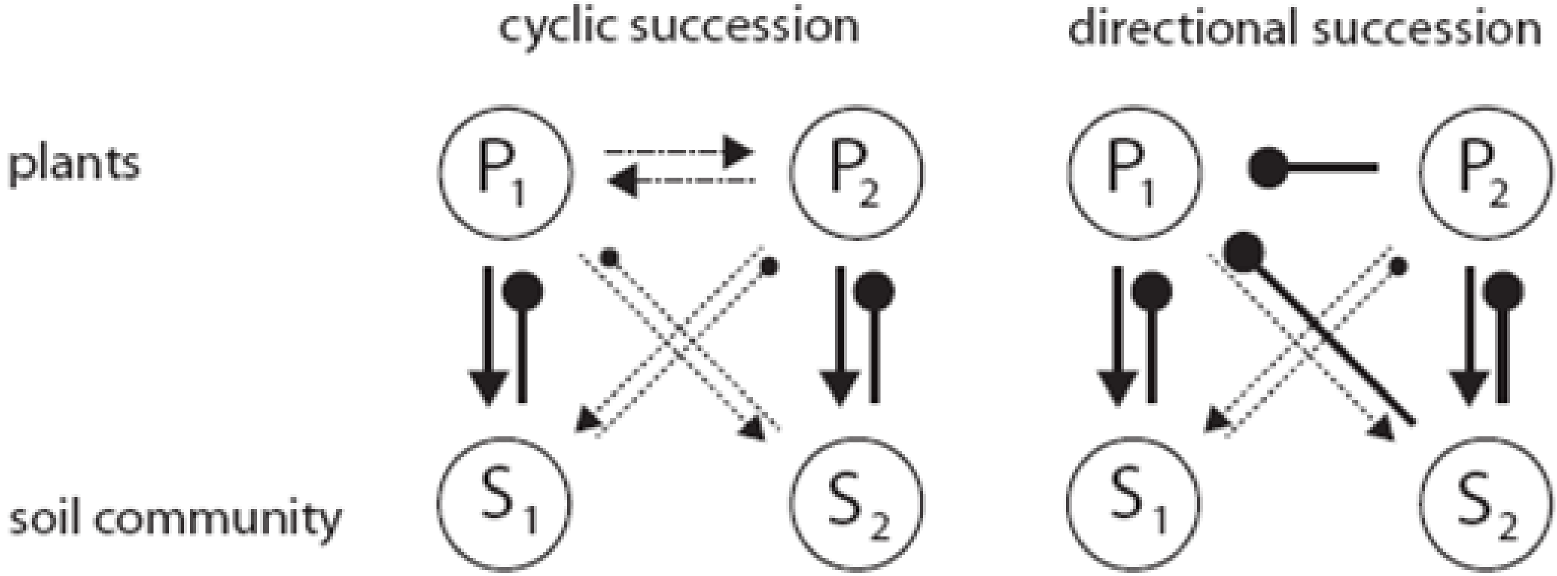


Fig. 4 Illustration of the potential role of soil community dynamics in plant species coexistence. In all simulations, $K_A = 100$, $K_B = 120$, $r_A = 0.7$, $r_B = 0.5$, $c_A = 0.885$ and $c_B = 0.98$. In the absence of soil community dynamics Plant B is a superior competitor and quickly replaces Plant A (a,b). However, the plant species coexist over the long-term in the presence of strong negative soil community feedback ($\alpha_A = -0.03$, $\alpha_B = 0.1$, $\beta_A = 0.1$, $\beta_B = -0.2$, $v = 0.8$). The soil community dynamics drives oscillations in the abundance of the two plant species (c,d).

van der Putten (2003):



$$\frac{dN_A}{dt} = r_A N_A \left(1 + \alpha_A S_A + \beta_A S_B - \frac{N_A + c_B N_B}{K_A}\right), \quad \text{Eqn 1}$$

$$\hat{N}_A = K_A (1 + \alpha_A S_A + \beta_A S_B) - c_B N_B \quad \text{Eqn 2}$$

$$\frac{dS_A}{dt} = S_A(1 - S_A)\left(\frac{N_A}{N_A + N_B} - \nu \frac{N_B}{N_A + N_B}\right), \quad \text{Eqn 3}$$

$$K_A (1 + \alpha_A) < \frac{K_B}{c_A}(1 + \alpha_B) \text{ and } K_B (1 + \beta_B) < \frac{K_A}{c_B}(1 + \beta_A).$$

Eqn 4

$$c_A c_B < \frac{(1 + \alpha_B)(1 + \beta_A)}{(1 + \alpha_A)(1 + \beta_B)} \quad \text{Eqn 5}$$

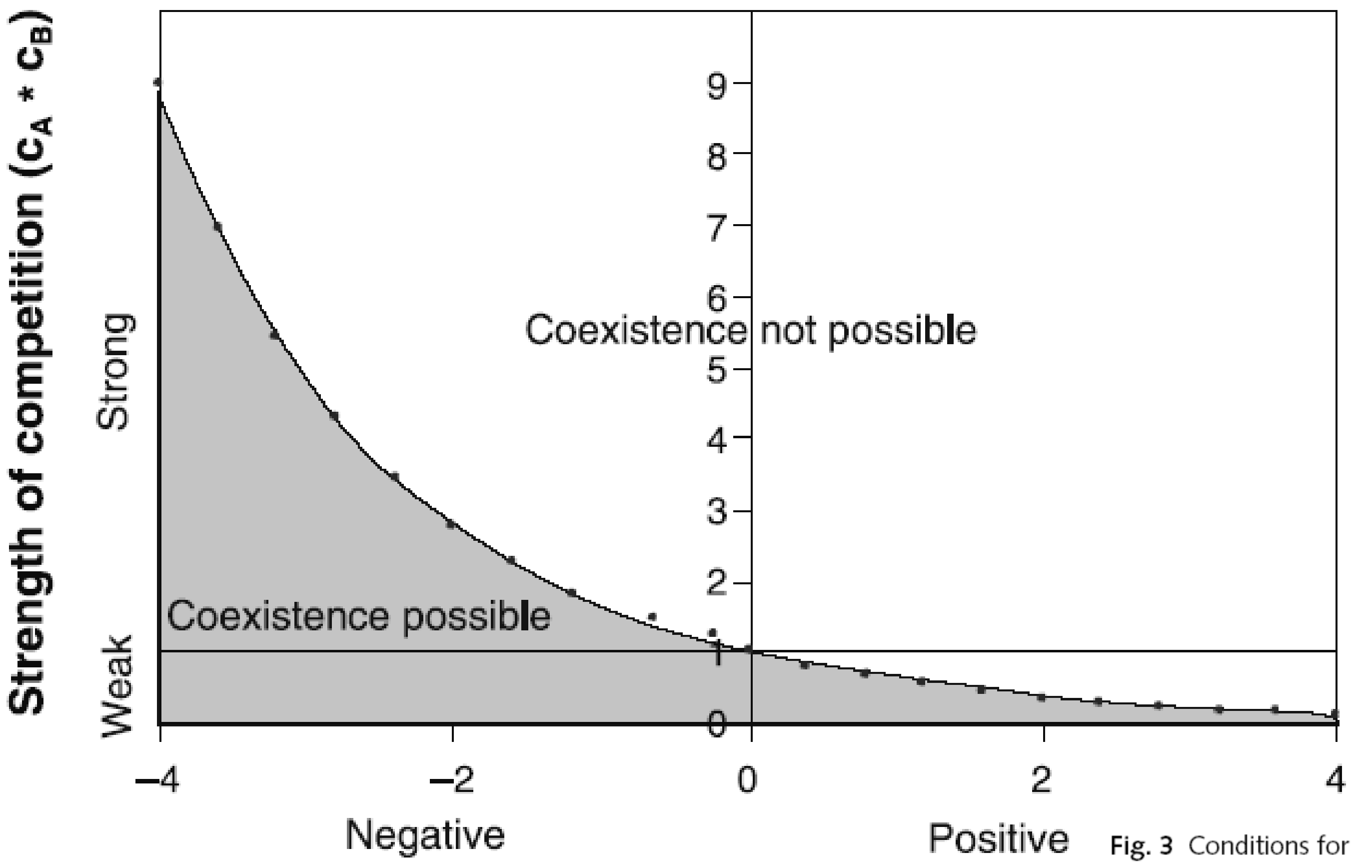
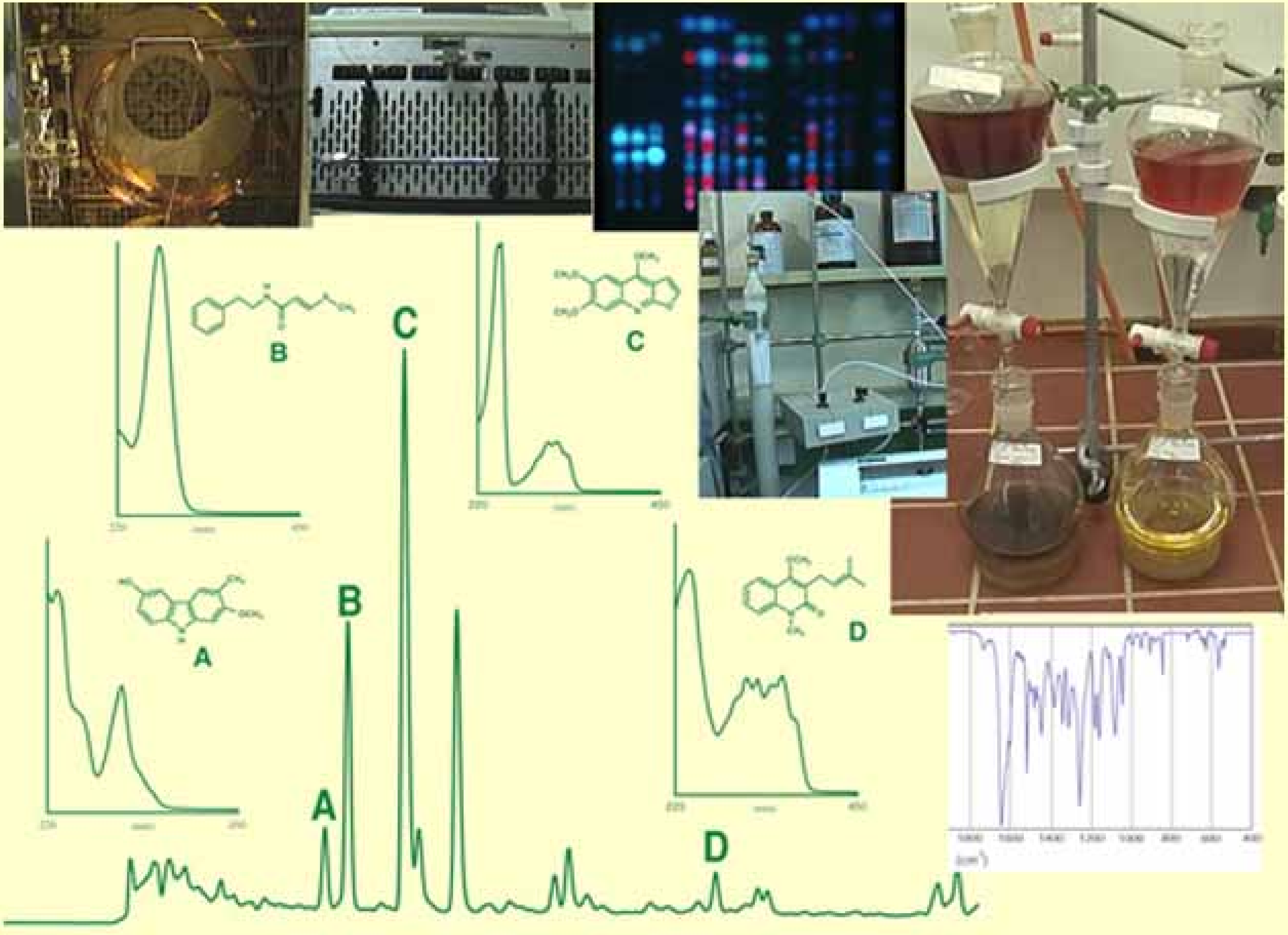


Fig. 3 Conditions for coexistence of competing plant species in the presence of soil community feedback. The shaded region represents the parameter values in which the coexistence of competing plant species is possible as a function of both the strength of interspecific competition and the strength of soil community feedback. The strength of interspecific competition is represented by the product of the competition coefficients ($c_A * c_B$). The strength of soil community feedback is represented by the parameter I_s, where $I_s = \alpha_A - \alpha_B - \beta_A + \beta_B$. In the absence of soil community feedback (i.e. where $I_s = 0$), coexistence is only possible when interspecific competition is weak (i.e. $c_A * c_B < 1$). However, negative soil community feedback increases the possibilities that competing species can coexist. Note that this relationship was calculated assuming that direct and indirect feedback were of equivalent magnitude; the function would vary slightly with differences in the relative magnitude of direct and indirect feedback.



column chromtaography, extraction,
HPLC, IR

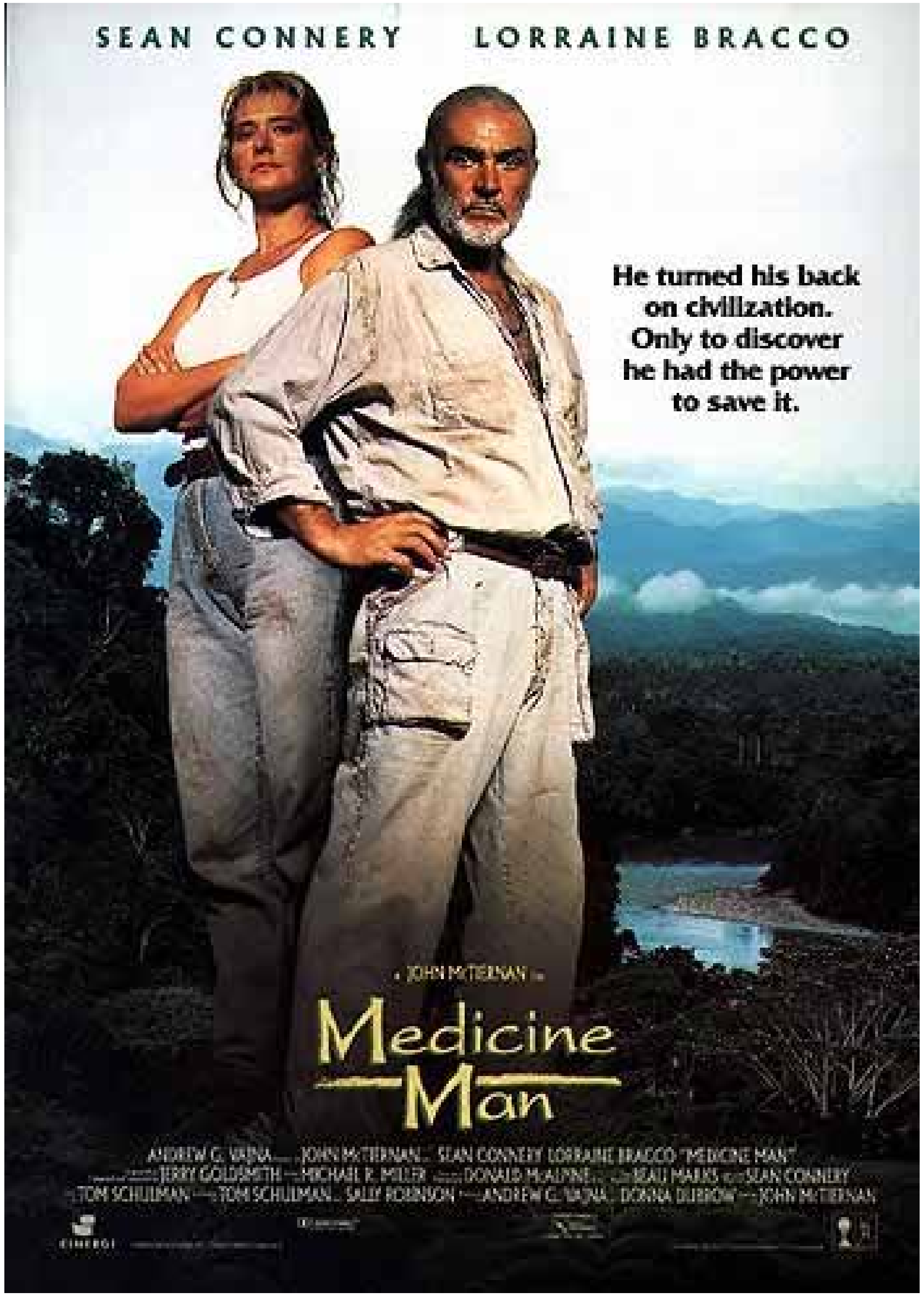
antibakteriell,

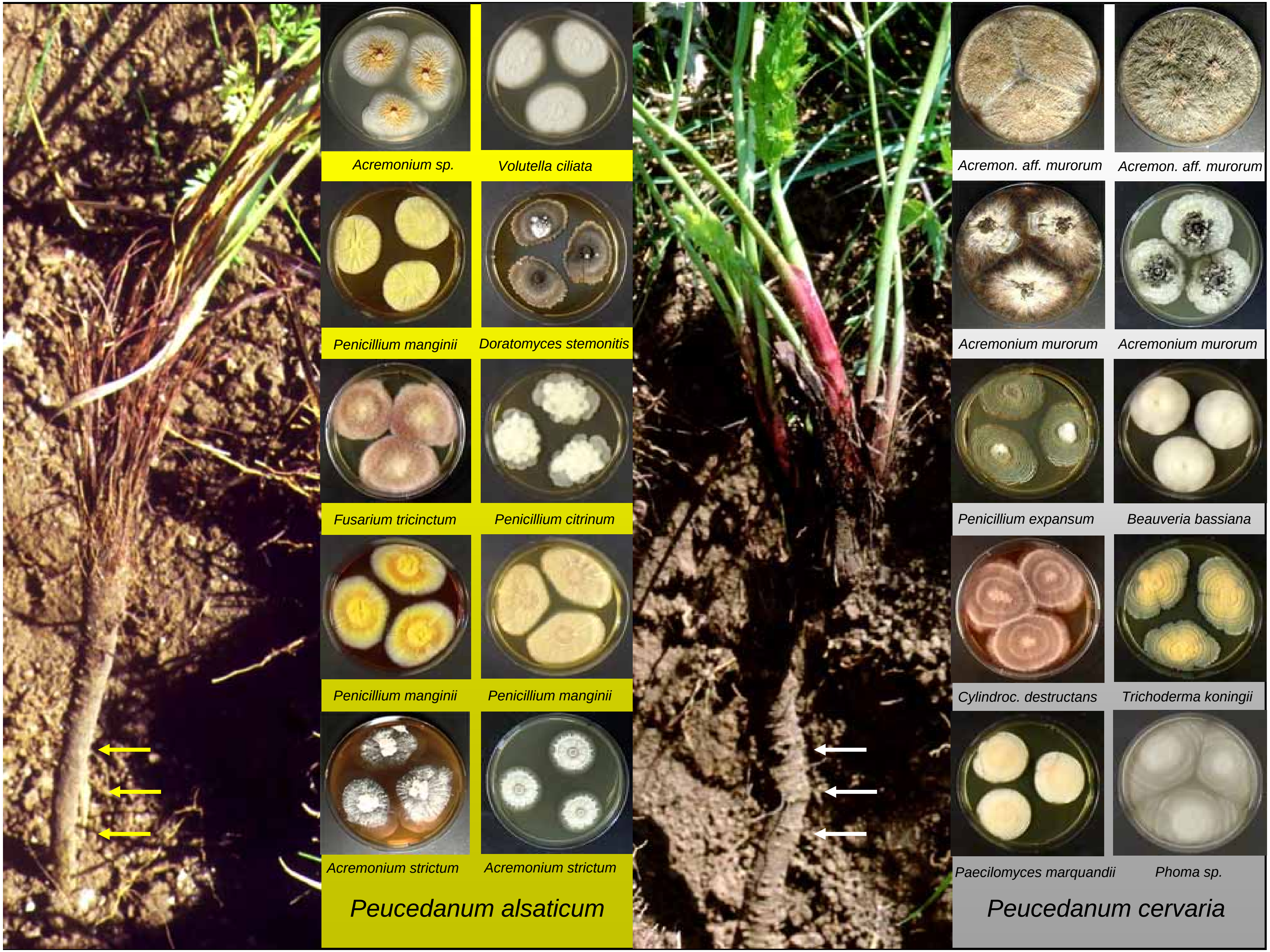
antifungal,

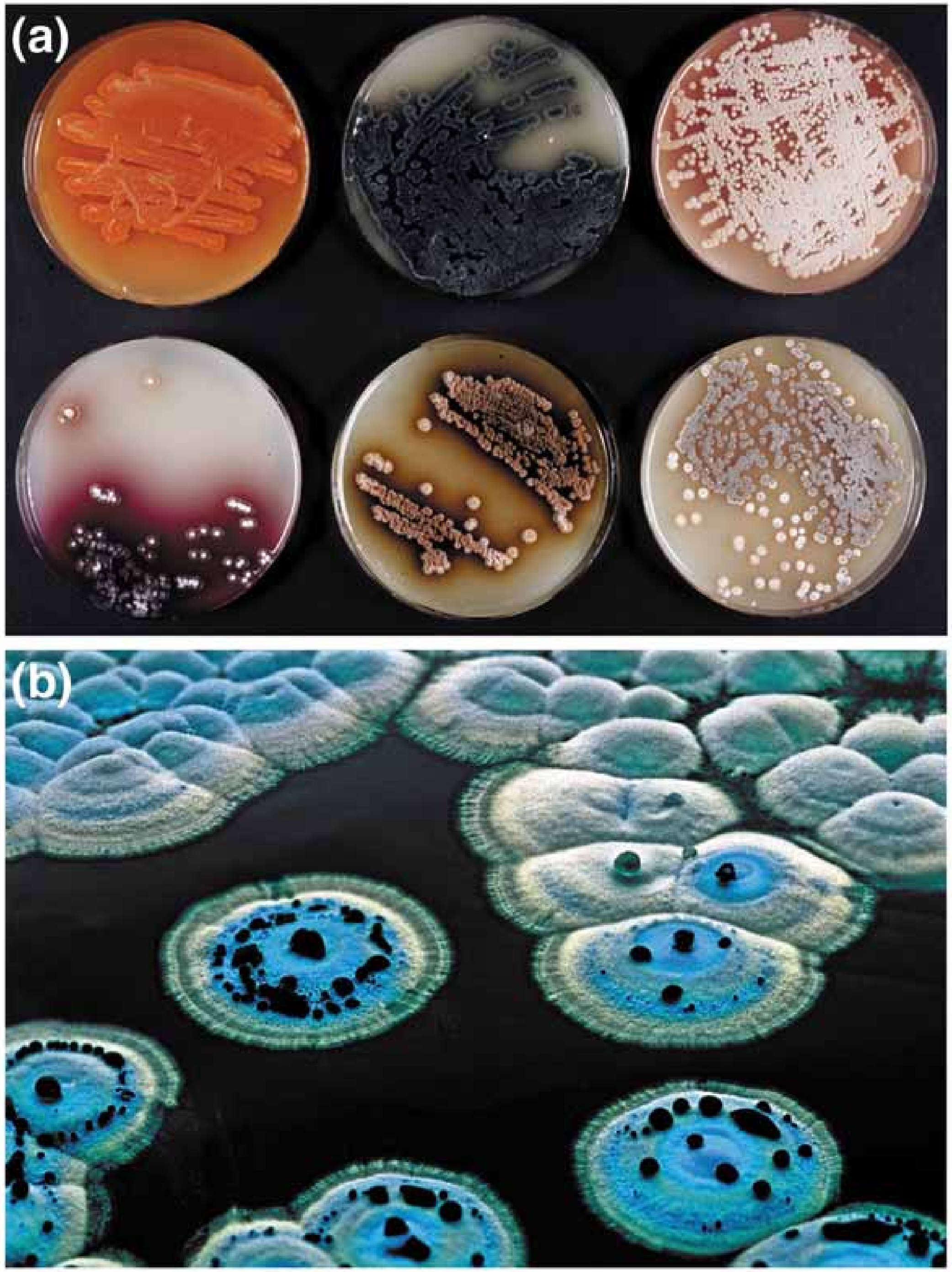
antiviral,

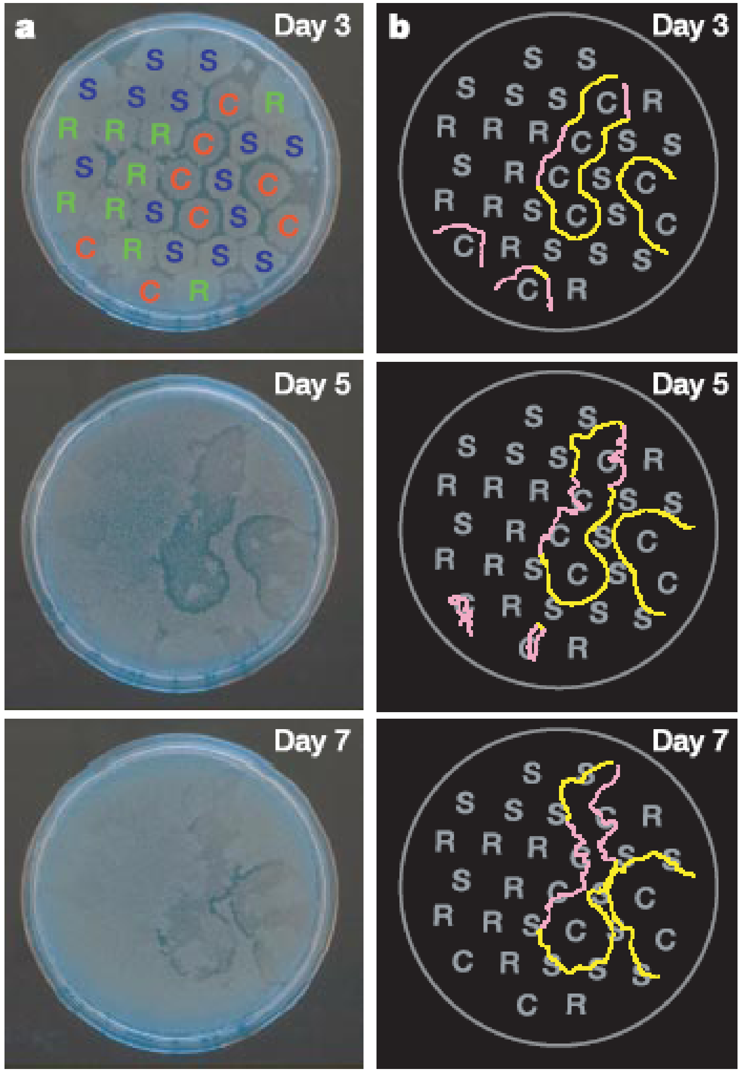
insektenabschreckend,

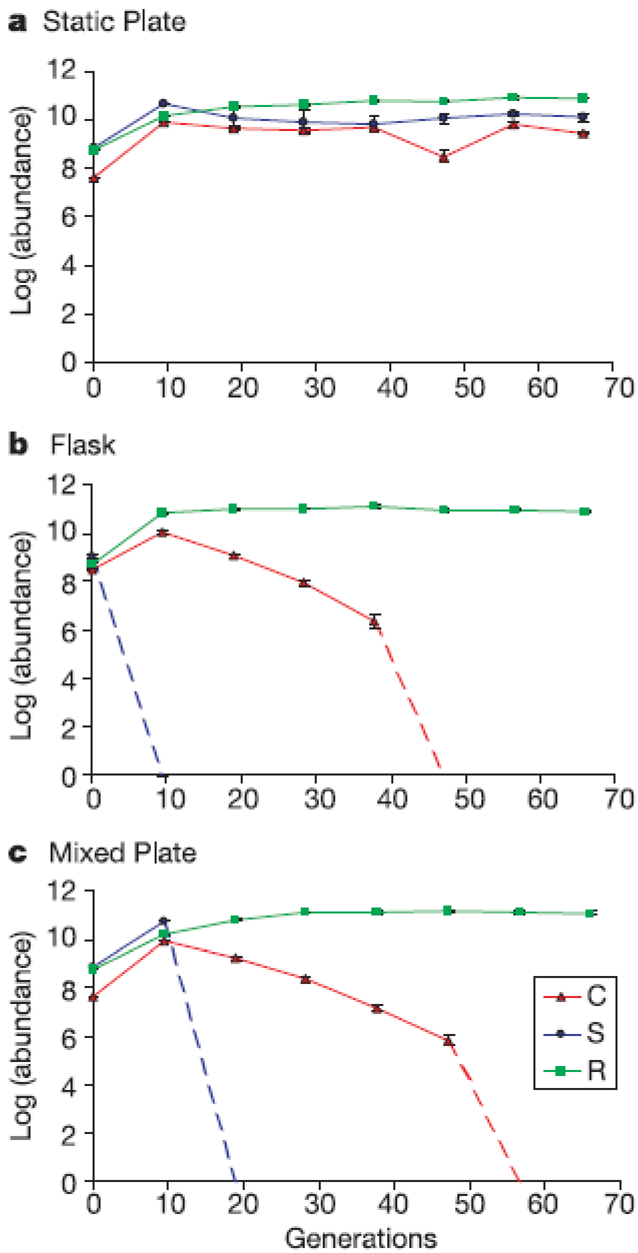
.....


SEAN CONNERY LORRAINE BRACCO
He turned his back
on civilization.
Only to discover
he had the power
to save it.
JOHN McTIERNAN
Medicine
Man
ANDREW G. VAJNA JOHN McTIERNAN SEAN CONNERY LORRAINE BRACCO "MEDICINE MAN"
JERRY GOLDSMITH MICHAEL R. MILLER DONALD McALPINE BEAU MARKS SEAN CONNERY
TOM SCHULMAN TOM SCHULMAN SALLY ROBINSON ANDREW G. VAJNA DONNA DUBROW JOHN McTIERNAN
CINERGI


Acremonium sp.
Volutella ciliata
Penicillium manginii
Doratomyces stemonitis
Fusarium tricinctum
Penicillium citrinum
Penicillium manginii
Penicillium manginii
Acremonium strictum
Acremonium strictum
Peucedanum alsaticum
Acremon. aff. murorum
Acremon. aff. murorum
Acremonium murorum
Acremonium murorum
Penicillium expansum
Beauveria bassiana
Cylindroc. destructans
Trichoderma koningii
Paecilomyces marquandii
Phoma sp.
Peucedanum cervaria

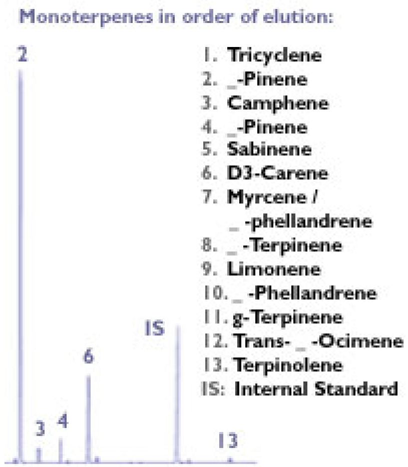

(a)
(b)





C .. Colicinproduzent
R .. Colizin-resistent
S .. Colicin-empfindlich

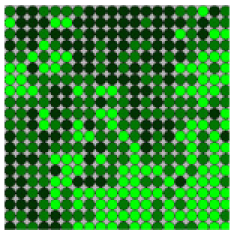
Gas chromotography used to determine mono and sesquiterpene concentrations.



Gas chromatogram of needle monoterpenes.

Native pine forest.

Spatial Ecology



To incorporate spatial variation in biochemical polymorphism, species number and distribution and measures of ecological function into a simple, spatial model of structure and function of a natural native Scots pine forest read more >>

Jack Lennon, Peter Dennis,Glenn Iason, Vera Thoss, Robin Pakeman, Colin Campbell..

Vertebrate herbivore and vegetation interactions

To determine the spatial variation in ground vegetation composition and its interaction with seed predation, germination and seedling establishment read more >>

To determine spatial variability in Scots pine seedling mortality and its relationship to phytochemical phenotype read more >>

Plant-invertebrate Interactions

To test whether the contrasting needle morphology and terpene chemistry of pine trees significantly alters the species composition, population performance and ecosystem consequences of insect herbivores read more >>

Soil microbial and mycorrhizal diversity and function

Quantification of mycorrhizal species diversity in relation to pine phytochemistry and relationship between functional and taxonomic diversity read more >>

Ecology Letters, (2005) **8**: 364–369 doi: 10.1111/j.1461-0248.2005.00732.x

LETTER

Does chemical composition of individual Scots pine trees determine the biodiversity of their associated ground vegetation?

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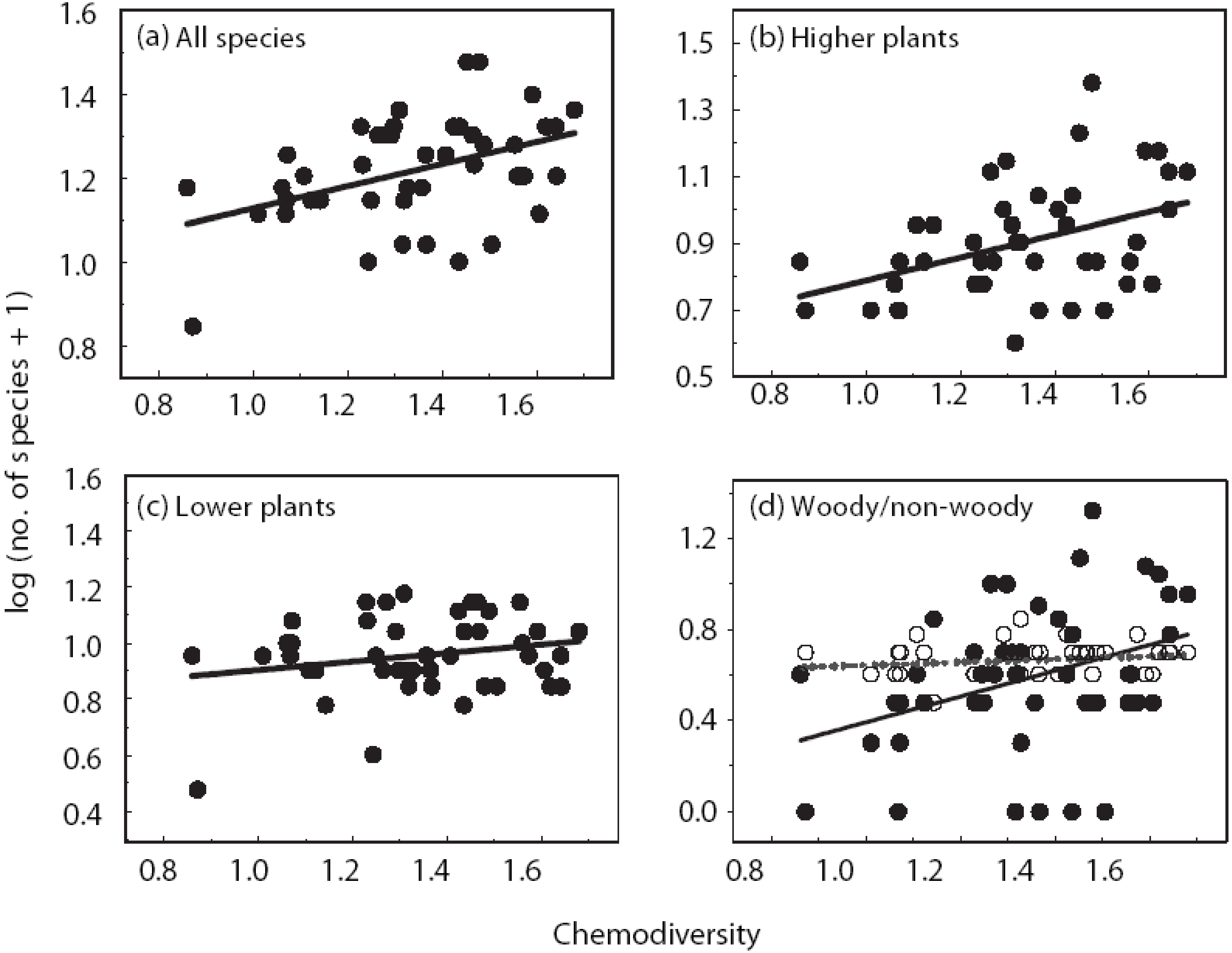
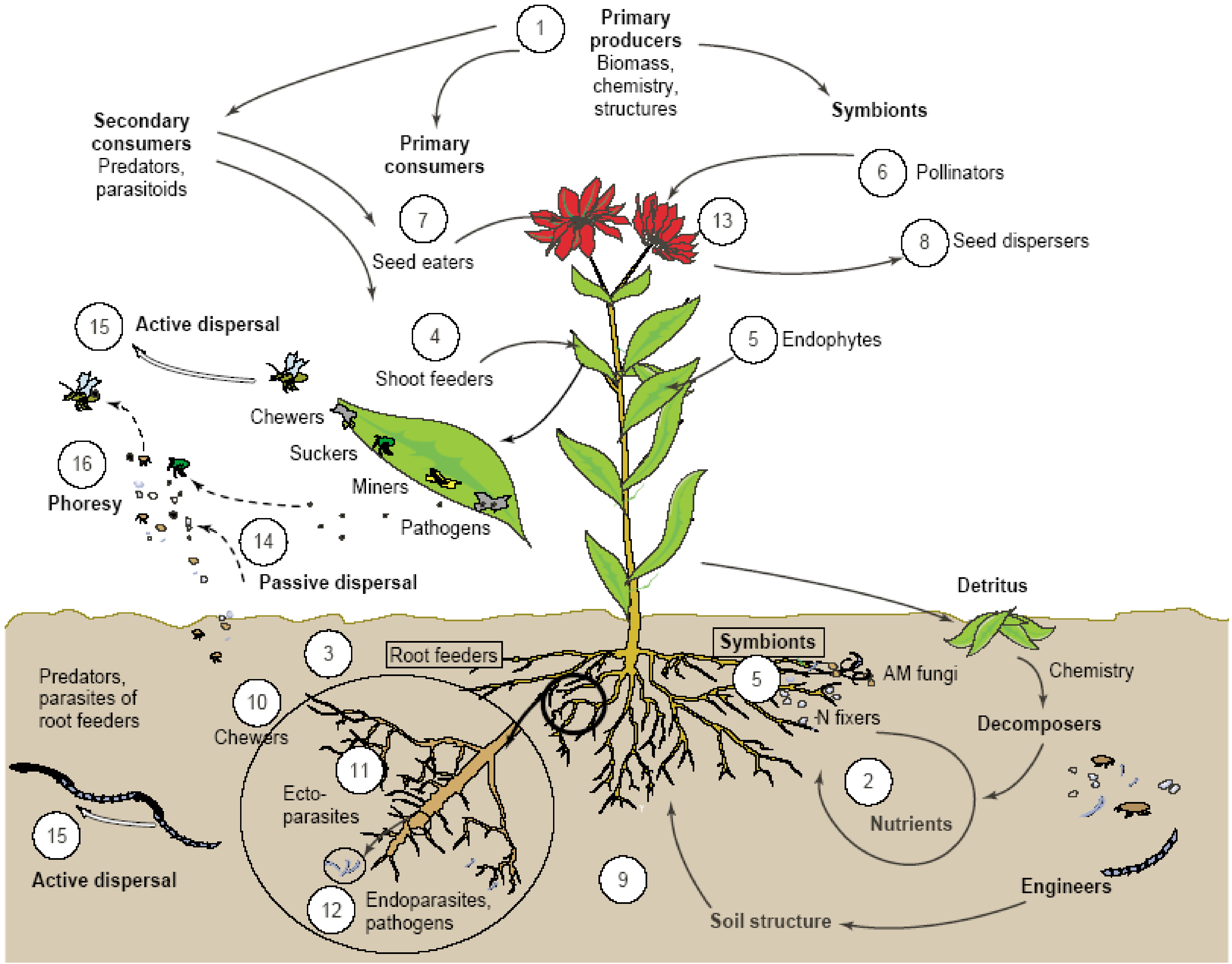
**Correspondence: E-mail: g.iason@macaulay.ac.uk*

Abstract

Despite plant secondary metabolites being major determinants of species interactions and ecosystem processes, their role in the maintenance of biodiversity has received little attention. In order to investigate the relationship between chemical and biological diversity in a natural ecosystem, we considered the impact of chemical diversity in individual Scots pine trees (*Pinus sylvestris*) on species richness of associated ground vegetation. Scots pine trees show substantial genetically determined constitutive variation between individuals in concentrations of a group of secondary metabolites, the monoterpenes. When the monoterpenes of particular trees were assessed individually, there was no relationship with species richness of associated ground flora. However, the chemical diversity of monoterpenes of individual trees was significantly positively associated with the species richness of the ground vegetation beneath each tree, mainly the result of an effect among the non-woody vascular plants. This correlation suggests that the chemical diversity of the ecosystem dominant species has an important role in shaping the biodiversity of the associated plant community. The extent and significance of this effect, and its underlying processes require further investigation.

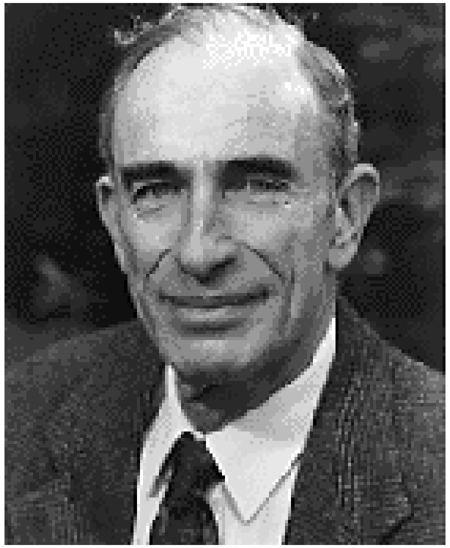


(a) All species
(b) Higher plants
(c) Lower plants
(d) Woody/non-woody
log (no. of species + 1)
Chemodiversity
1.6
1.4
1.2
1.0
0.8
1.5
1.3
1.1
0.9
0.7
0.5
0.6
0.4
0.0

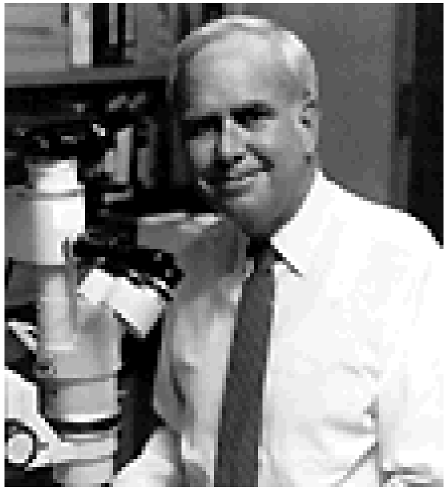


1
Primary producers
Biomass, chemistry, structures
Symbionts
Secondary consumers
Predators, parasitoids
Primary consumers
6
Pollinators
7
Seed eaters
13
8
Seed dispersers
15
Active dispersal
4
Shoot feeders
5
Endophytes
Chewers
Suckers
Miners
Pathogens
16
Phoresy
14
Passive dispersal
Detritus
3
Root feeders
Symbionts
5
AM fungi
N fixers
Chemistry
Decomposers
Predators, parasites of root feeders
10
Chewers
11
Ecto-parasites
12
Endoparasites, pathogens
2
Nutrients
15
Active dispersal
9
Soil structure
Engineers

Larven des Admirals,*Vanessa atlanta,* fressen nur Brenesselblätter



Paul Ehrlich



Peter Raven

Ehrlich P R & Raven P H. Butterflies and plants: a study in coevolution. *Evolution* **18**:586-608, 1964.
[Department of Biological Sciences, Stanford University, CA]

The relationships of butterflies and their larval food plants were described and the patterns were hypothesized to result from a reciprocal evolutionary process for which the term 'coevolution' was coined. The primary function of secondary plant chemicals was claimed to be defense against herbivores. [The *Science Citation Index*® (*SCI*®) and the *Social Sciences Citation Index*® (*SSCI*®) indicate that this paper has been cited in over 295 publications since 1964.]

Paul R. Ehrlich
Department of Biological Sciences
Stanford University
Stanford, CA 94305

April 16, 1984

"Our work began over the coffee table when I remarked to Peter Raven that it seemed strange that the *Euphydryas* butterflies that were the subject of my ecological research fed on plants of the families Plantaginaceae and Scrophulariaceae. Peter thought that combination not strange at all, and we began to have daily discussions in which I would describe patterns of food-plant use in butterflies, and he would see what sort of botanical 'sense' they made.

"We began ransacking the literature for data on which plants were eaten and for information on the common characteristics of those plants. The diets of butterflies turned out to be better documented than those of any other large group (12,000-15,000 species) of herbivores. Something was known of the food plants of roughly half of the genera, largely because of the interest of amateurs in raising butterflies in order to get perfect specimens for their collections. It was not long before we realized that the so-called 'secondary compounds' of the plants played a major role in the interactions.

"From that point on, it was a matter of brainstorming between two close colleagues, both evolutionists, one with much experience with butterflies and the other with plants. We did the work with a rising sense of excitement, as we suspected that coevolution was generally an underrated process. Zoologists tended to view plants almost as part of the physical environment; too many parasitologists did not consider the evolution of hosts; and so forth.

"I believe that our paper has been so widely cited because it provided for the first time a detailed discussion of the evolutionary relationships between two large, ecologically intimate groups of organisms. While various of the ideas can be found as far back as the writings of Darwin, and other people had suggested the defensive nature of plant chemicals, no one had put the picture together in this way before and discussed its manifold implications.

"The paper certainly helped spark the development of the now vast field of plant-herbivore coevolution and interest in the process of coevolution in general. Some idea of the ways in which this area of population biology has developed over the past two decades can be gained from a perusal of the excellent new volume edited by Futuyma and Slatkin.[1]

"Quite naturally, some of the ideas in our paper have been criticized, and some were probably quite wrong. Nonetheless, it seems to have stimulated the thinking of a great many people. It is probably the most-cited article either Peter or I have ever published, but that is not the thing that interests us most about it. Unlike our other work, it was done entirely around the coffee table and in the library—neither of us looked at an organism, living or dead, in the course of the work. Therefore our advice to young scientists, should they wish to publish a highly cited paper, apparently ought to be 'study books, and not nature!' "

1. **Futuyma D J & Slatkin M**, eds. *Coevolution*. Sunderland, MA: Sinauer Associates, 1983. 555 p.

Koevolution

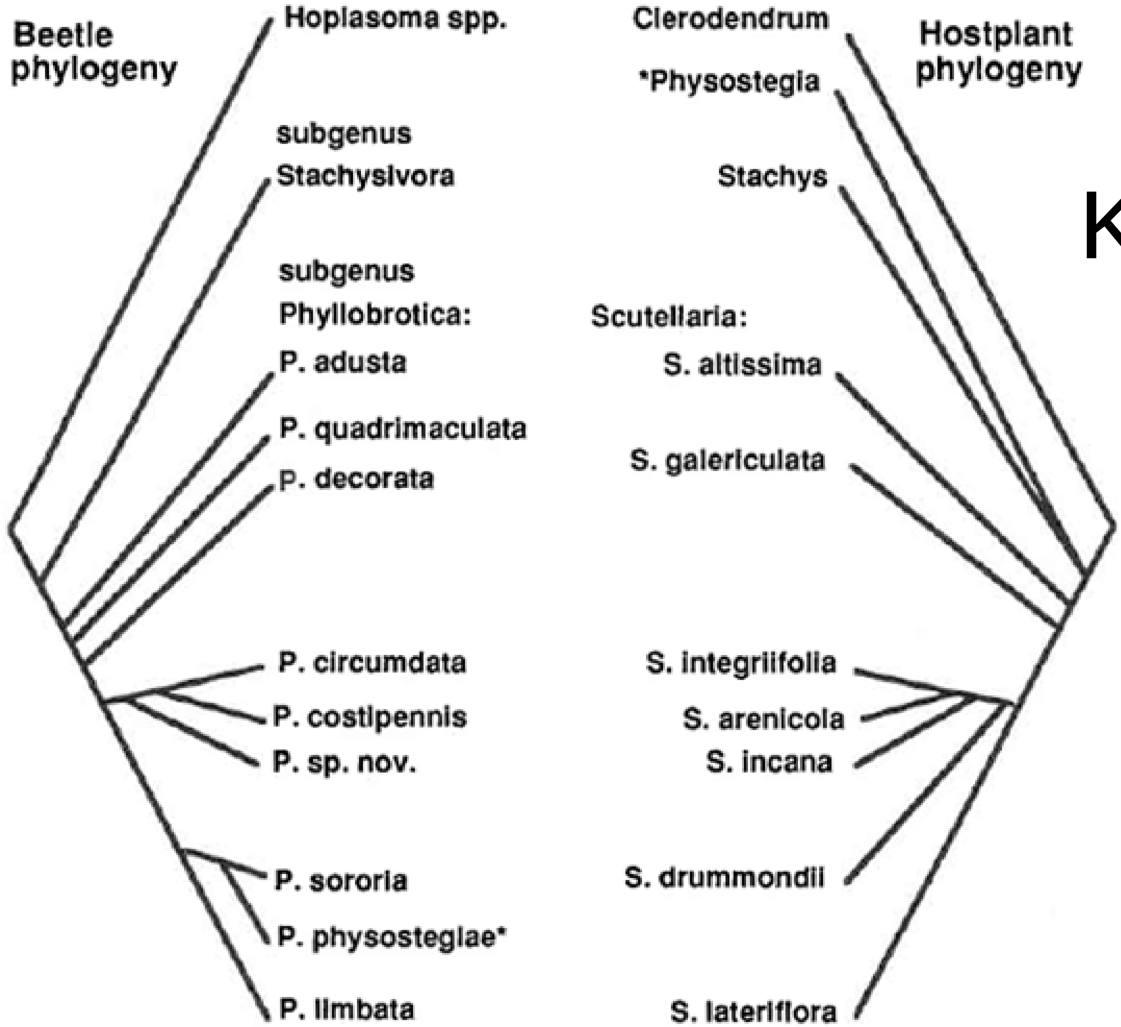


Figure 6. Phylogeny estimate of *Phyllobrotica* leaf beetles compared with host Lamiales phylogeny synthesized from the published literature (Farrell and Mitter 1990). Beetle taxa are placed opposite their hosts (*Phyllobrotica quadrimaculata* and *Phyllobrotica decorata* both attack *Scutellaria galericulata*, in the Palearctic and Nearctic, respectively), except for *Phyllobrotica phytostegiae* and its host *Physostegia*, which are marked by asterisks. Cladogram correspondence is significant or nearly so under several randomization models. The exceptional association of *Phyllobrotica physostegiae* with the perennial mint *Physostegia* probably represents recent colonization from an annual, xeric-adapted ancestral host in the same habitat.

Hypothesen zur Verteidigungsfunktion von Sekundärstoffen

„Optimal Denfense“ Hypothese
(McKey und Rhoades)

- Organismen entwickeln eine Verteidigung, die zu maximaler Fitness des Individuums beiträgt
- Verteidigung kostet und zieht Ressourcen von anderen Bedürfnissen ab
- 4 Subhypothesen

„Plants Apparency“ Subhypothese (Feeny, Rhoades und Cates)

- Abundante Pflanzen investieren in quantitative Verteidigung
- Seltene Pflanzen investieren in qualitative Verteidung

Widerspruch: trifft nicht immer zu

„Optimal Defense within Plant“
Subhypothese (McKey, Rhoades)

- Chemische Verteidigung ist entsprechend dem Angriffsrisiko ausgeprägt

Widerspruch : kann erst mit transgenen Pflanzen wirklich getestet werden.

„**Inducible Defense**“ Subhypothese (Rhoades)

- Ressourcenaufwendige Verteidigung nur bei Bedarf

  Widerspruch: Ein- und Ausschalten der Biosynthese oft stark zeitverzögert

„**Allocation Cost to Phenotypic Defense**“ Subhypothese (Rhoades)

- Wachstum und Entwicklung wird bei starker Ausprägung von chemischer Verteidigung beeinträchtigt

„Carbon-Nutrient Balance“ Hypothese (Bryant und Tuomi)

- Zuteilung von Ressourcen für Wachstum und Verteidigung flexibel

- Veränderung der Nährstoffversorgung ruft in langsamwachsenden Planzen keine und in schnellwachsenden starke Veränderungen in der chemischen Verteidigung hervor

Problem: notwendige Basisverteidigung nicht eruierbar

„Growth Rate“ Hypothese (Coley)

Konkurrenz bevorzugt in

- bei Nährstoffreichtum schnellwüchsige Pflanzen (mehr niedermolekulare Sekundärstoffe)

- Nährstoffmangel langsamwüchsige Pflanzen (mehr Biopolymere)

Problem: Überprüfung führte zu gemischten Ergebnissen

„Growth-Differentiation Balance“ Hypothese

(Loomis, Herms, Mattson)

- Umweltfaktoren beeinträchtigen Wachstum stärker als Photosynthese

- Ressourcenmangel führt zu Verteidigungsdifferenzierung

- Konzentration von Sekundärstoffen in
  - Langsamwachsende Pflanzen niedrig
  - durchscnittlich wachsenden Pflanzen hoch
  - schnell wachsenden Pflanzen mittel

Aber:

Screening Hypothese (Firn und Jones):

„Aktive Sekundärstoffe sind rar“