Modul Bodenökologie WS 2014/15 :

Stoffkreisläufe in Bodenökosystemen

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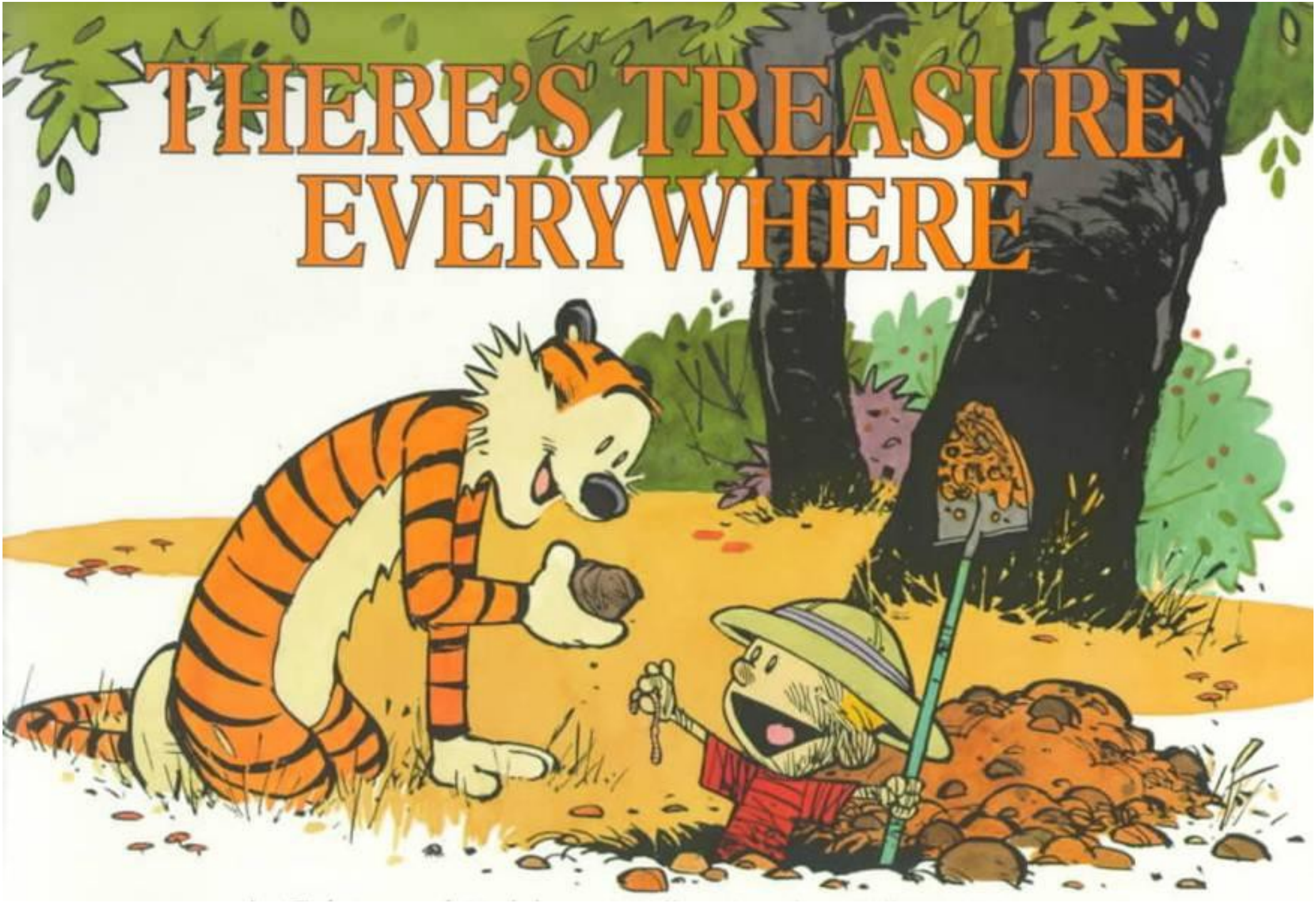
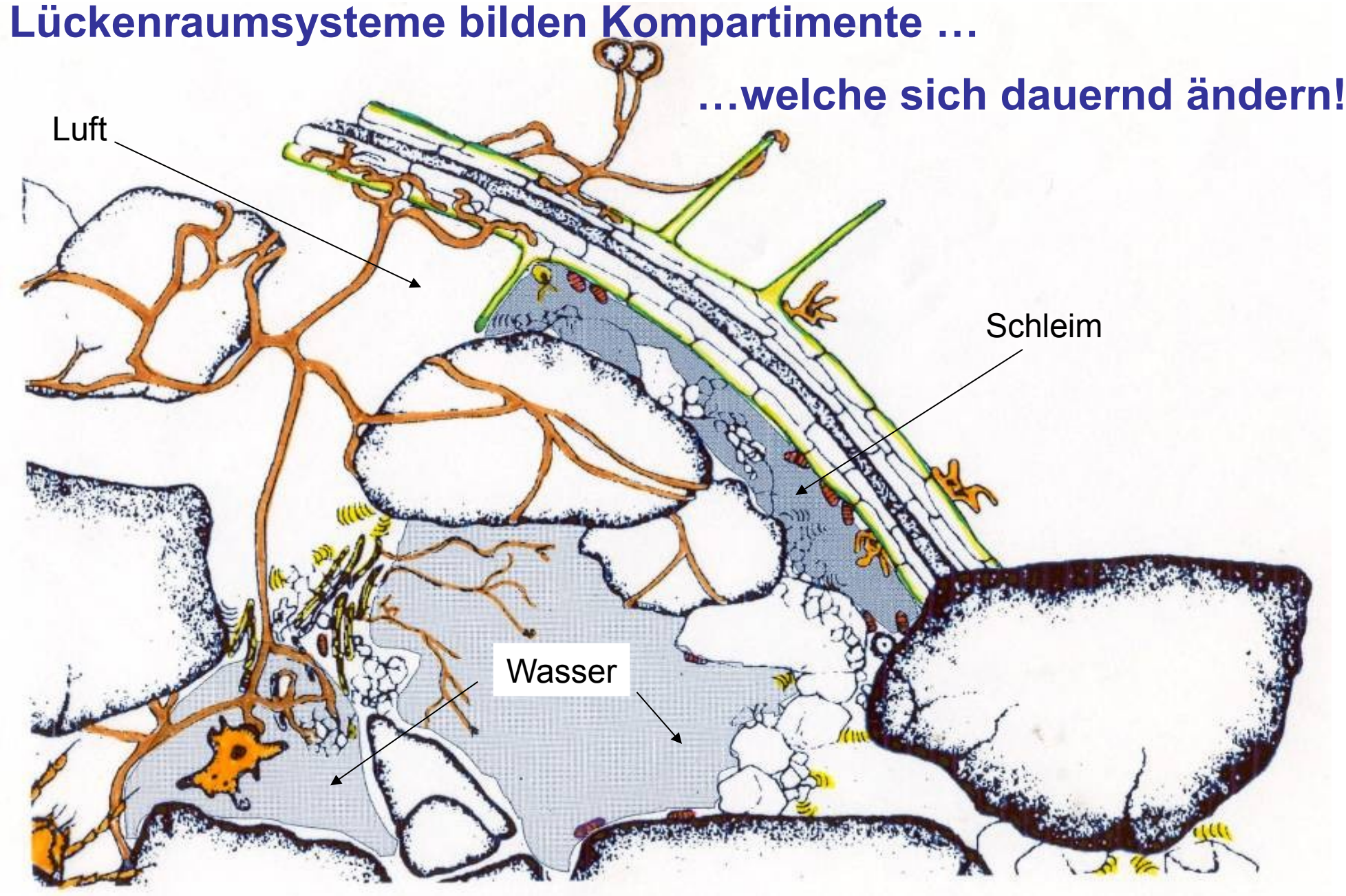
- **Vom allgemeinen Schema zum spezifischen Ökosystemmodell**
- **Pools und Flüsse verstehen**
- **Systeme vergleichen**
- **Systemänderungen abschätzen**

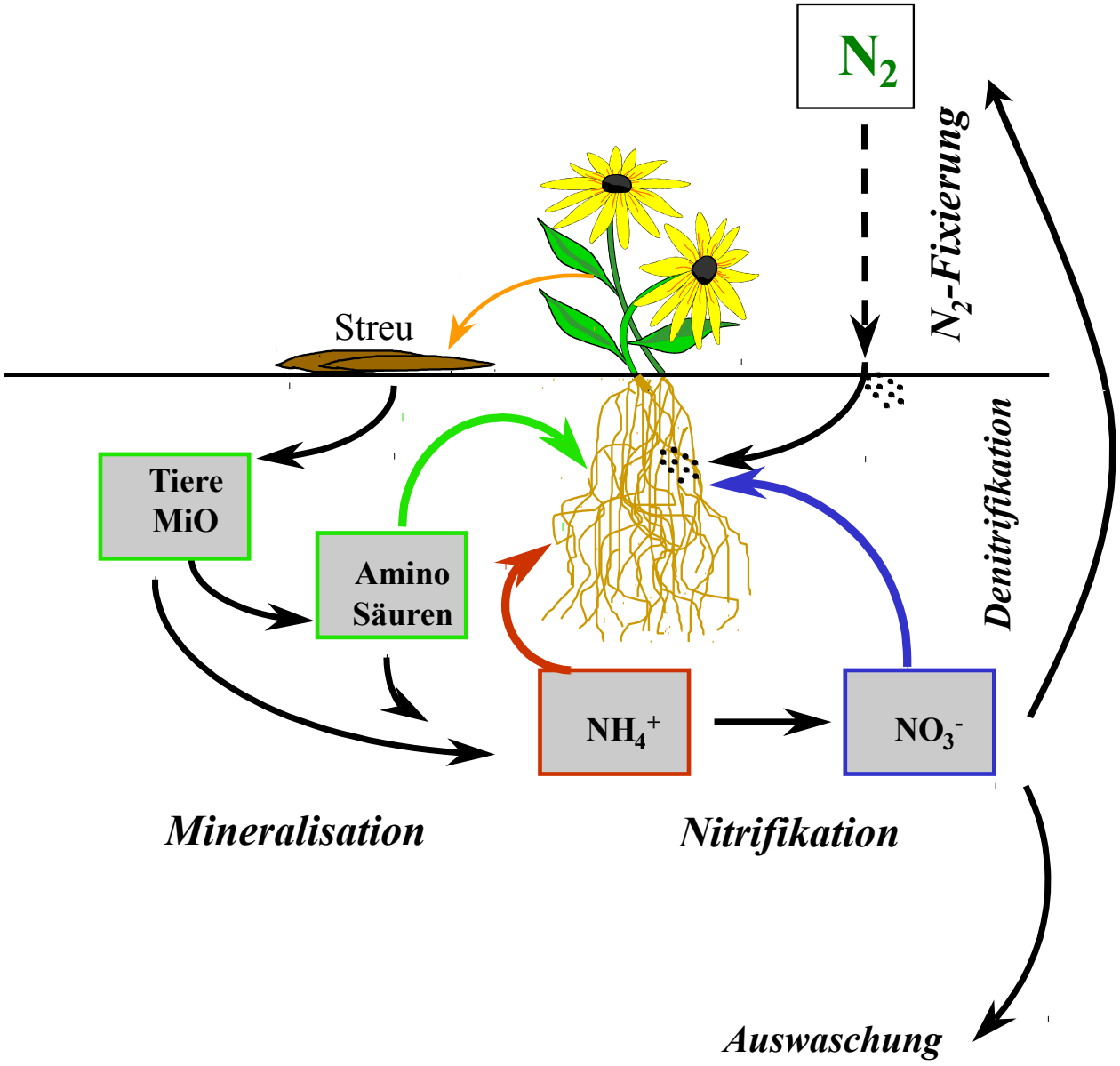

THERE'S TREASURE
EVERYWHERE

Lückenraumsysteme bilden Kompartimente …

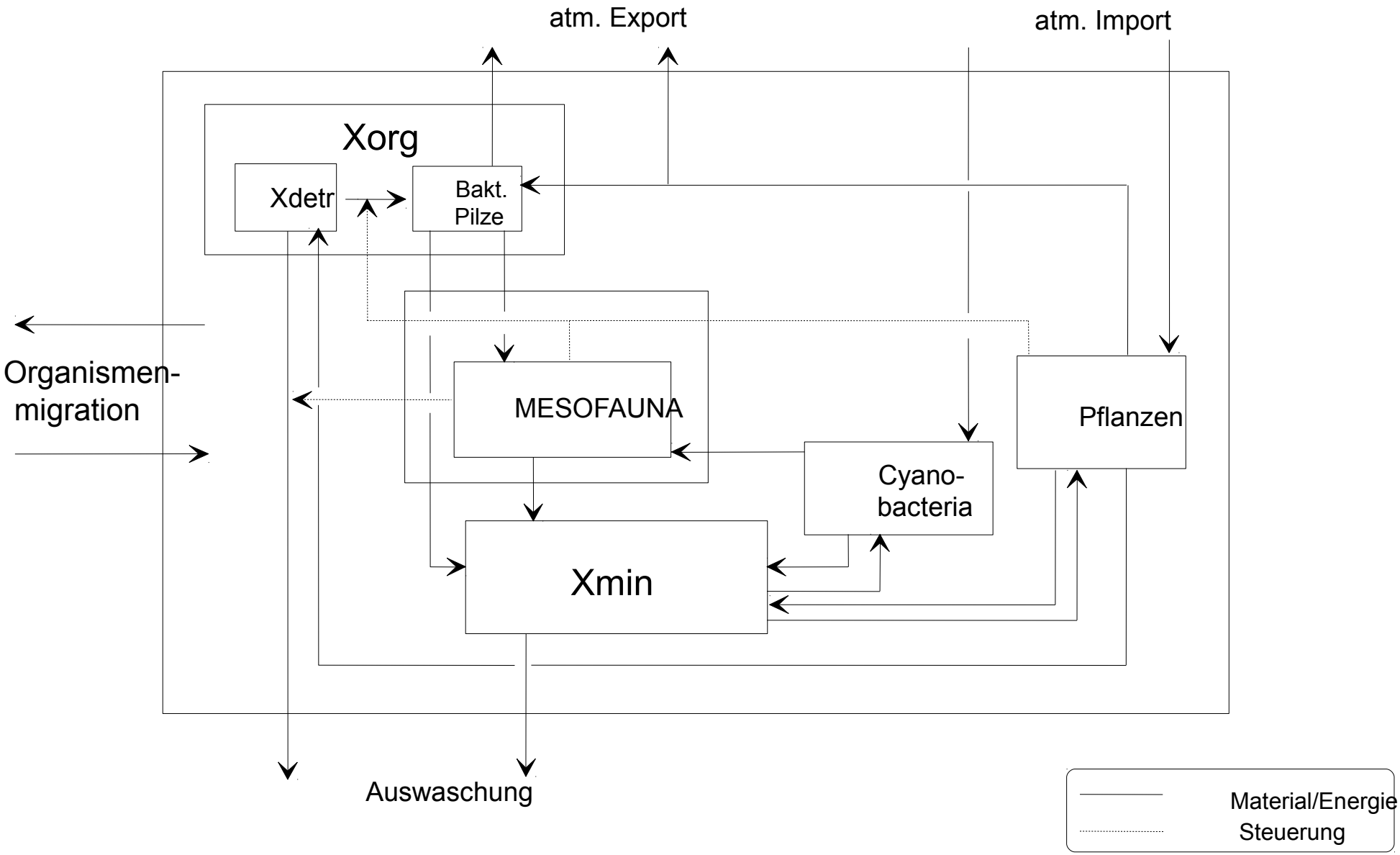
…welche sich dauernd ändern!



Der Stickstoffkreislauf
im Ökosystem



Basisinteraktionen, mechanistischer Ansatz



Die Darstellung maximaler Komplexität hilft nicht weiter …

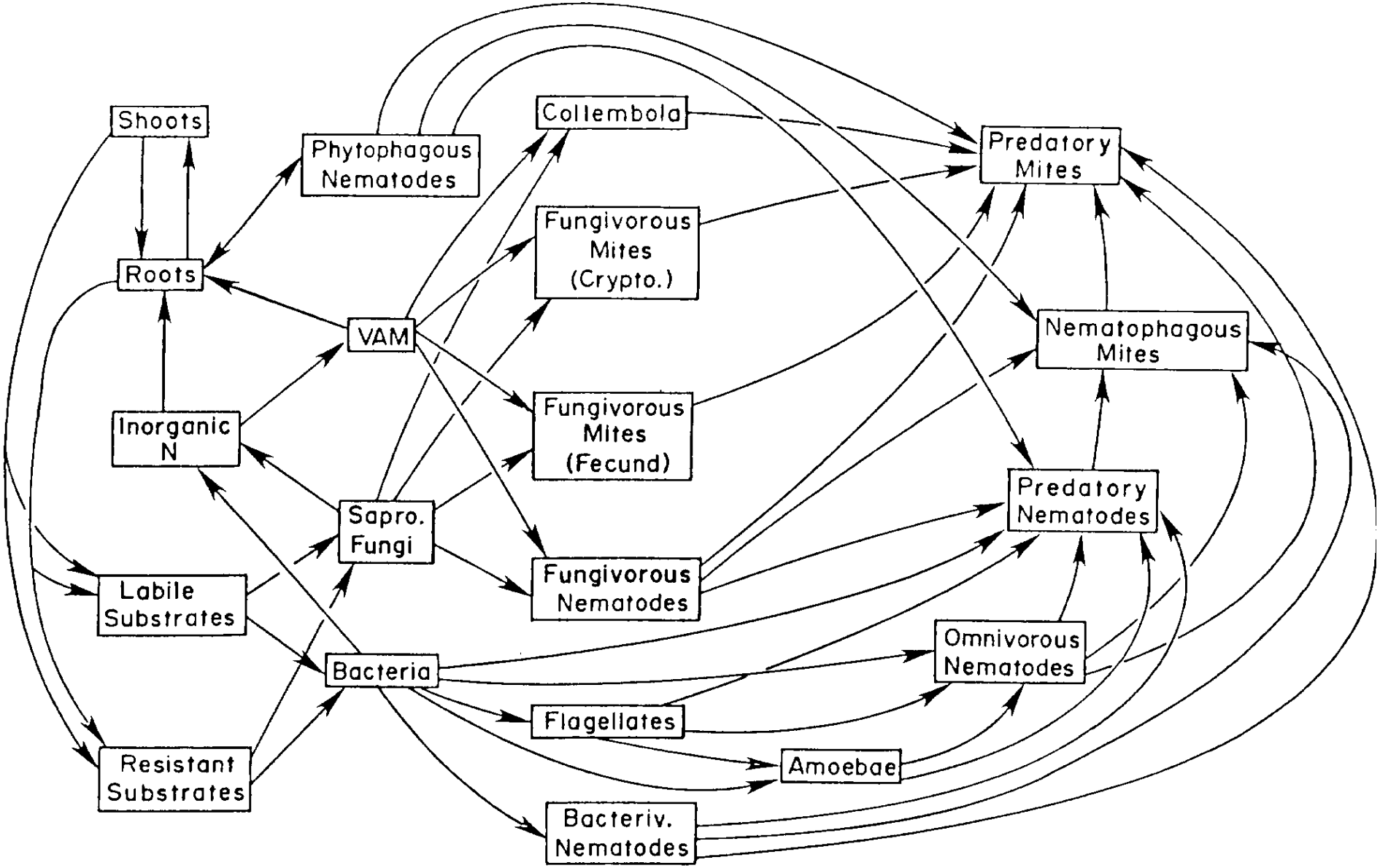
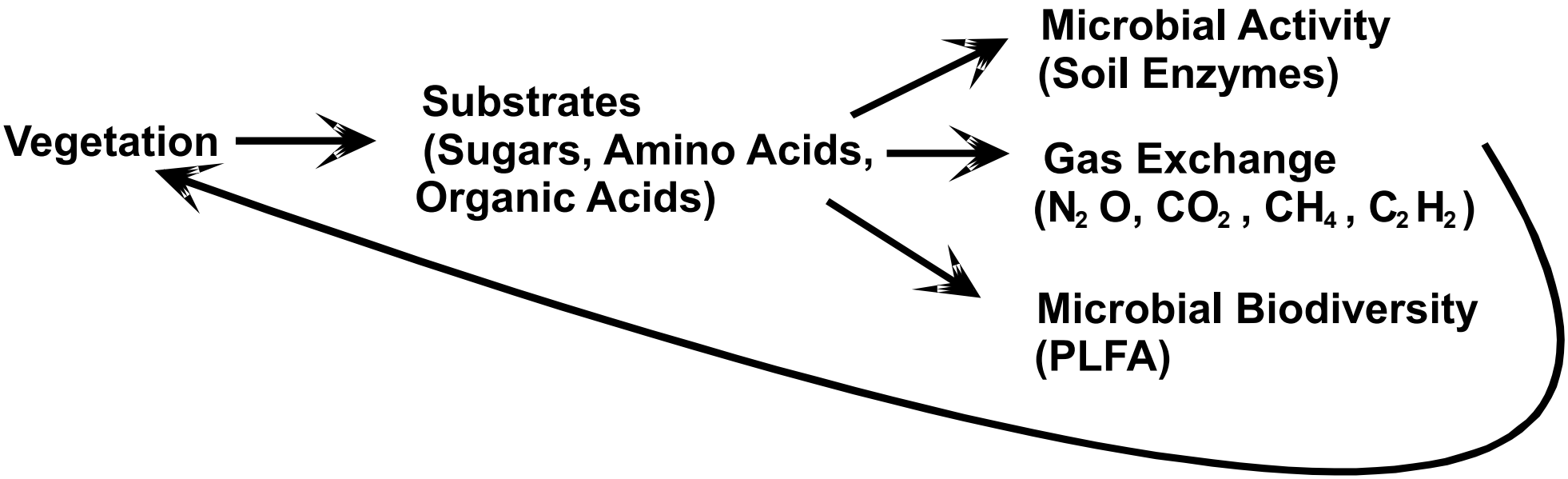
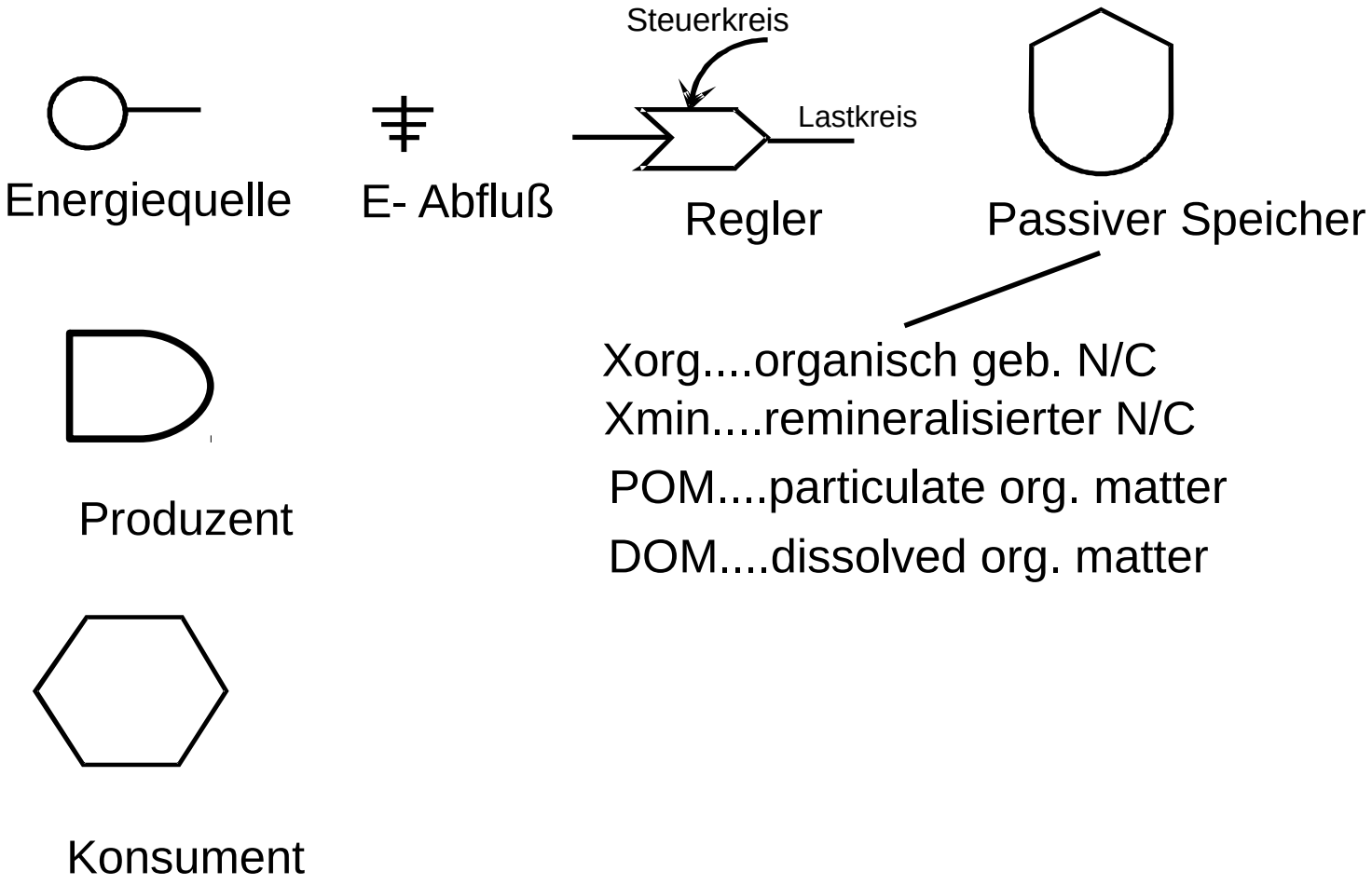


FIG. 9. A model of trophic interactions among plants, substrates, microflora, and fauna in a shortgrass prairie. (From Hunt *et al.* unpubl.)

Kompletter Reduktionismus hilft auch nicht

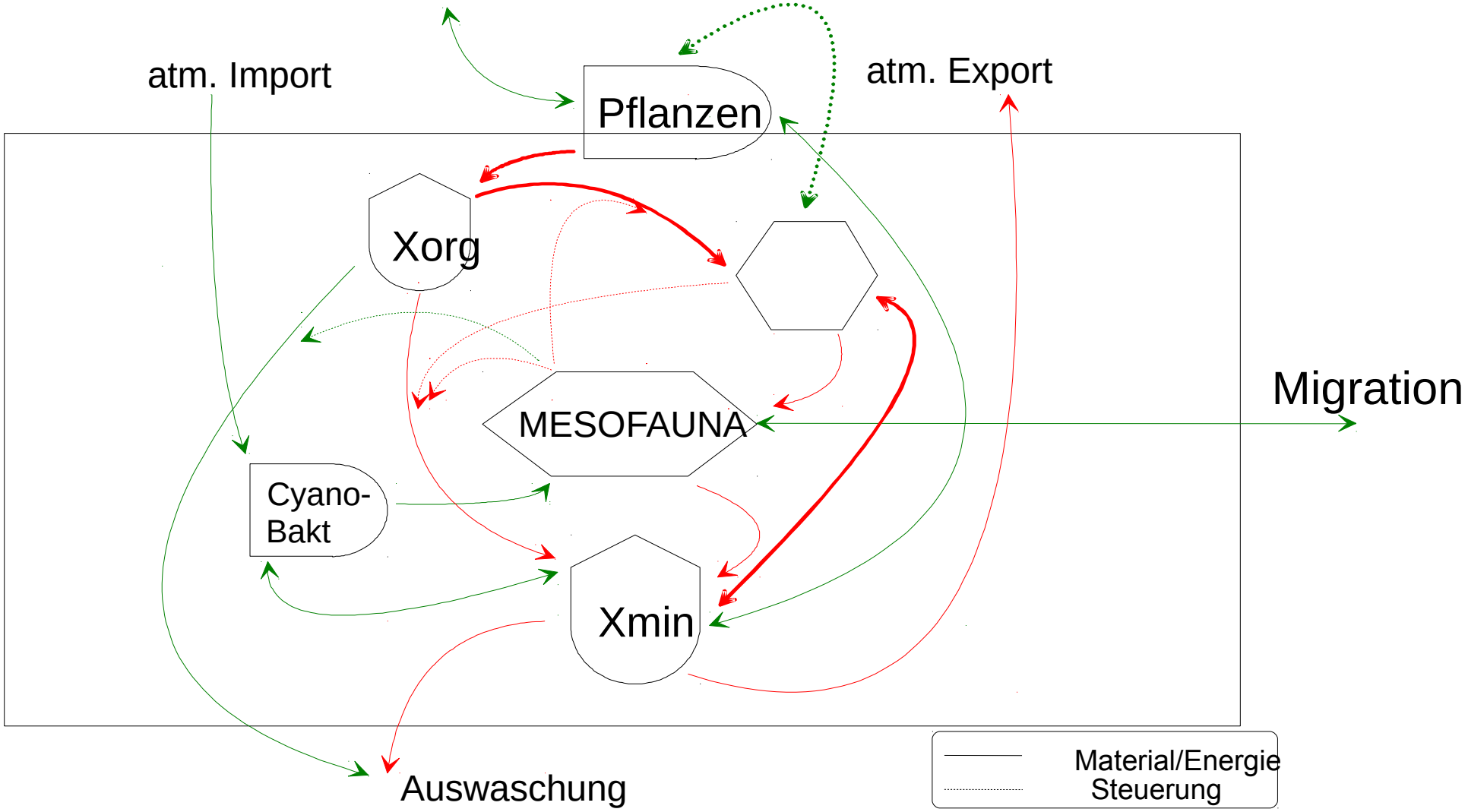


Formelsprache für Ökosysteme mit Symbolen



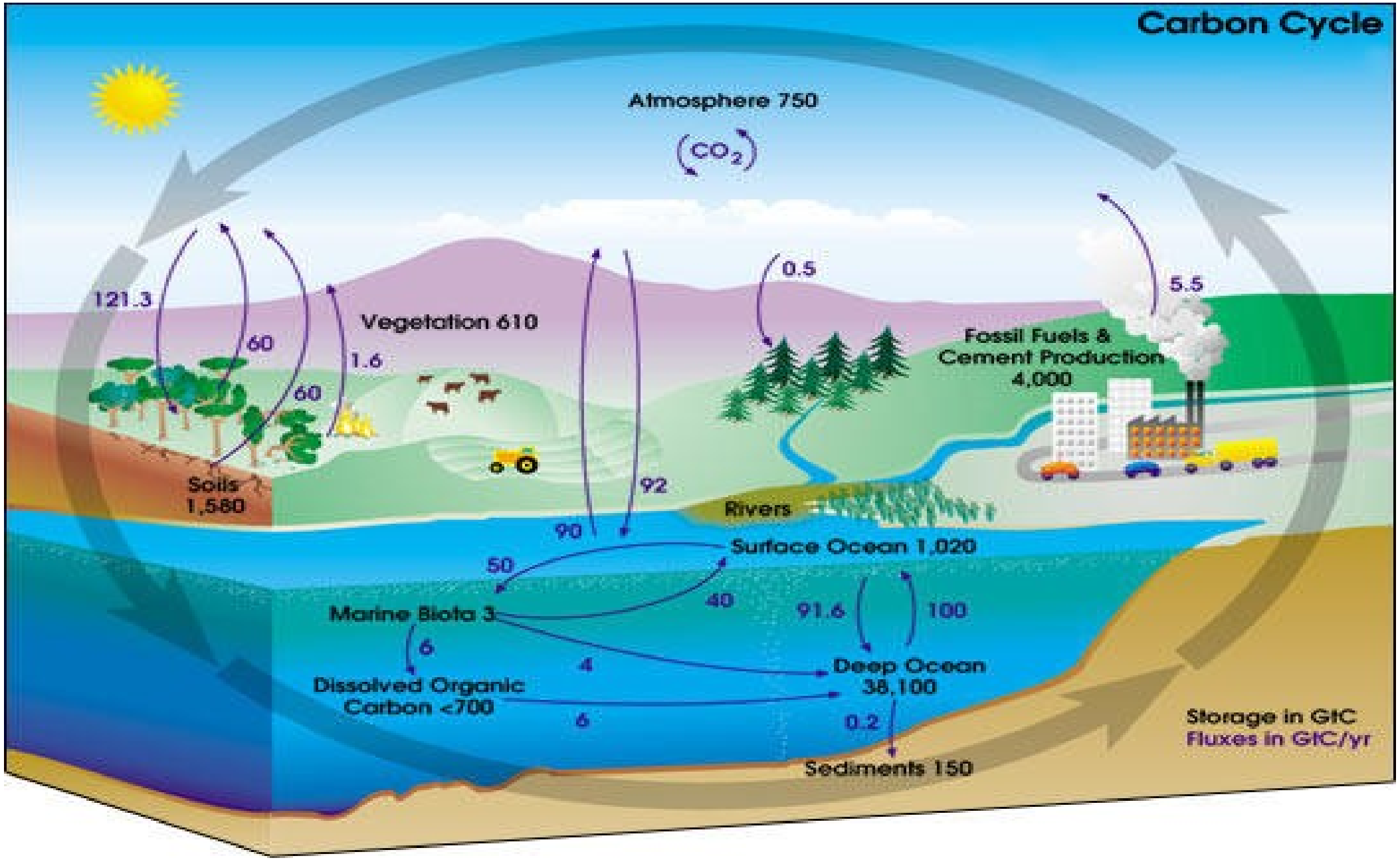
Nach H.T.Odum, 1971

Basisinteraktionsdiagramm / mechanistisches Modell



„Conceptual Model“

The carbon cycle



C-Quellen (sources)

	Gt	+/-
Fossil	6,4	0,5
Agrar	1,6	1,0
Total	8,0	1,1

C-Senken (sinks)

	Gt	+/-
Ozeane	2,0	0,8
Bor.Wälder	0,5	0,5
Atmosphäre	3,2	0,2
Total	5,7	0,2

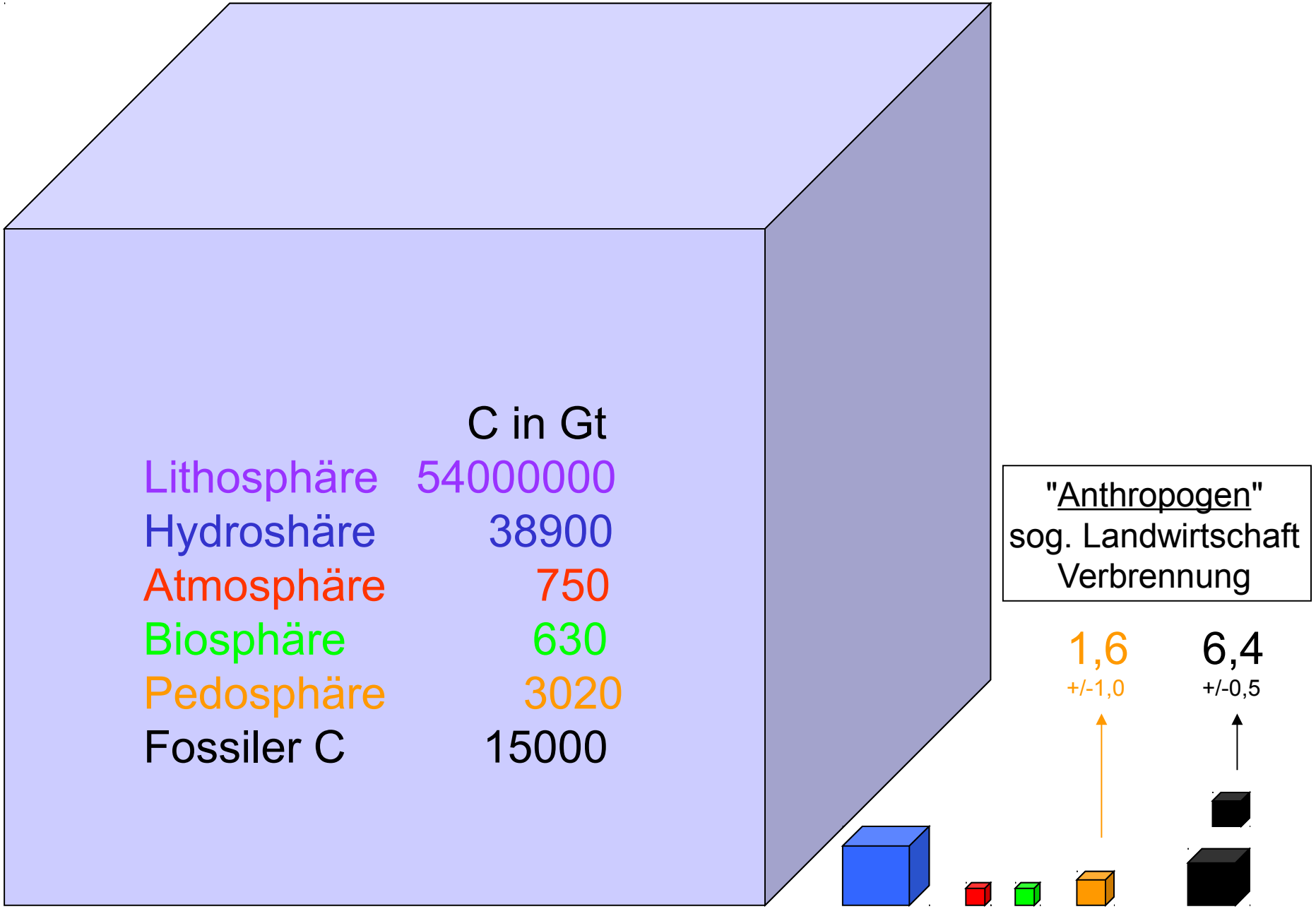
"Missing Carbon Sink": 2,3 Gt/a +/2,0

"Natürliche" C-Deposition: ca. 0,0025 Gt/a

Flussmatrix

	Litho	Hydro	Atmo	Bio	Pedo	Fossil
Litho	0					
Hydro		0	105			
Atmo		107	0	120		
Bio			60	0	60	
Pedo			60		0	
Fossil						0

Globale Kohlenstoffpools



Key concerns associated with thawing permafrost

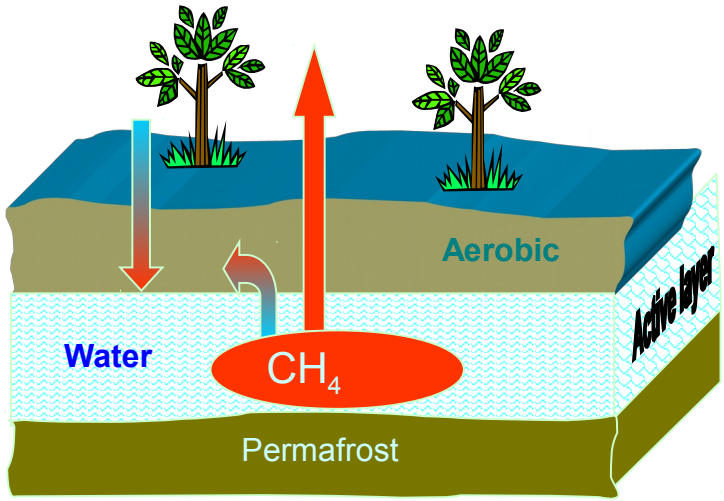
- Threats to ecosystems, loss of wildlife habitat, geopolitical issues

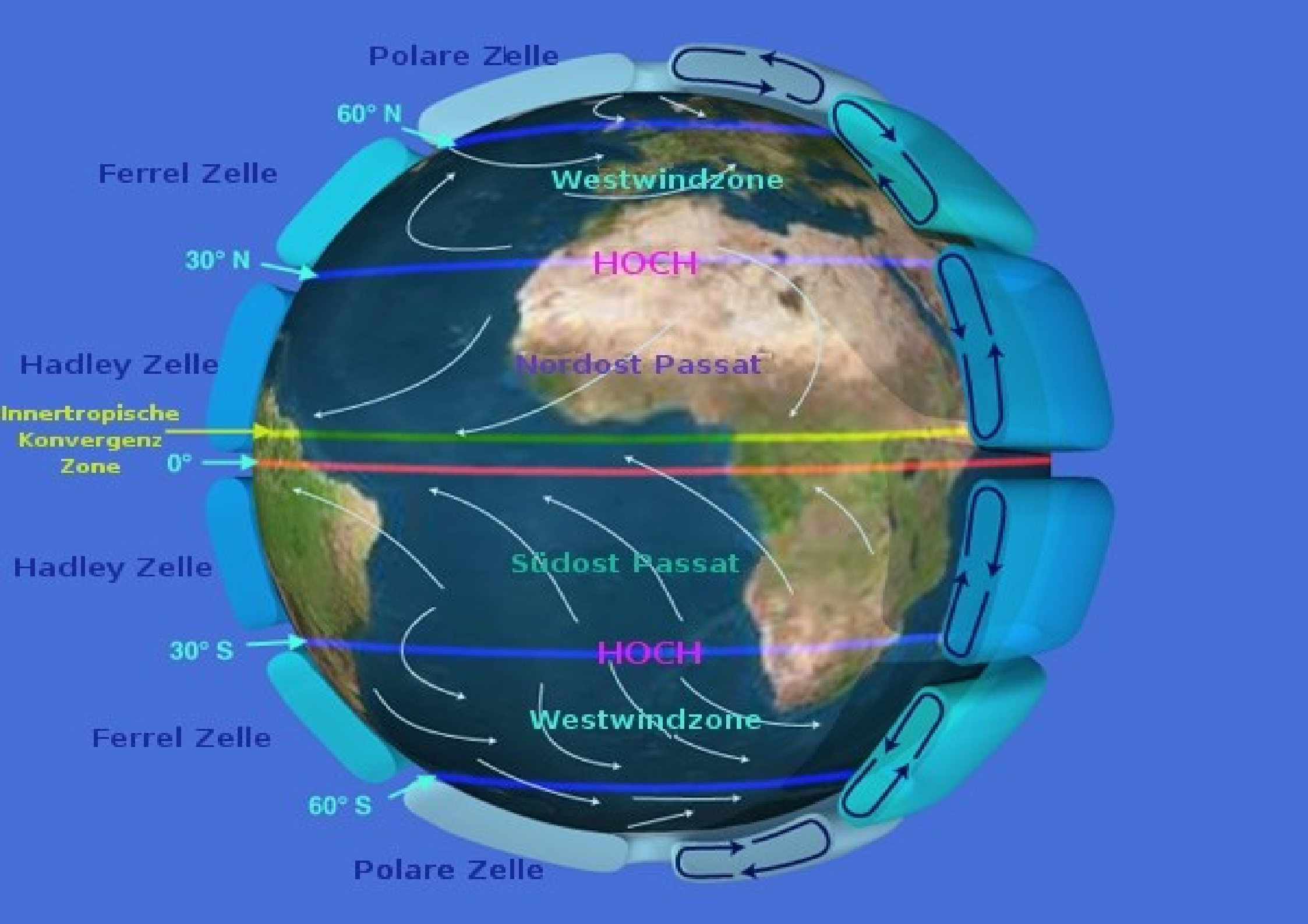
Vicinity of Yakytsk,2008. Photo: T.Maksimov

- Permafrost and economy of the North: impacts on the infrastructure

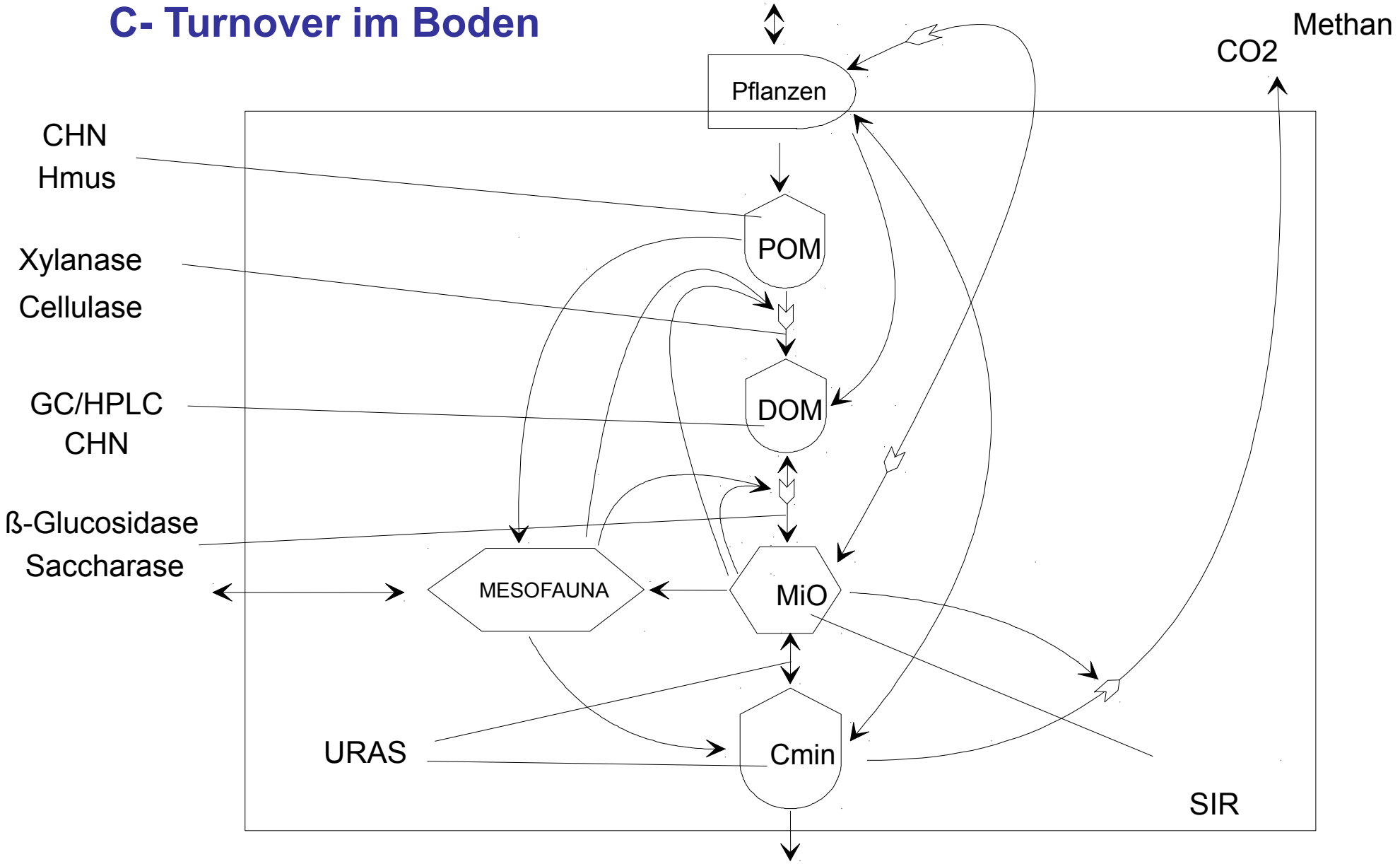
Baikal-Amur main track. Photo: D.Drozdov

- Permafrost and global climate: potential feedback through methane emission

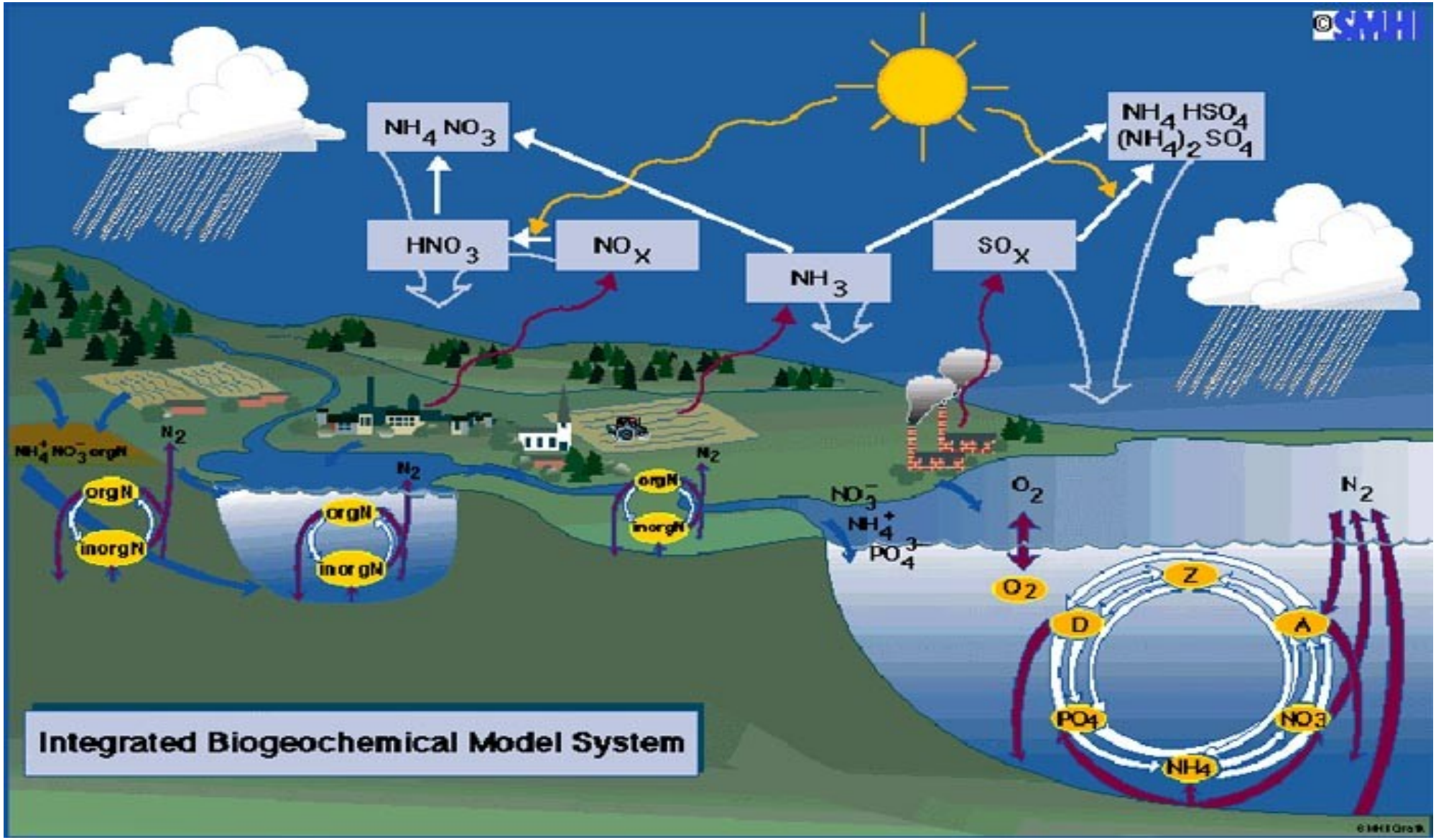



Polare Zelle
60° N
Ferrel Zelle
Westwindzone
30° N
HOCH
Hadley Zelle
Nordost Passat
Innertropische
Konvergenz
Zone
0°
Hadley Zelle
Südost Passat
30° S
HOCH
Westwindzone
Ferrel Zelle
60° S
Polare Zelle

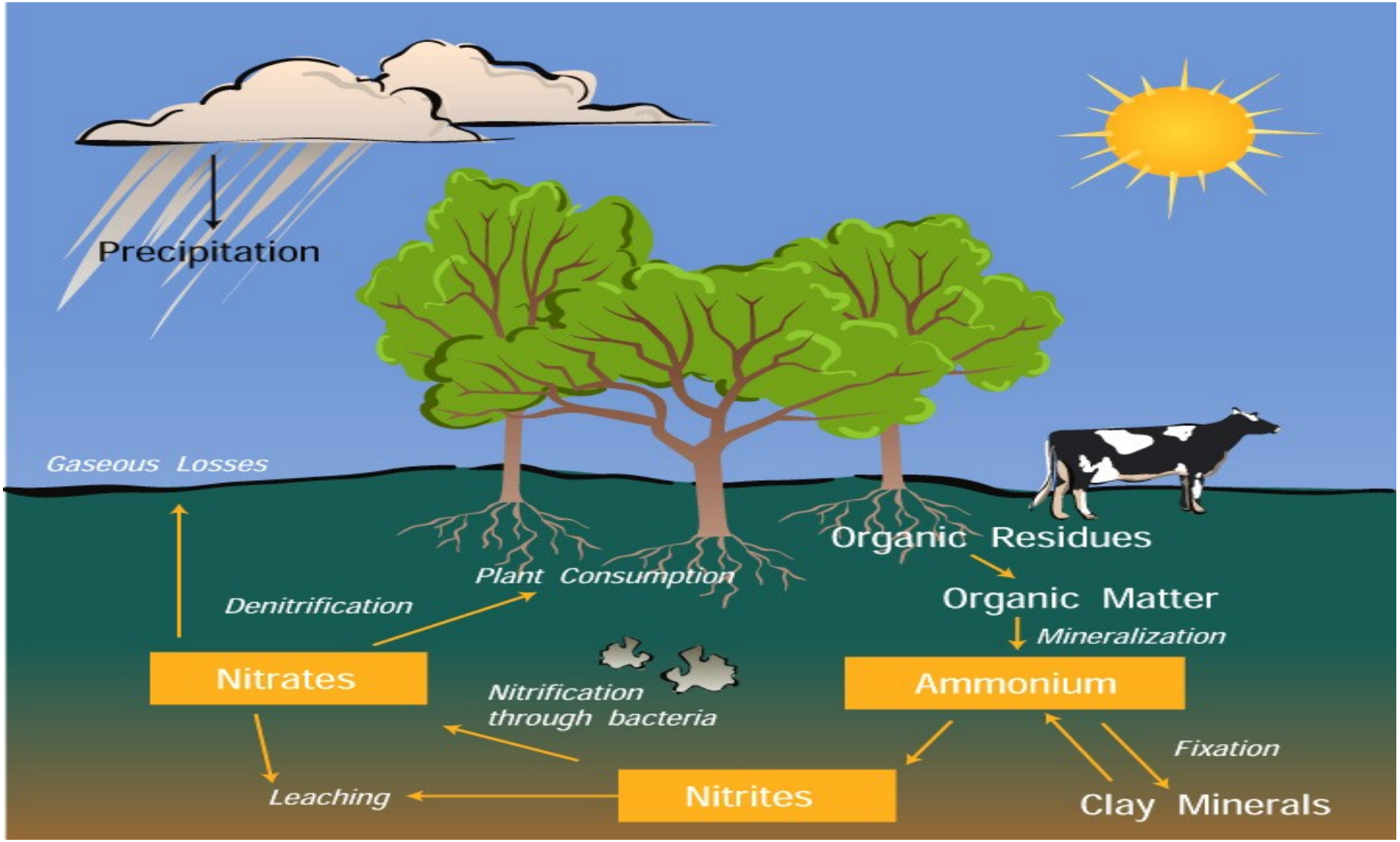
C- Turnover im Boden

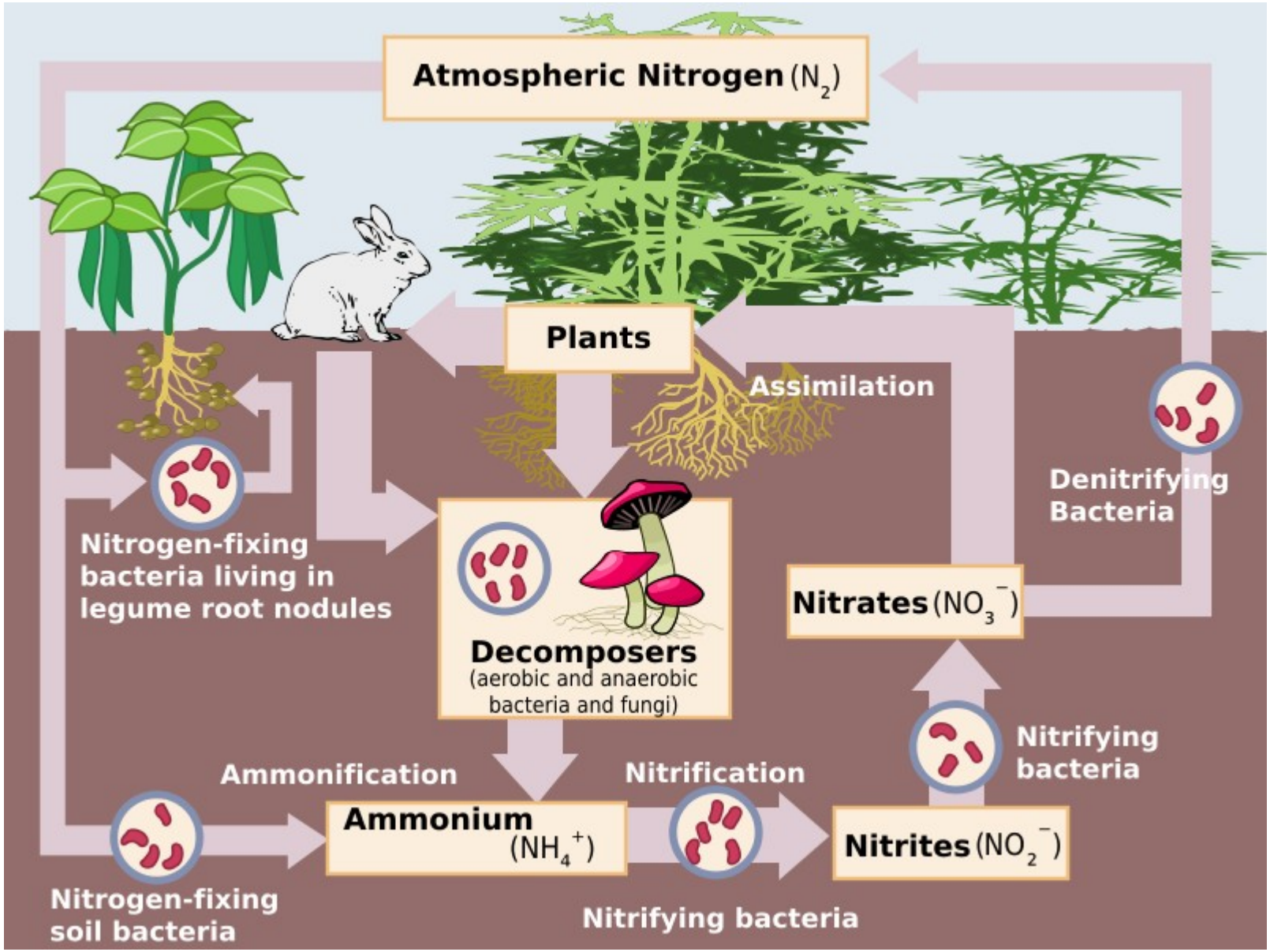


The N cycle

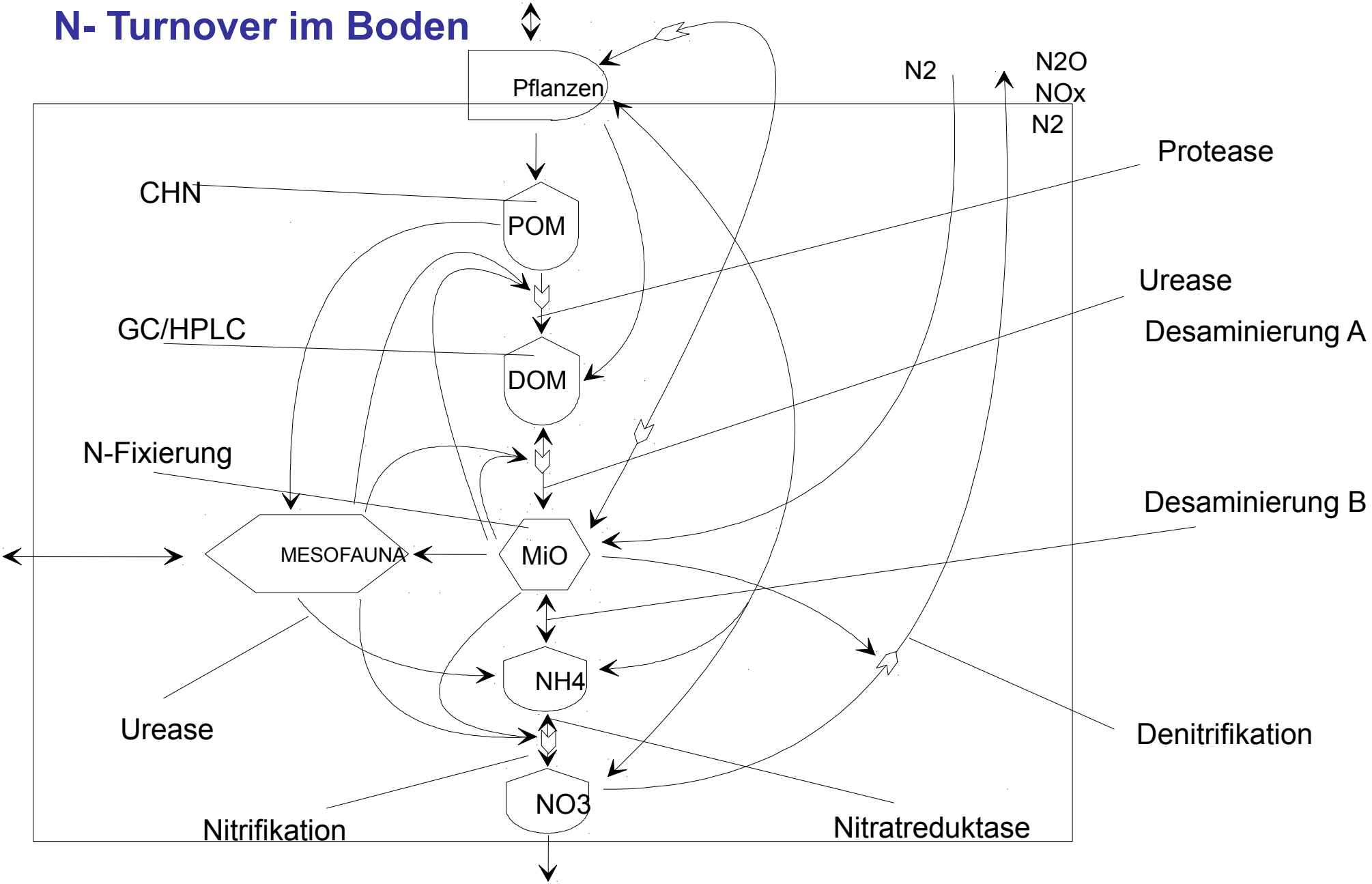

©SMHI
NH_4NO_3
HNO_3
NO_X
NH_3
SO_X
NH_4HSO_4
$(NH_4)_2SO_4$
N_2
orgN
inorgN
NO_3^-
NH_4^+
PO_4^{3-}
O_2
Z
D
A
PO_4
NO_3
NH_4
Integrated Biogeochemical Model System

The N cycle, terrestrial




Atmospheric Nitrogen (N_2)
Plants
Assimilation
Denitrifying Bacteria
Nitrogen-fixing bacteria living in legume root nodules
Decomposers
(aerobic and anaerobic bacteria and fungi)
Nitrates (NO_3^-)
Nitrifying bacteria
Ammonification
Nitrification
Ammonium (NH_4^+)
Nitrites (NO_2^-)
Nitrogen-fixing soil bacteria
Nitrifying bacteria

N- Turnover im Boden



The P cycle

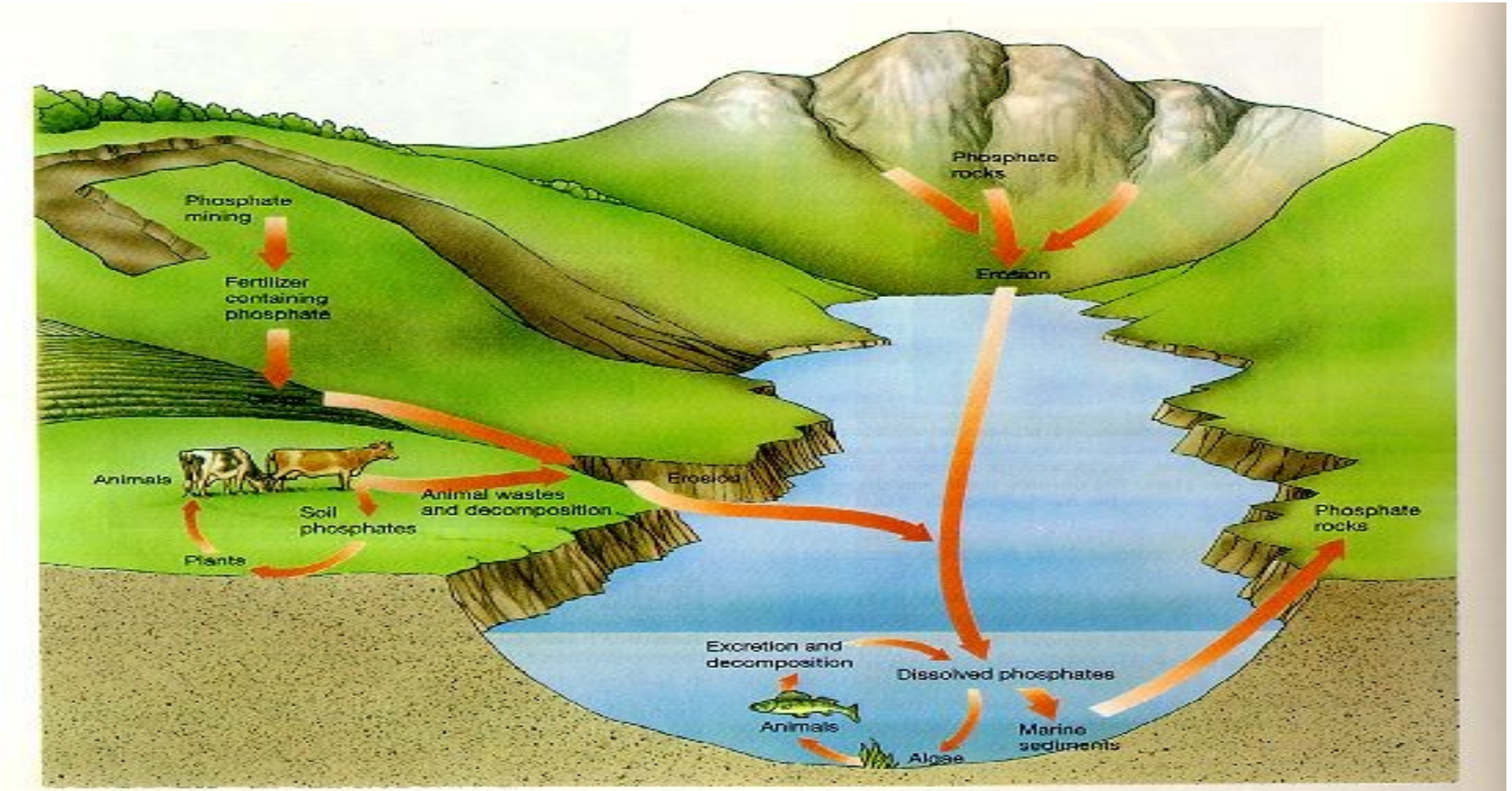
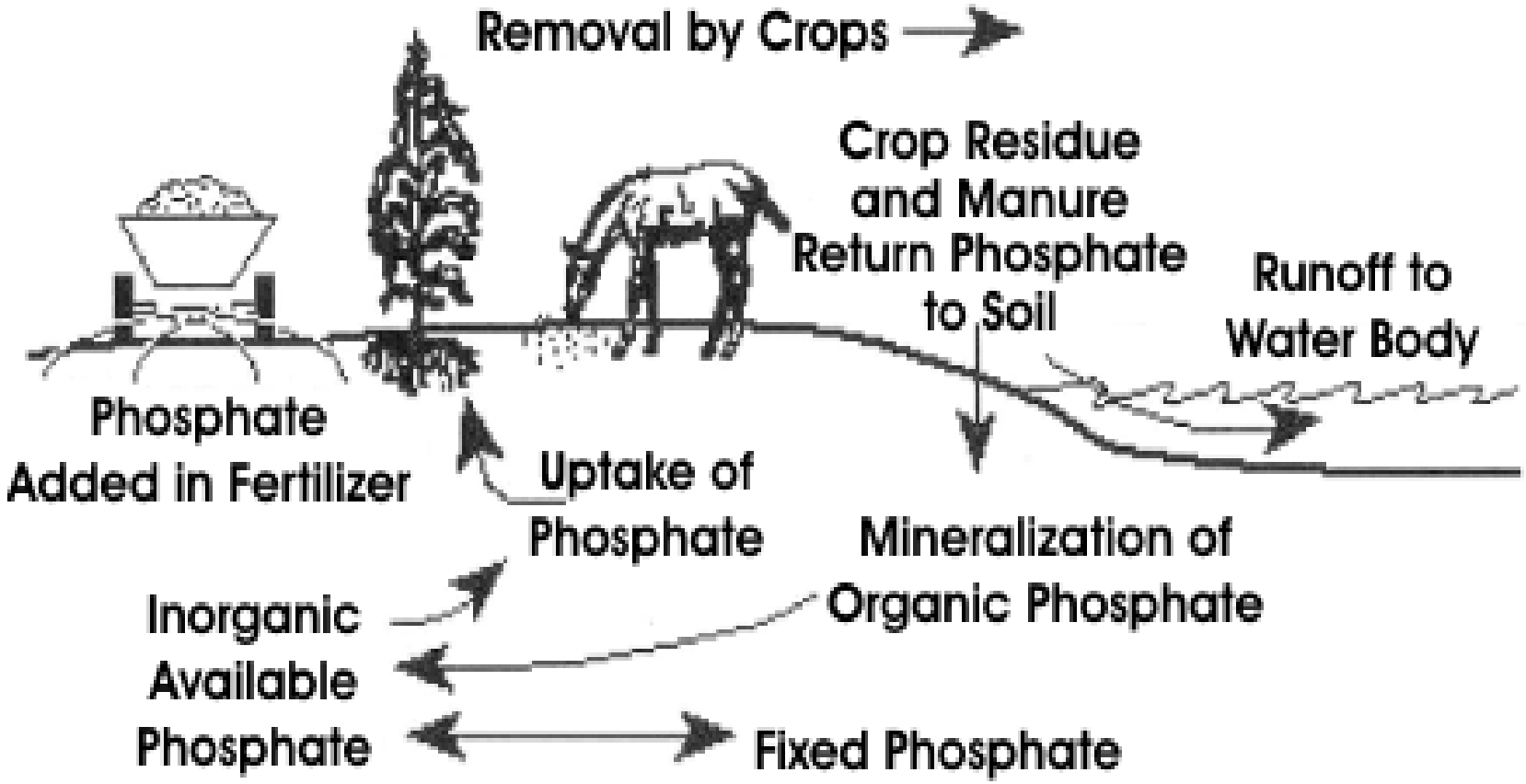


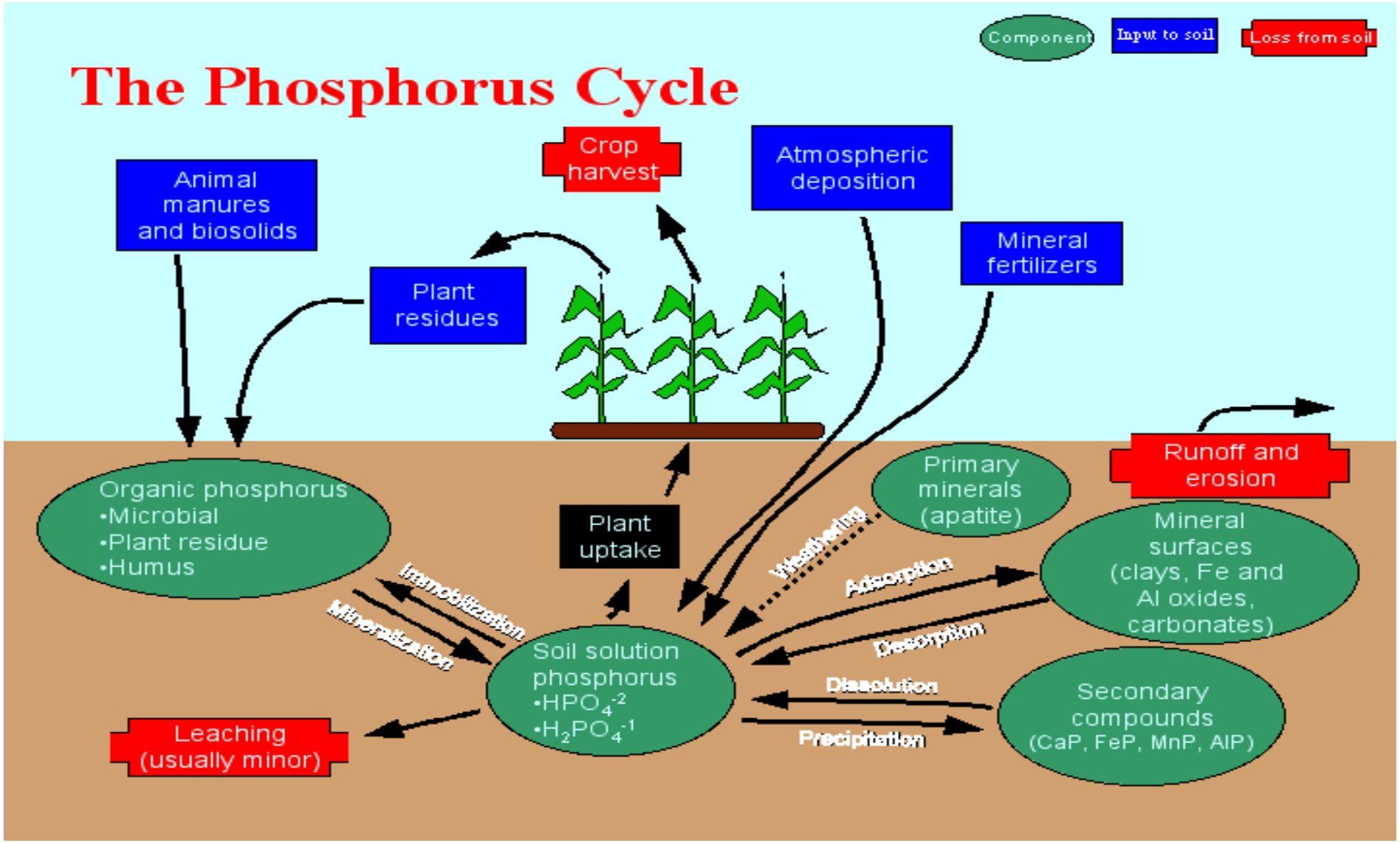
Figure 54–5 The phosphorus cycle in terrestrial and aquatic environments. Recycling of phosphorus (as phosphate, PO_4^{3-}) is slow because no biologically important form of phosphorus is gaseous. Phosphate that becomes part of marine sediments may take millions of years to solidify into rock, uplift as mountains, and erode again to become available to living things.

The Phosphorus Cycle

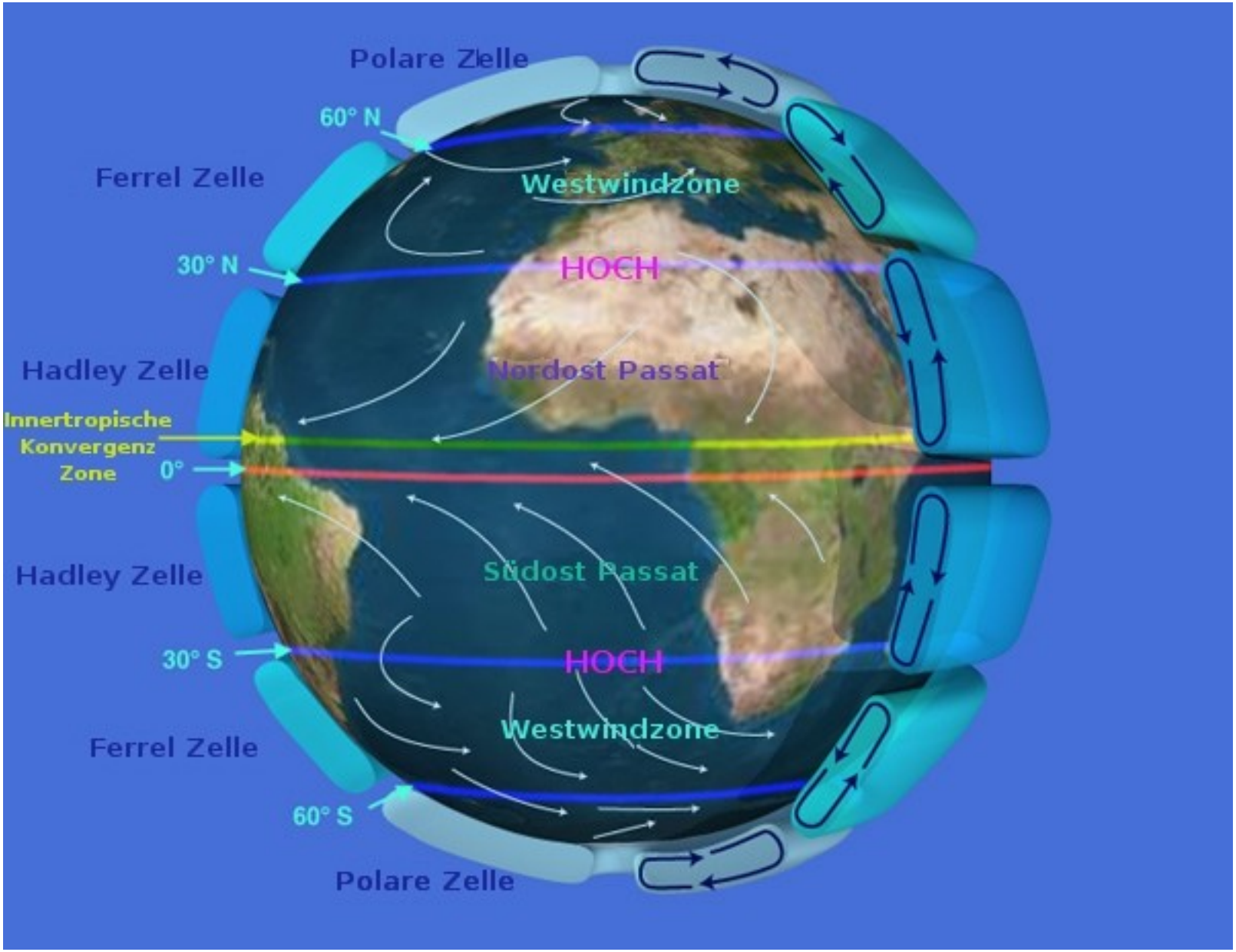


Source: Busman et al., 1997.

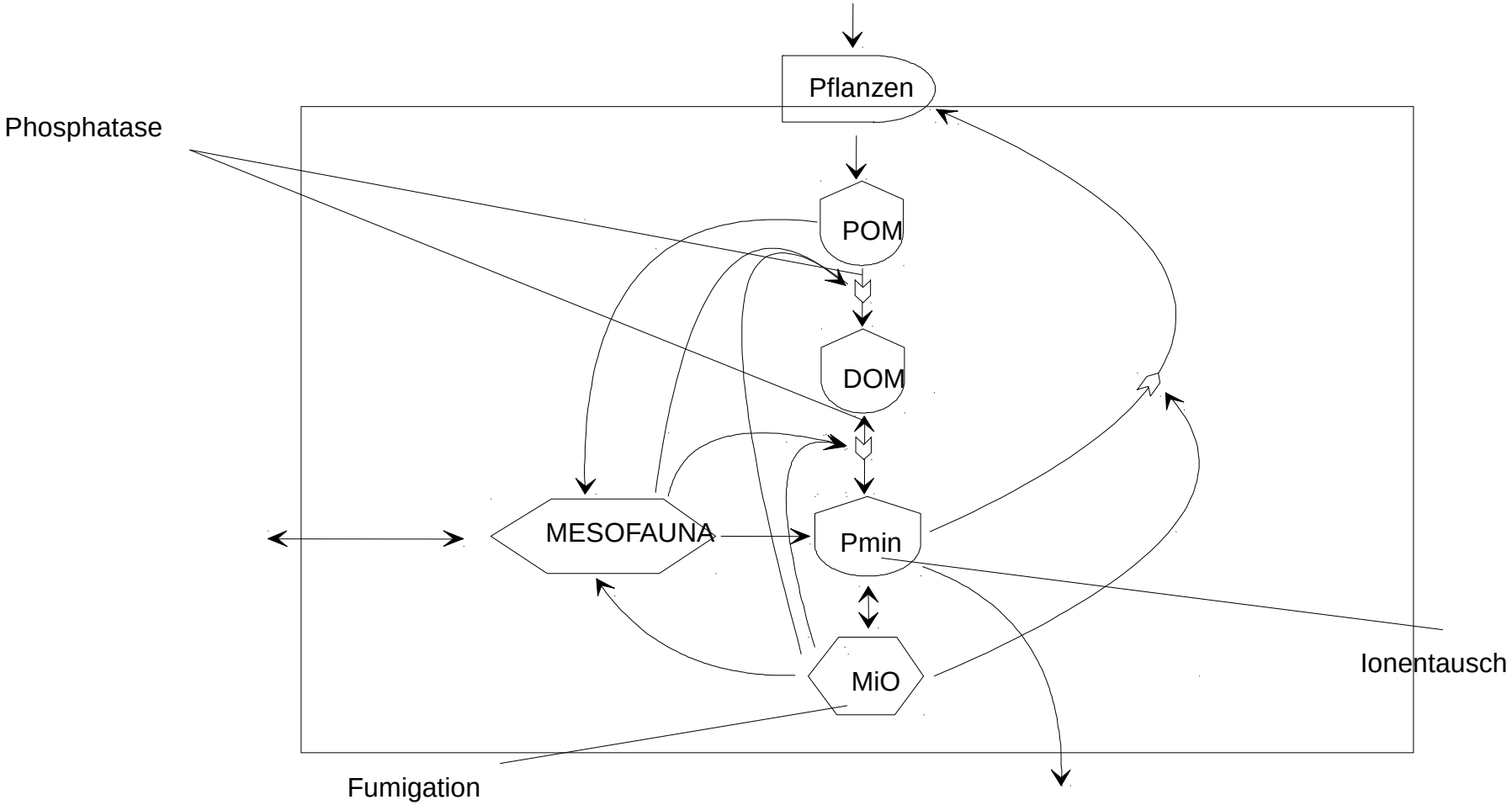
The P cycle, terrestrial

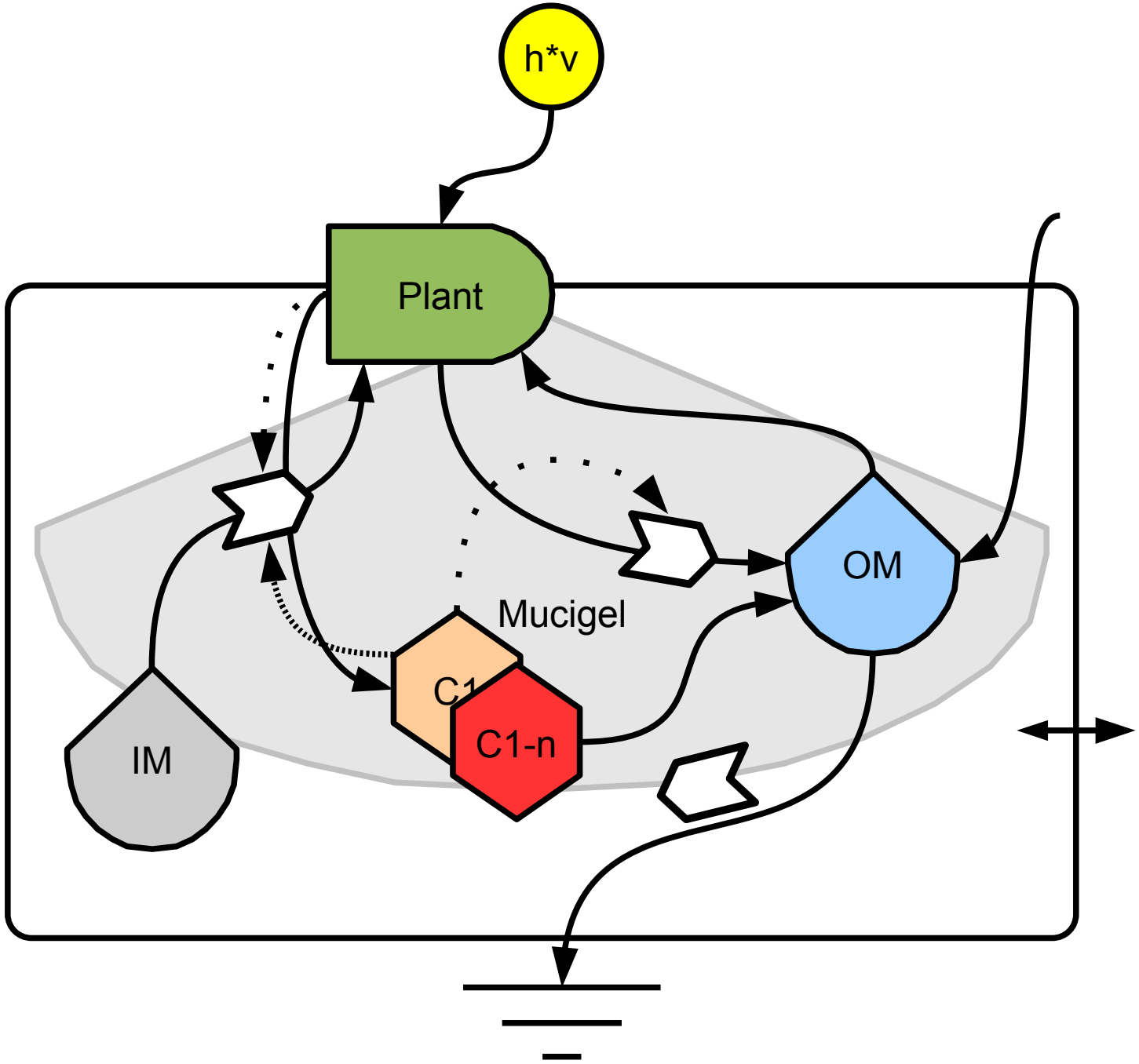


Klimaentwicklung als Folge der Vegetationsdecke



P- Turnover im Boden




h*v
Plant
OM
Mucigel
C1
C1-n
IM

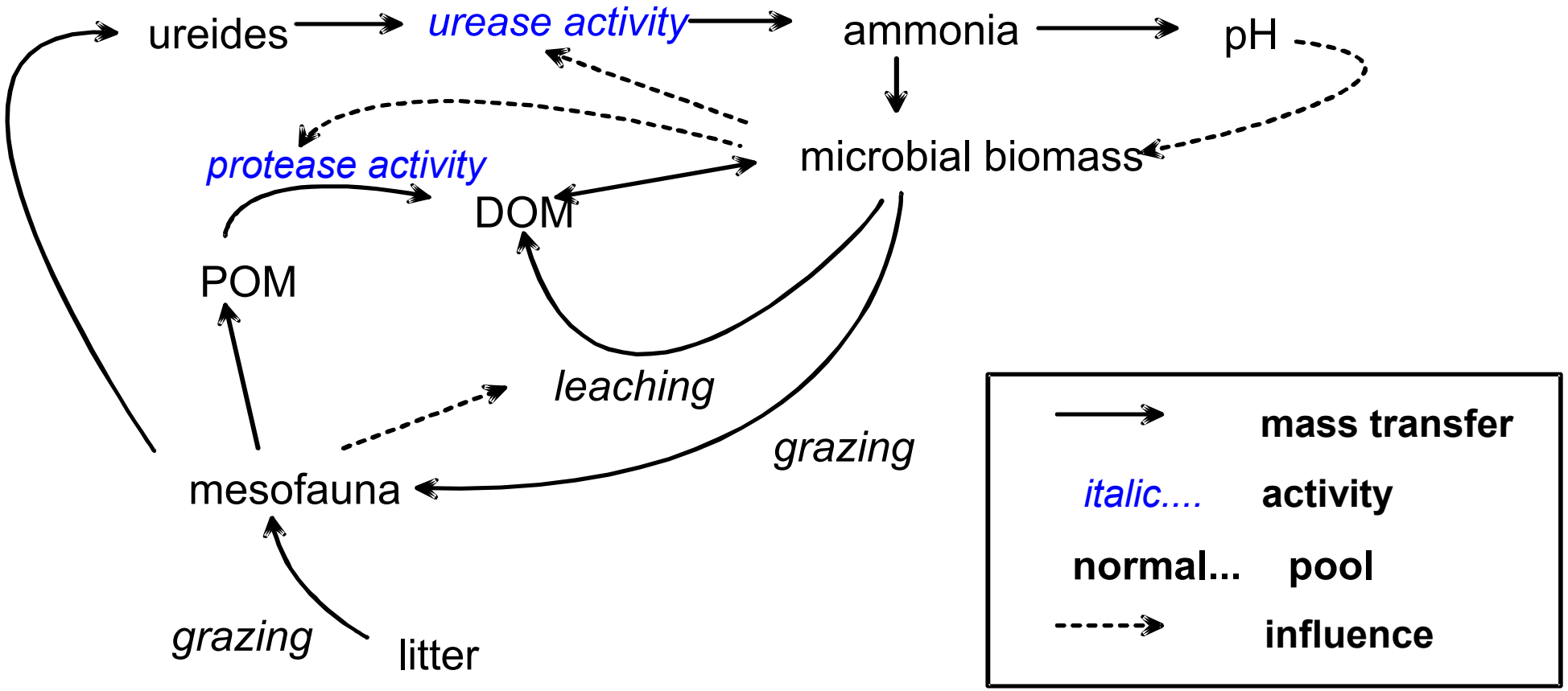
Root Mucilage / Soil Mucigel

many origins, many qualities, and many functions of a homoiodynamic, metastable matrix

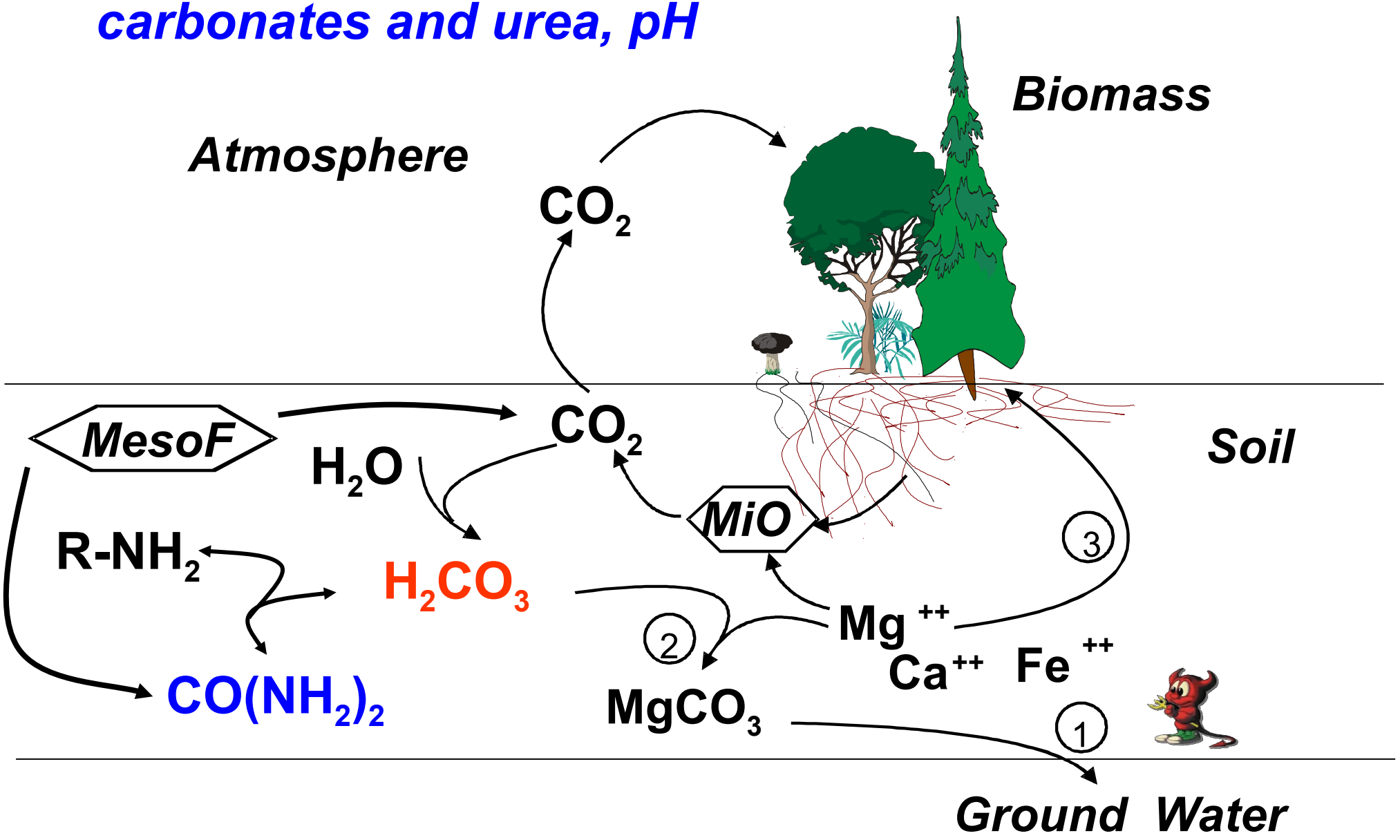
1. humidity conserving and pH/RP buffering
2. soil aggregate stabilising and cytostatic environment
3. vegetation specific composition (root exudates)
4. lubricant for growing roots
5. dynamic nutrient uptake matrix of roots
   (permeation control, chelation, availability optimisation)
6. regenerated/ing habitat for microorganisms
7. nutrient coctail for microorganisms
8. communication matrix of the soil organisms

- Vom allgemeinen Schema zum spezifischen Ökosystemmodell
- **Pools und Flüsse verstehen**
- Systeme vergleichen
- Systemänderungen abschätzen

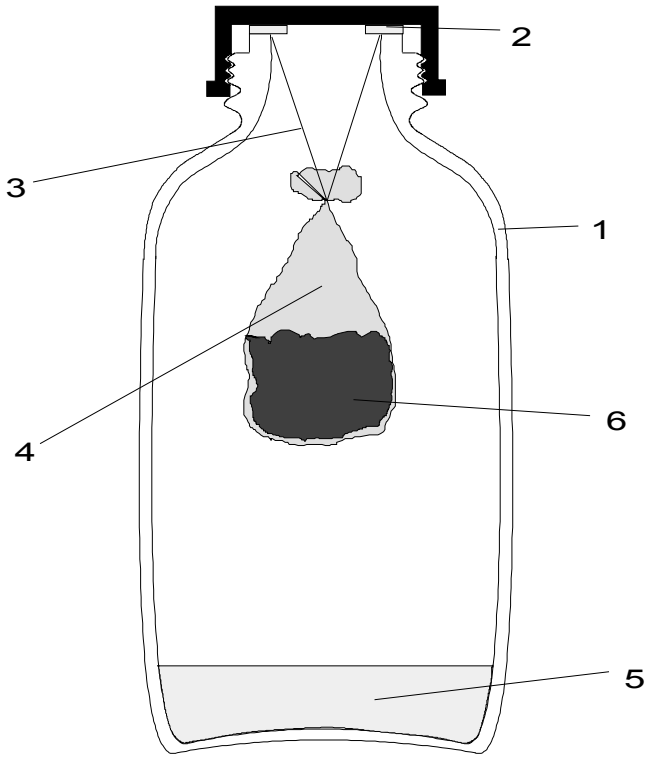
Organisms, Activities, Pools, Transfers ….



basal C/N transfer mechanisms in the soil system: *carbonates and urea, pH*



Rücktitration nach Isermeyer (1952)



1... Schott- Flask
2... Sealing
3... Nylon Thread
4... Small Bag from Nylon Mesh
5... Sodiumhydroxide
6... Soil

IRGA (Infra Rot Gas Analyse)

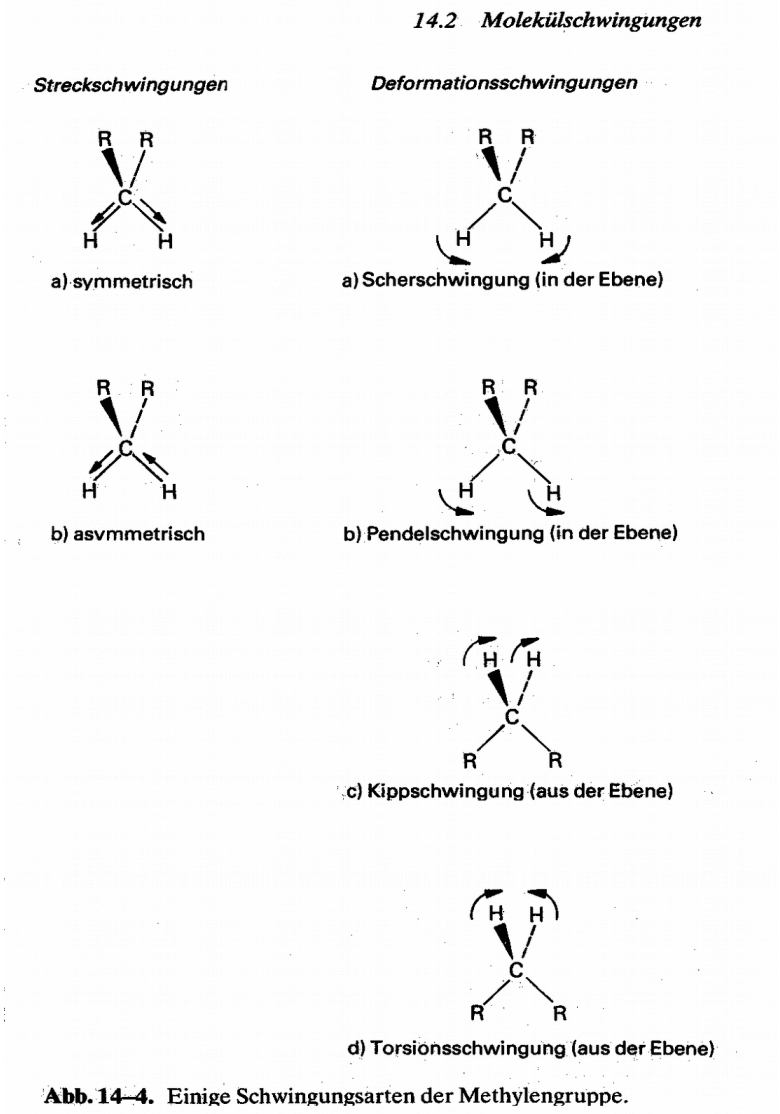
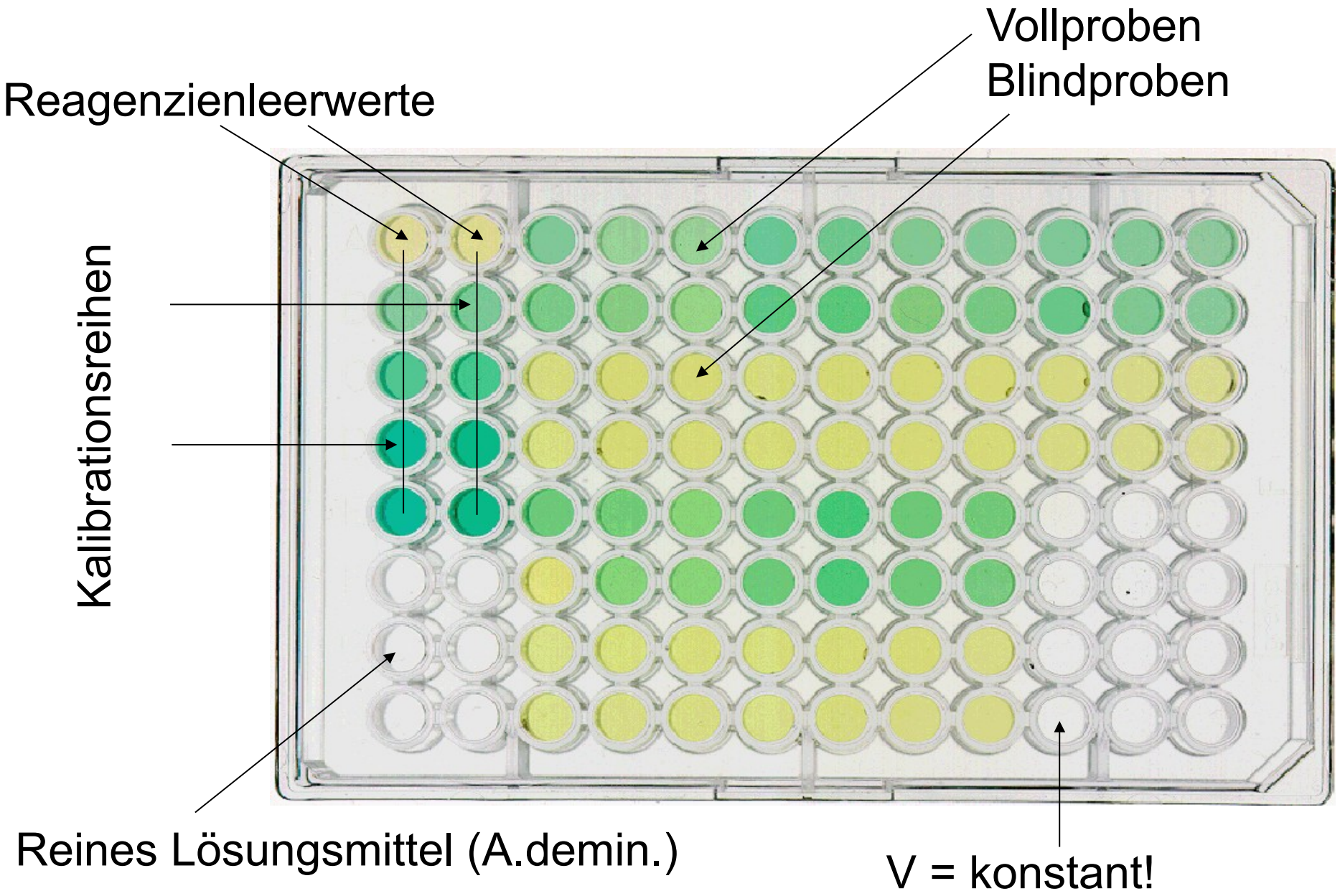


Abb. 14–4. Einige Schwingungsarten der Methylengruppe.

Mikroplattenphotometer, Enzymtests (Urease)



- Vom allgemeinen Schema zum spezifischen Ökosystemmodell
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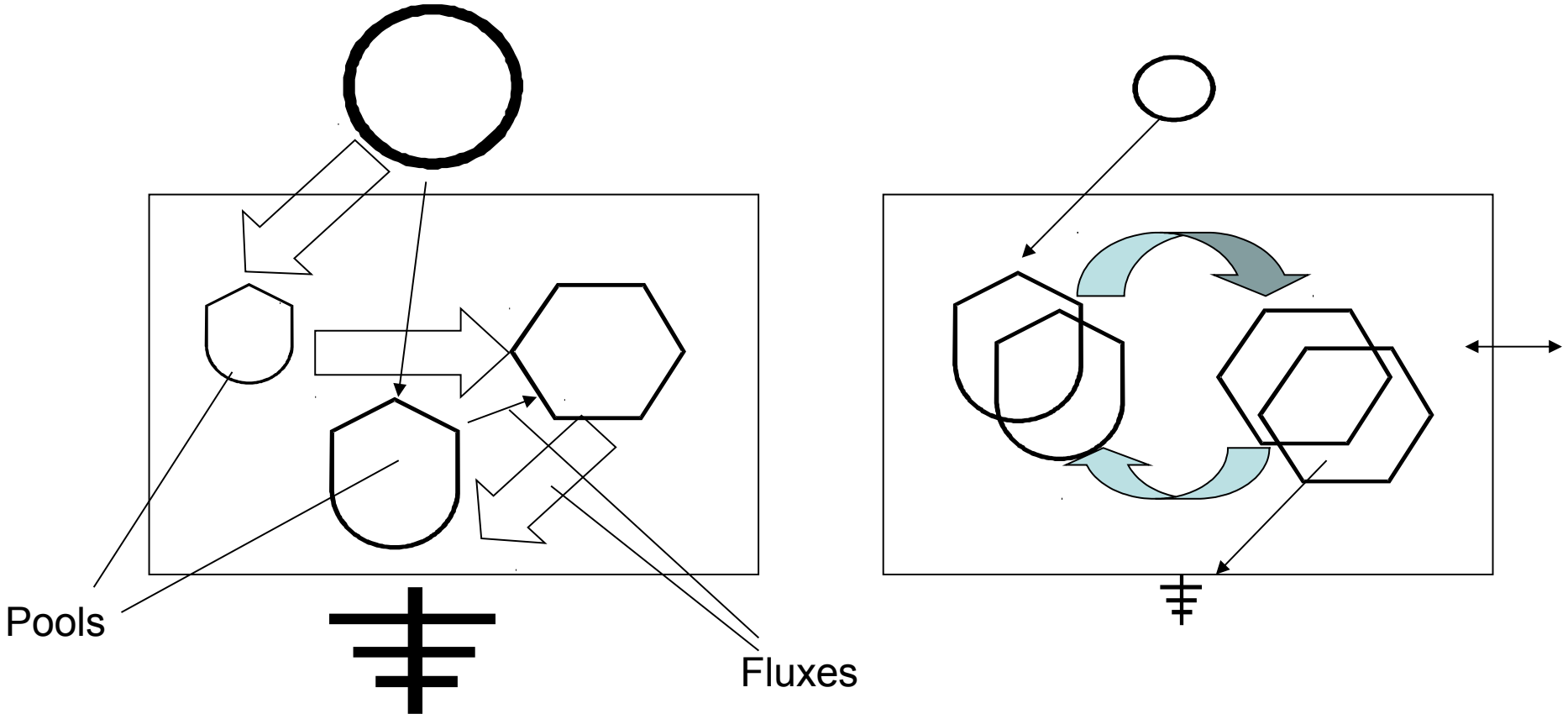
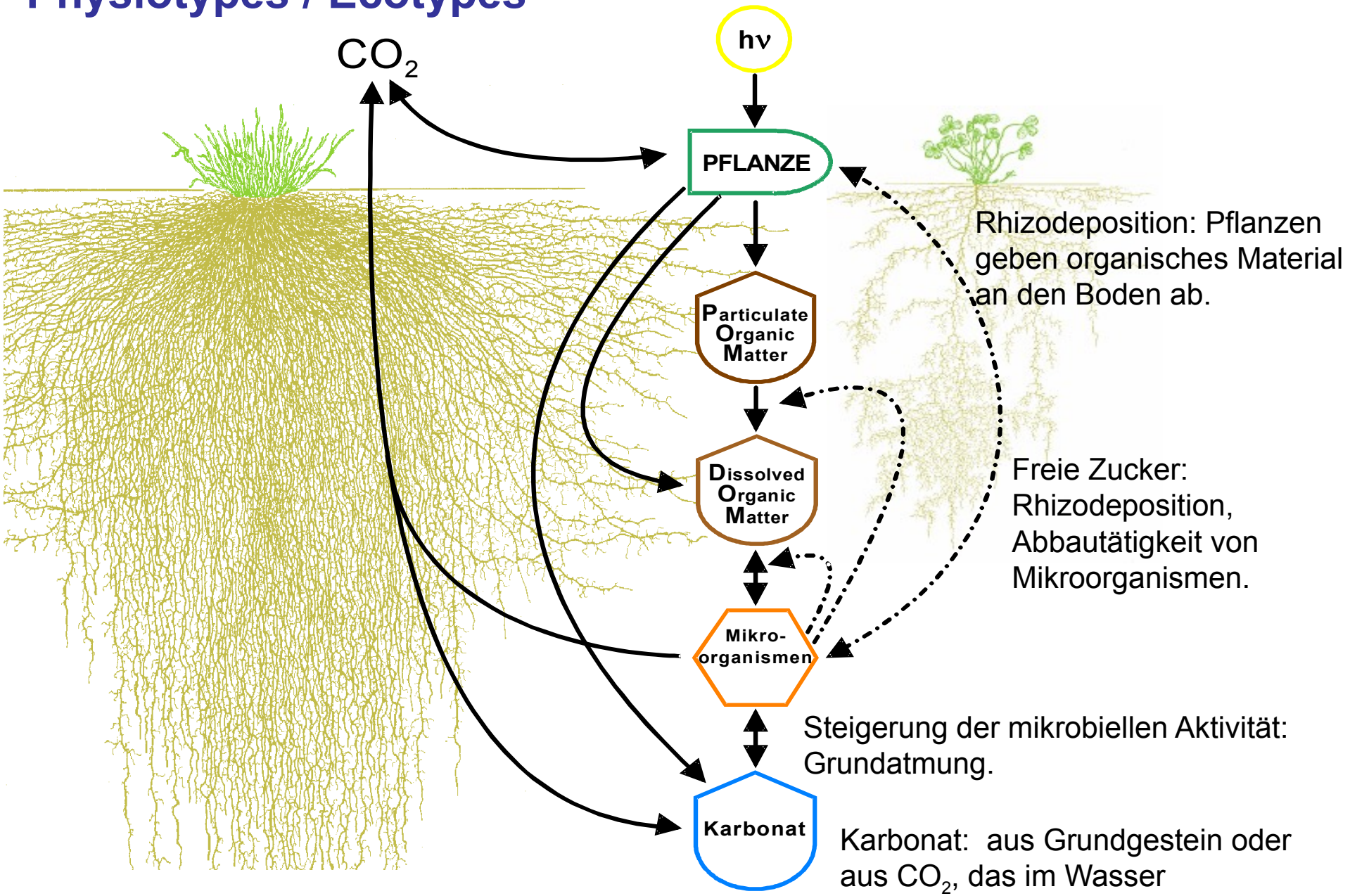
Pools, Fluxes, metastabile Systeme



Durchfluss

Recycling

Physiotypes / Ecotypes



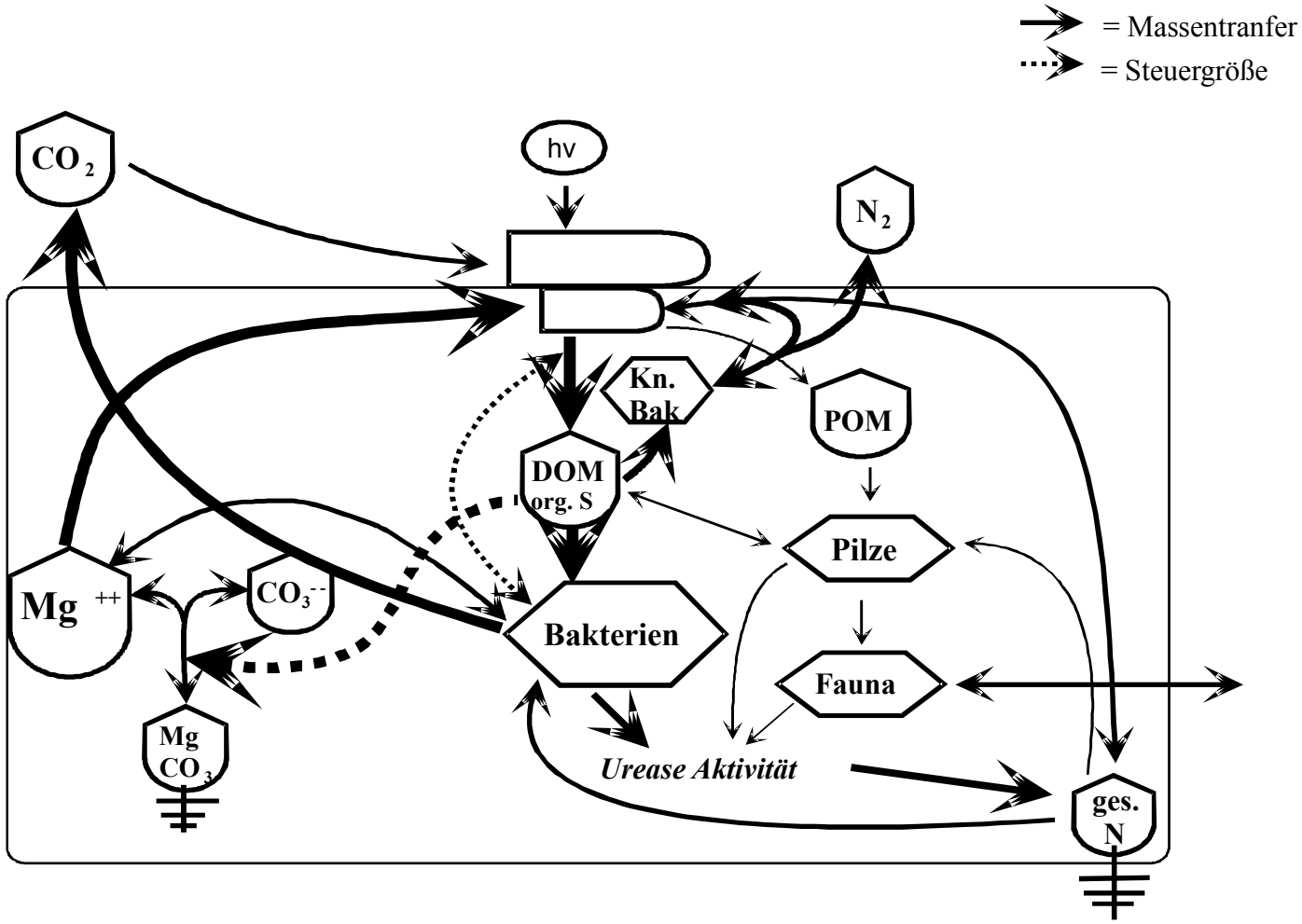
Rhizodeposition: Pflanzen geben organisches Material an den Boden ab.

Freie Zucker: Rhizodeposition, Abbautätigkeit von Mikroorganismen.

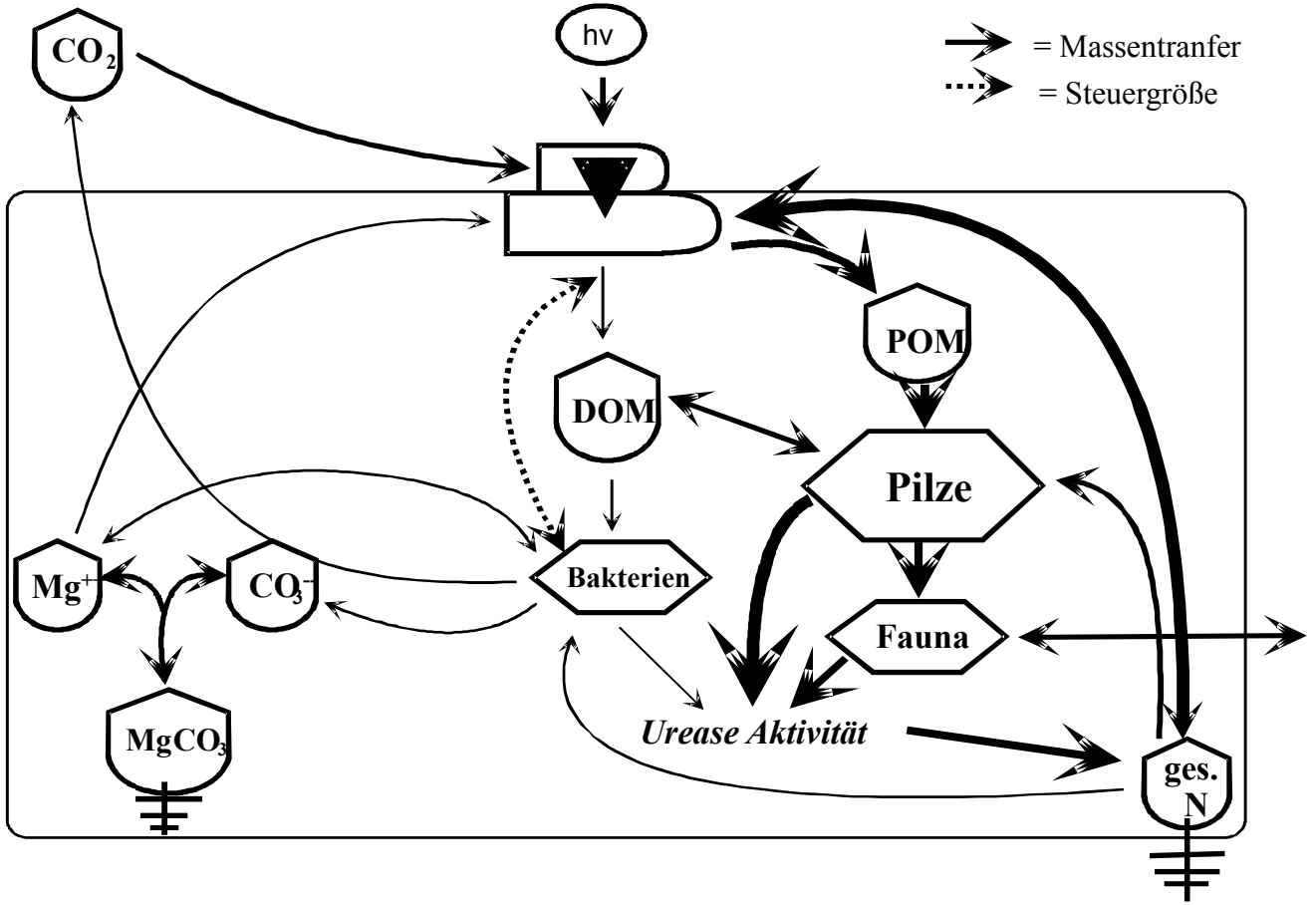
Steigerung der mikrobiellen Aktivität: Grundatmung.

Karbonat: aus Grundgestein oder aus CO_2, das im Wasser Kohlensäure bildet.

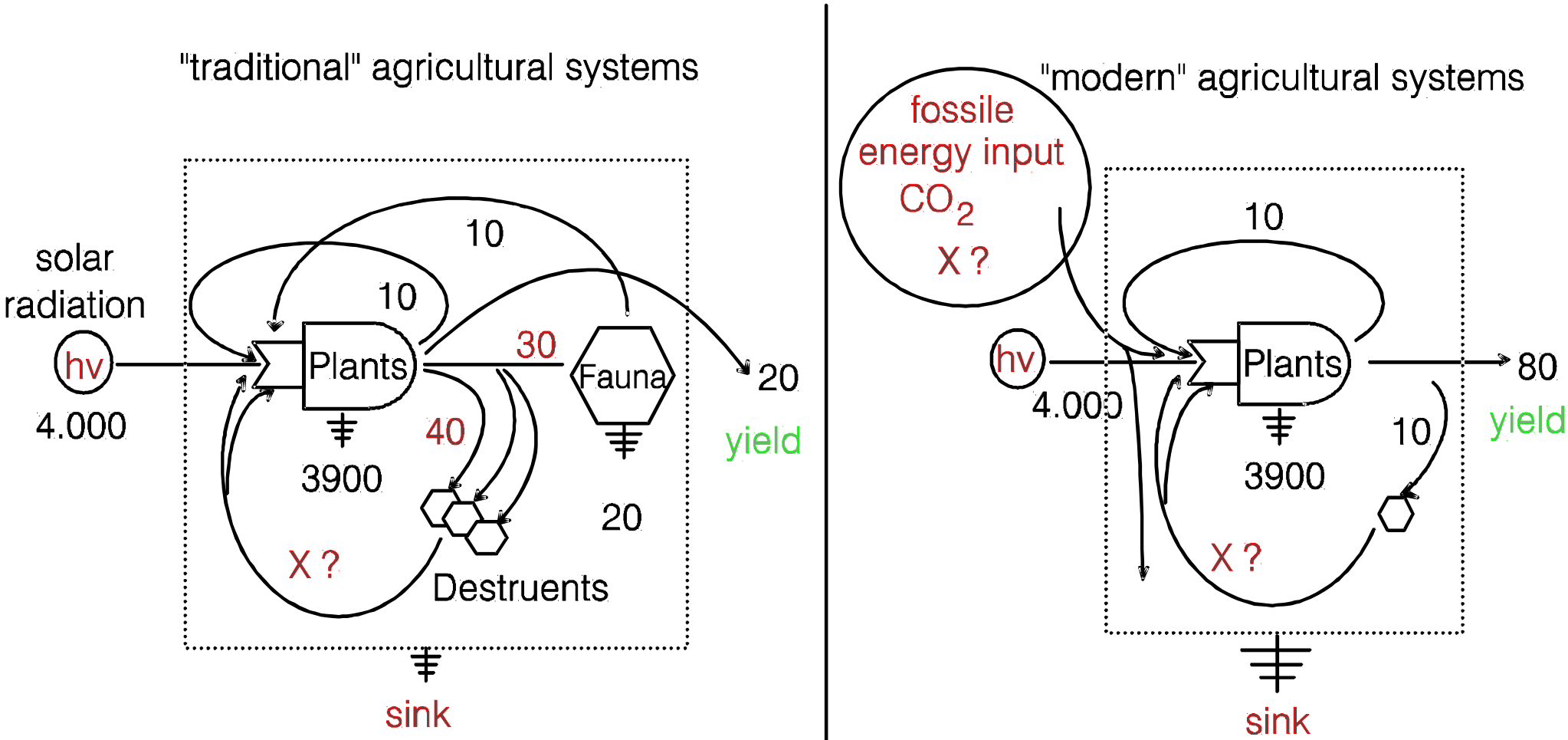
TRIFOLIUM


= Massentranfer
= Steuergröße
CO_2
hv
N_2
Kn.
Bak
POM
DOM
org. S
Pilze
Mg $^{++}$
CO_3^{--}
Bakterien
Fauna
Mg
CO_3
Urease Aktivität
ges.
N

LOLIUM


= Massentranfer
= Steuergröße
CO_2
hv
POM
DOM
Pilze
Bakterien
Mg^+
CO_3^-
Fauna
$MgCO_3$
Urease Aktivität
ges. N

Description of Sustainability



energy balance in agriculturally used systems (after H.T.Odum, 1971).

Rhizodeposition Strategies of Plant Species

high biomass production

- keeping a reserve for remineralisation by slow decomposers (K-strategy)

high exudation of low molecular weight organic substances

- quick substrates for fast remineralizing microorganisms (R- strategy)

<u>Combinations (extremes) and their impact on ecosystems</u>

high biomass and **high** exudation high turnover, steady state or shift?

high biomass and **low** exudation steady state, slow shift of biodiversity

low biomass and **high** exudation quick depletion of nutrients, degradation?

low biomass and **low** exudation steady state, slow turnover rates

- Vom allgemeinen Schema zum spezifischen Ökosystemmodell
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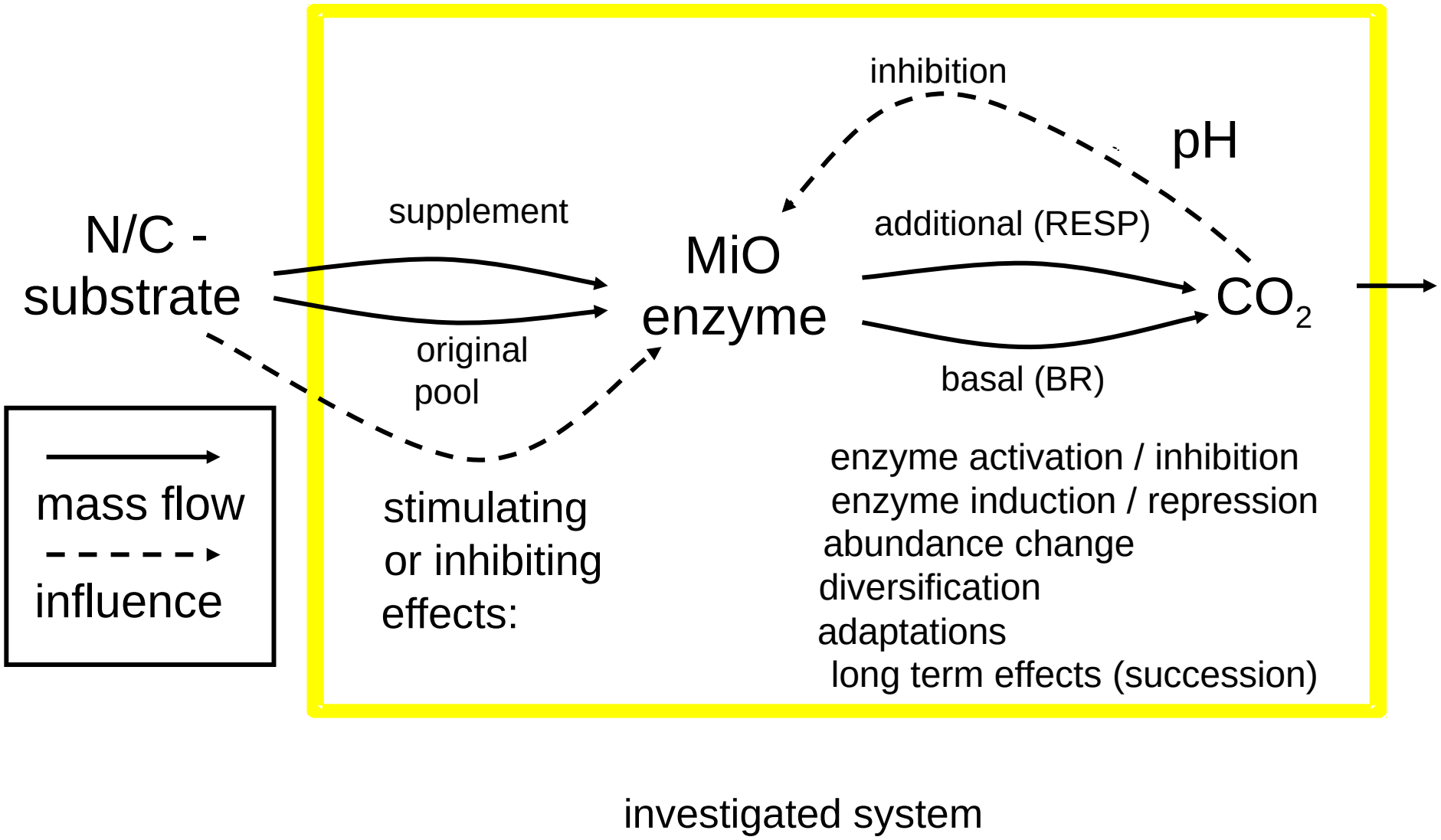
Definitionen: Bodenökologie, Bioaktivität

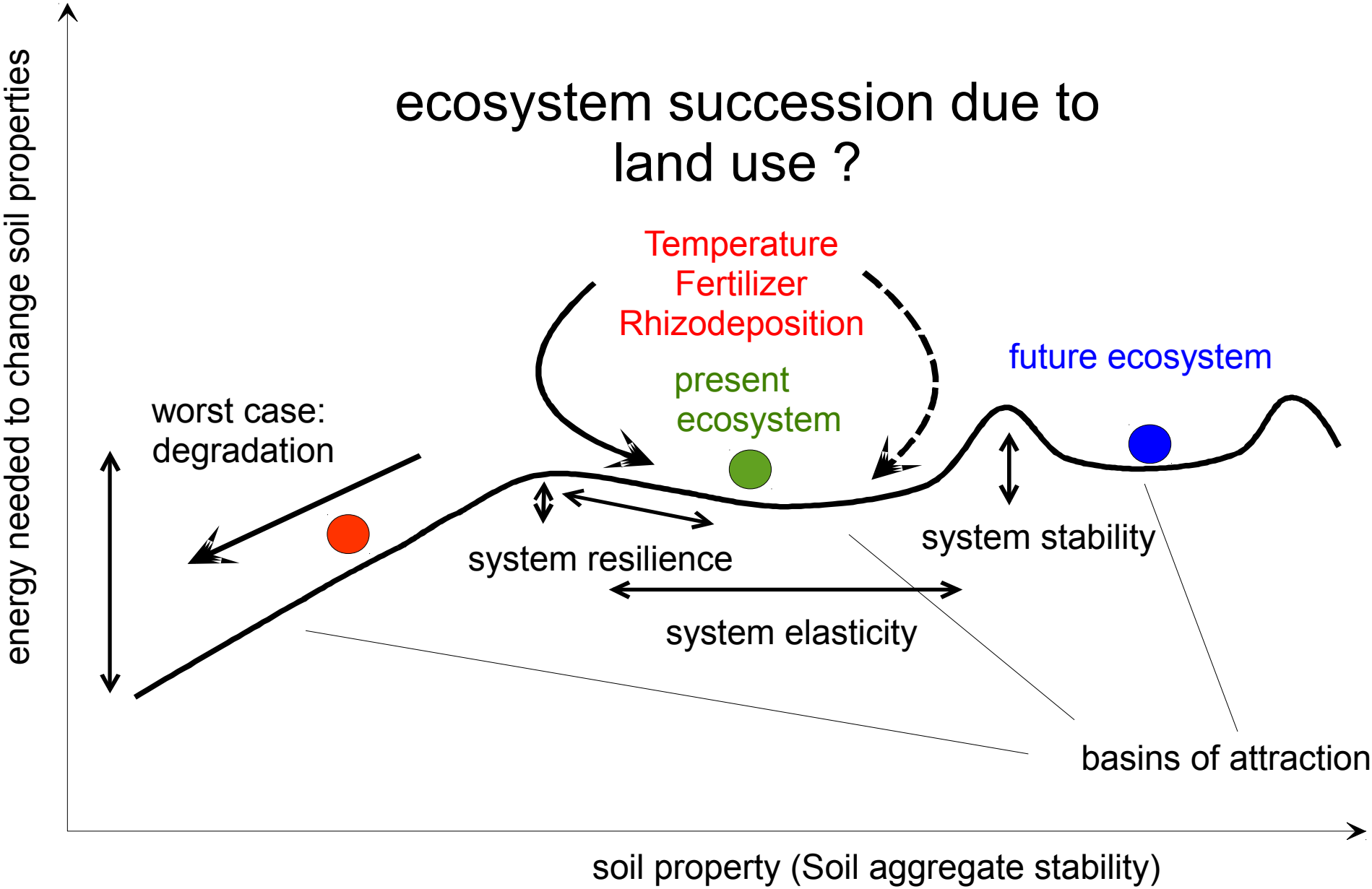
Bodenökologie

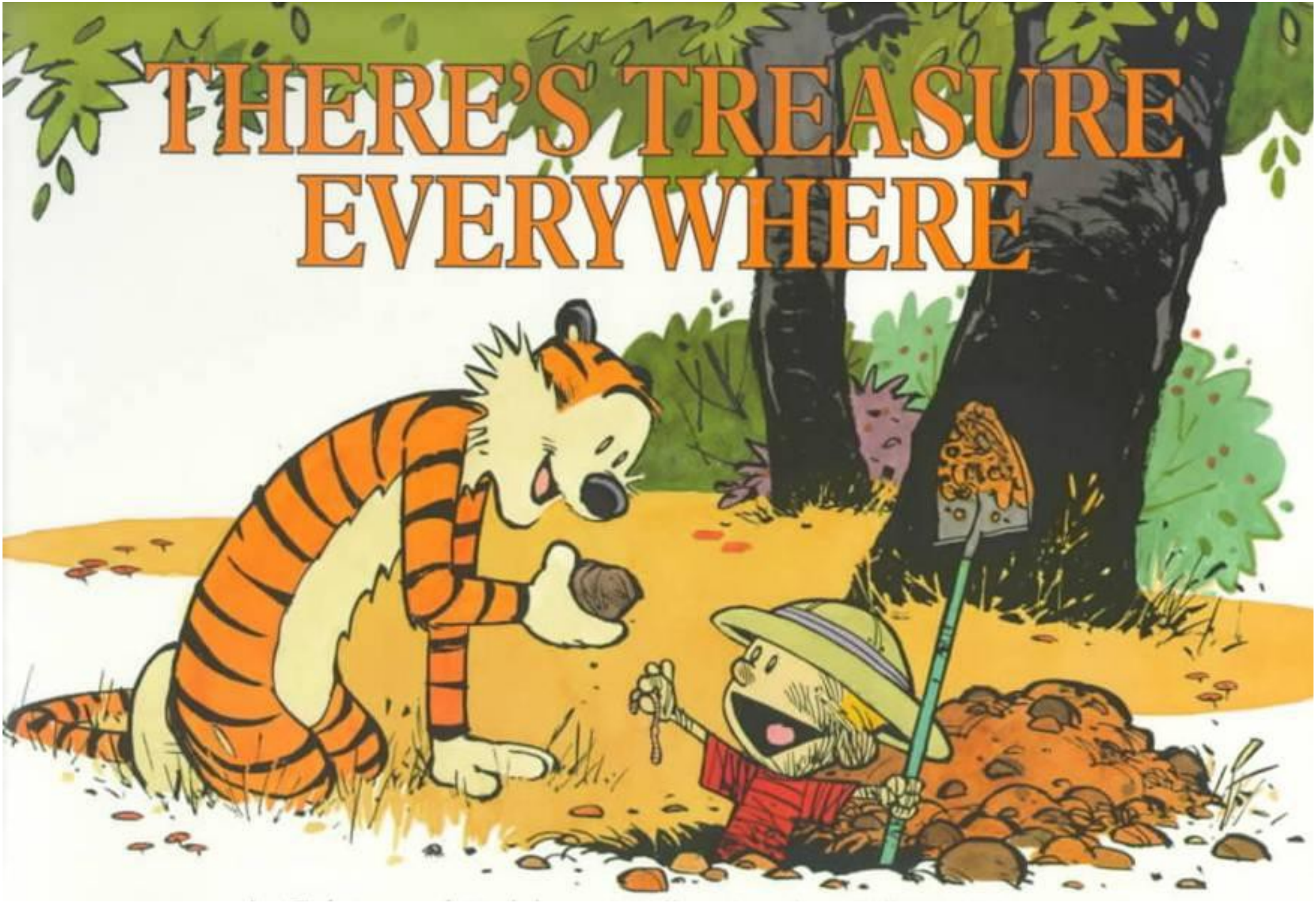
Rhizosphäre	Durchwurzelter Bodenraum, s.s. von der Wurzel direkt beeinflußter Boden.
Rhizoplane	Wurzeloberfläche, von Organismen besiedelt.
Rhizospährenorganismen	An der Wurzeloberfläche lebende Organismen.
Rhizodeposition	Deposition organischer fester und gelöster Substanz durch Wurzeln.
Wurzelexudation	Sekretion gelöster organischer Substanz durch die Wurzel.
Bioaktivität	Aktuelle meßbare metabolische Aktivität lebender Organismen oder Exoenzyme.
Potentielle Bioaktivität	Maximale induzierbare Bioaktivität.
Potentielle Biomasse	Maximale Abundanz bei optimalen Bedingungen (Induktion).
Biomasse	In g oder g C angegebene Masse lebender oder in Lysis befindlicher Organismen.
Abundanz	Häufigkeit der Individuen einer Art.
Artenreichtum	Artenanzahl in einem System „species richeness“
Diversität	relative Anzahl vorhandener Arten bezogen auf….(Shannon Weaner u.v.a.m.)
Relative Bedeutung	Dominanz einzelner Arten bezogen auf Abundanz und Bioaktivität.
Poolgrößen	Mengen einzelner Metaboliten .
Flüsse	Umsatzraten einzelner Metaboliten.
Energiefluss	Translokation Potetieller Chemische Energie wie etwa ATP.
Materialfluss	Translokation von Substanz, s.s. potentieller Biosubstrate.
Residenzzeit	Verweilzeit einer Substanz in einem System.
Turnoverzeit	Zeitraum der vollständigen Rezyklierung einer Substanz in einem System.
Source_Quelle	Energie bzw. Kohlenstoffquelle
Sink_Senke	Ort, an dem eine Substanz bzw. Energie immobilisiert wird.

Level of Impact



Stability of Soil Systems

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EVERYWHERE