Brian D. Fath

Department of Biological Sciences at Towson University

Panel 1

Soil health in the context of ecosystem dynamics

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Brian D. Fath

Professor, Towson University, Maryland, USA

Principal Research Scholar, IIASA, Austria

Editor in Chief, *Frontiers in Sustainable Resource Management*

frontiers
in Sustainable Resource Management

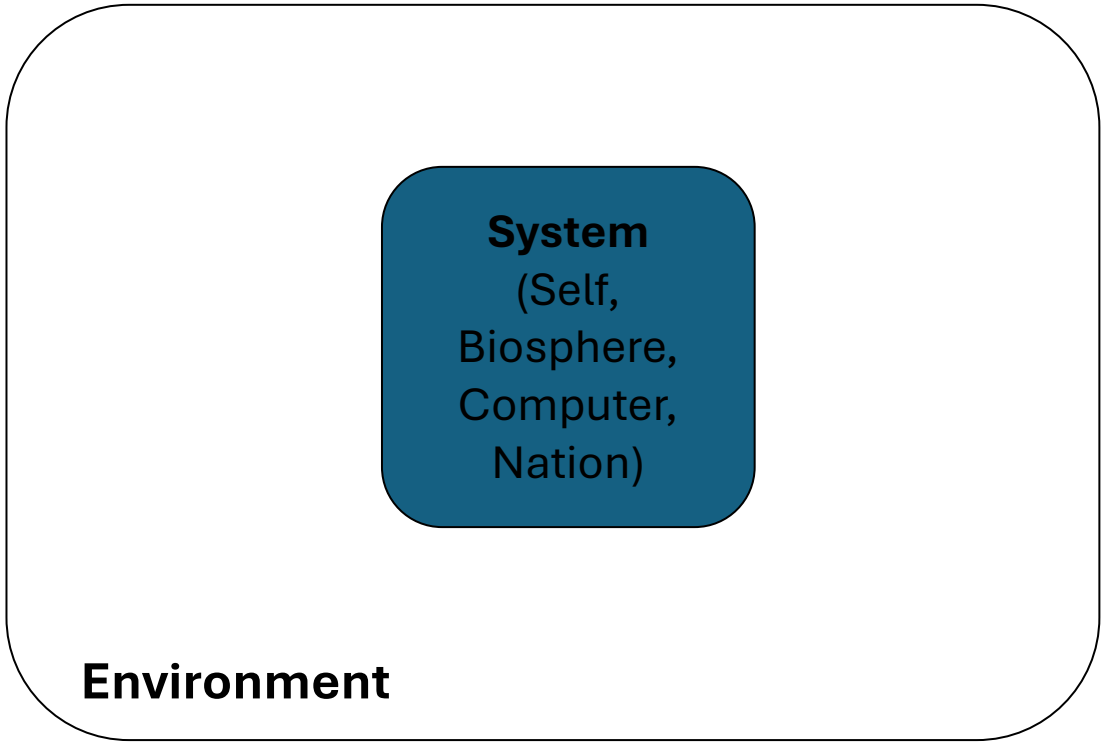
Ecosystems are awesomely complex, co-created, feedback systems

Agro-Ecosystems are simplified, managed, stressed systems

Three main messages:

- We are the Environment through the food we eat
- Growth vs. Development
- Soil: the critical Ecosystem Service

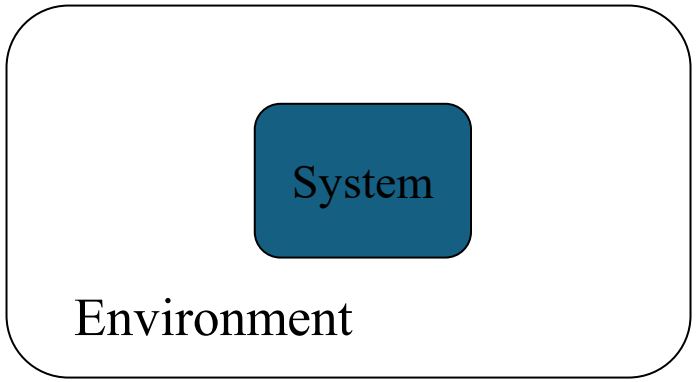
Fragmentation:
What we get wrong about Environment



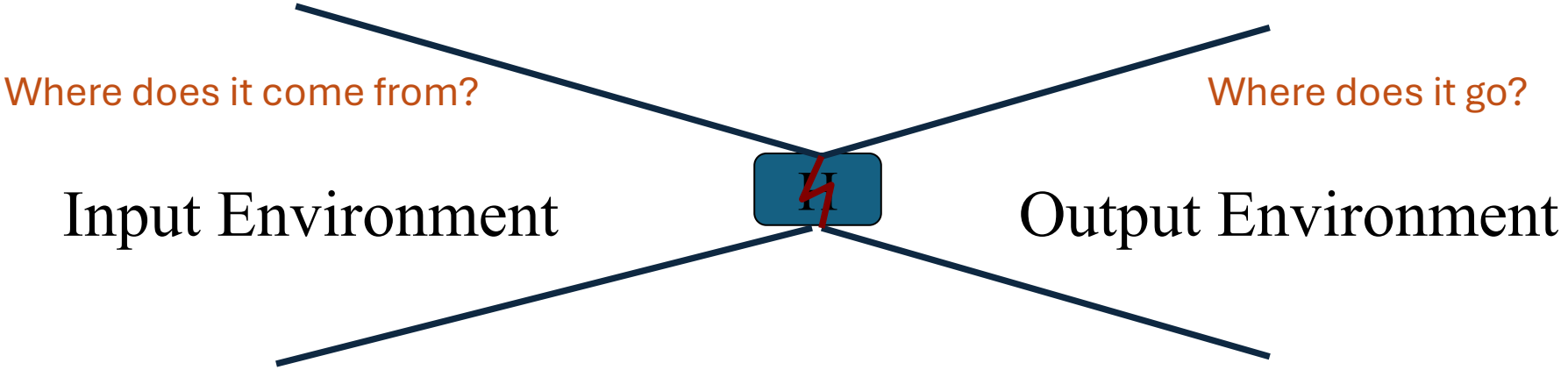
Separation and fragmentation of the system from its environment

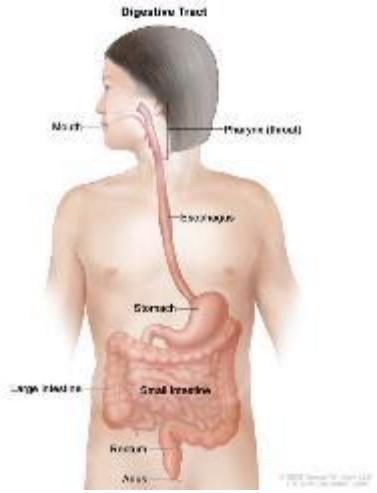
Environment is “out there”

Old perspective: fragmentation between bounded system and environment



New perspective: open, porous system is centrum of two environments





From Human Being to Human Becoming

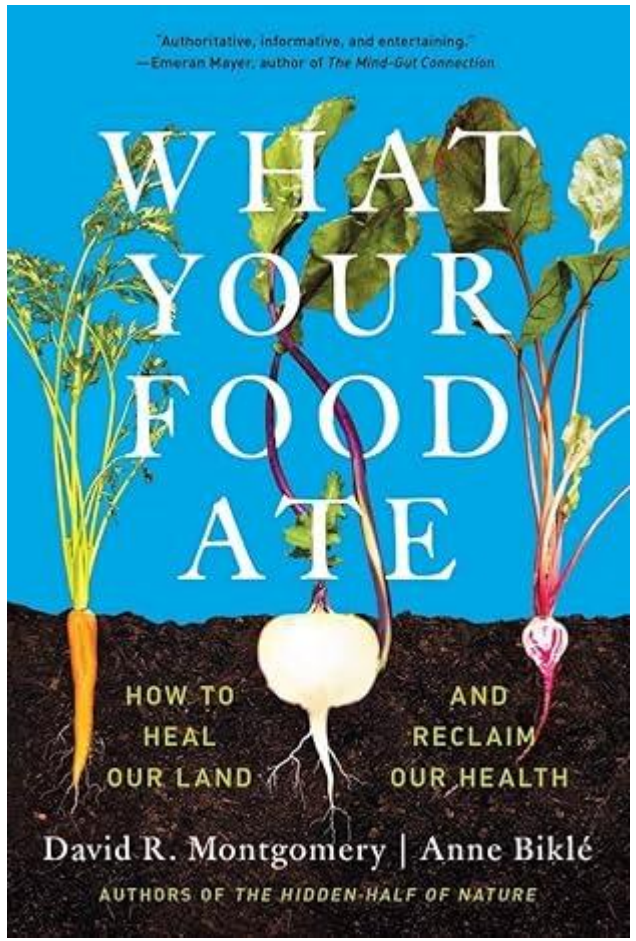
New perspective applied to agriculture

Where does it come from?

Input Environment

Output Environment

Where does it go?



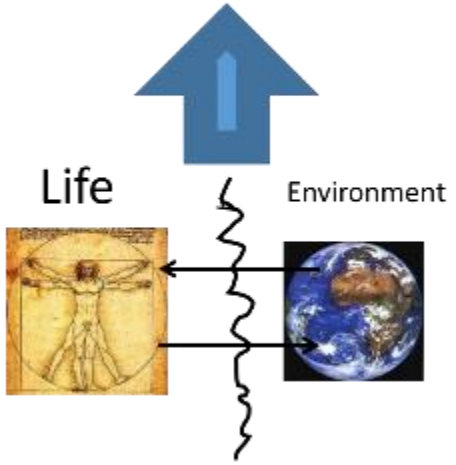
Proposal

1) Life and environment are best understood and modeled as a unified, single "life–environment" system.
2) A hyperset equation explicitly and formally *prohibits fragmentation of life from environment*

life–environment = {environment{ecosystems{organisms{environment}}}}

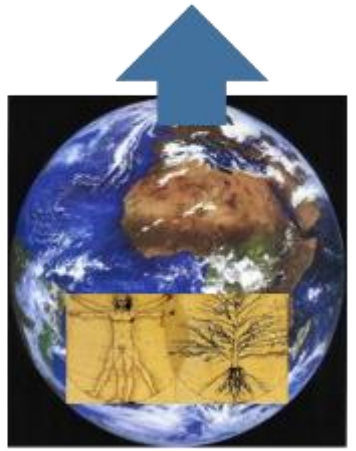
Separation and fragmentation lead to

Tragedy of the Commons
Humans win, environment degrades



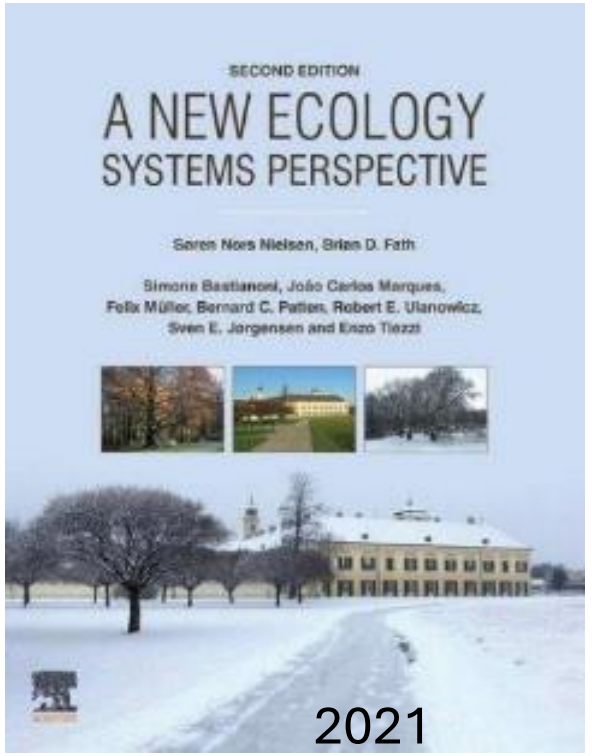
Figures by Dan Fiscus

Bounty of the Commons
Humans win, environment improves



Fiscus D, Fath BD, Goerner S. 2012. E:CO 14(3), 44–88.

9 properties of ecosystems



<u>Material constraints</u>

1) Ecosystems conserve matter and energy – 1st law
2) Energy quality decreases when work is done – 2nd law
3) All life uses largely the same biochemical constituents and processes

<u>Ontological properties – how they unfold</u>

4) An ecosystem uses surplus energy to grow (move further away from thermodynamic equilibrium)

5) An ecosystem develops (co-evolves) by adapting to and modifying its environment

<u>Phenomenological properties – what we observe</u>

6) Ecosystems have diversity of structure and function
7) Ecosystems network improve resource use
8) Ecosystems are exhibit hierarchies
9) Ecosystems have an enormous amount of information (genetic, biochemical, and process)

Understand and apply to agro-ecosystems

Quantity

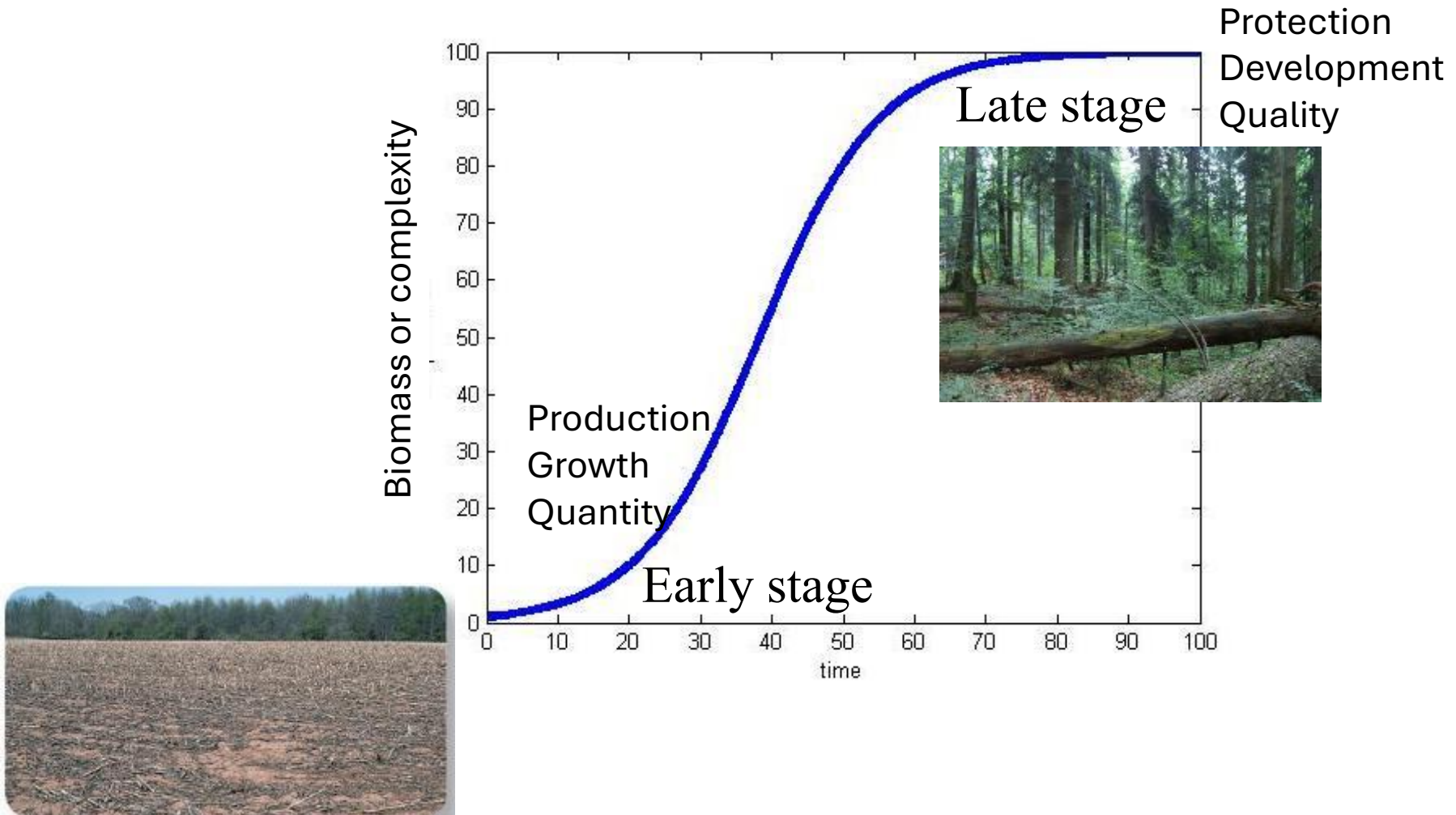
Quality

[Eco]system growth and development

Growth → *Quantitative* increase (Extensive variable)
Development → *Qualitative* increase (Intensive variable)

- "We must realize that growth and development are two very different things. You can develop without growing and vice versa.“
  - Tibor Vasko, 2009, www.solon-line.de/interview-with-tibor-vasko.html

Ecosystem growth and development from early to late successional stages



Bioenergetic model of succession

In early stages of succession, Production>Respiration and excess is channeled into growth and accumulation of biomass.

Increase capacity and complexity of the total biomass of all species and trophic levels as well as the complexity of energy transfer pathways.

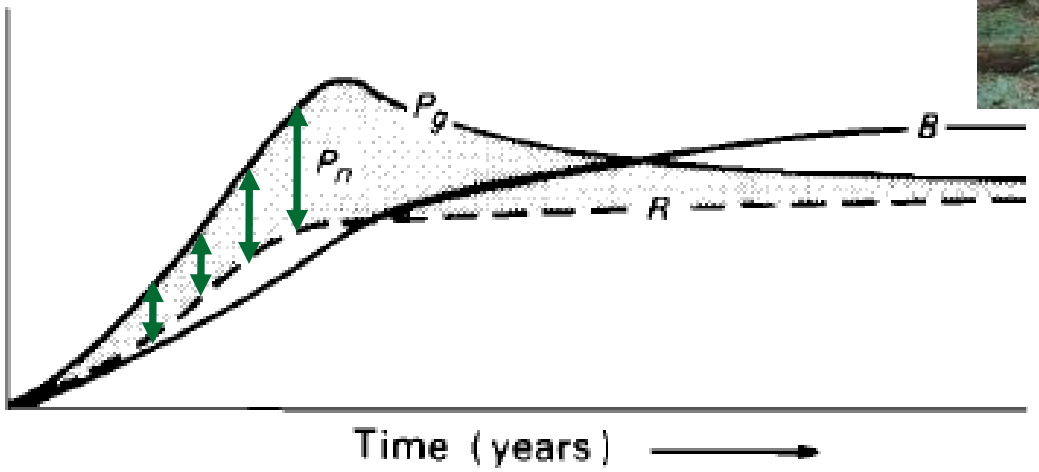


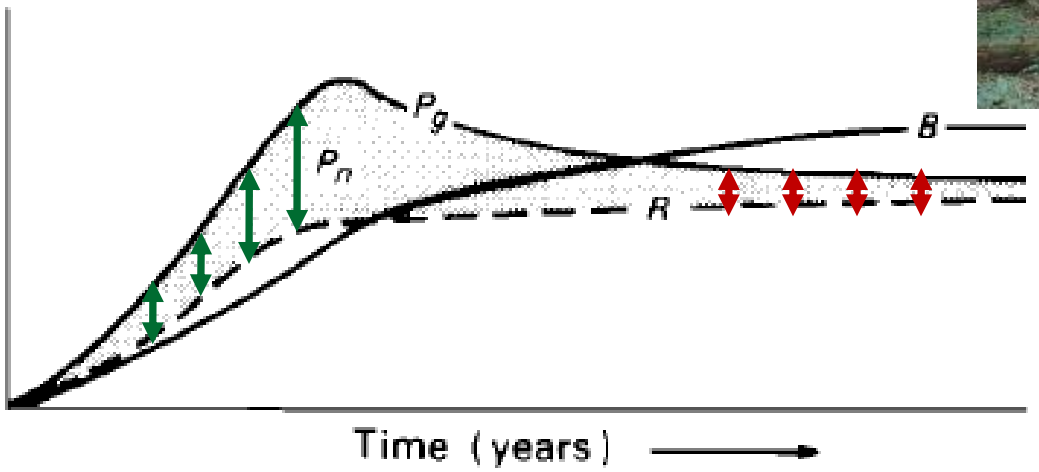
Fig. 25.17 Changes in gross (P_g) and net (P_n) production, respiration (R) and biomass (B) through succession.

a. During the first year, only the remains of corn plants are seen.

Bioenergetic model of succession

In late stages of succession, Production=Respiration as maintenance costs increase

Negative feedback maintains steady state, with little or no change in biomass

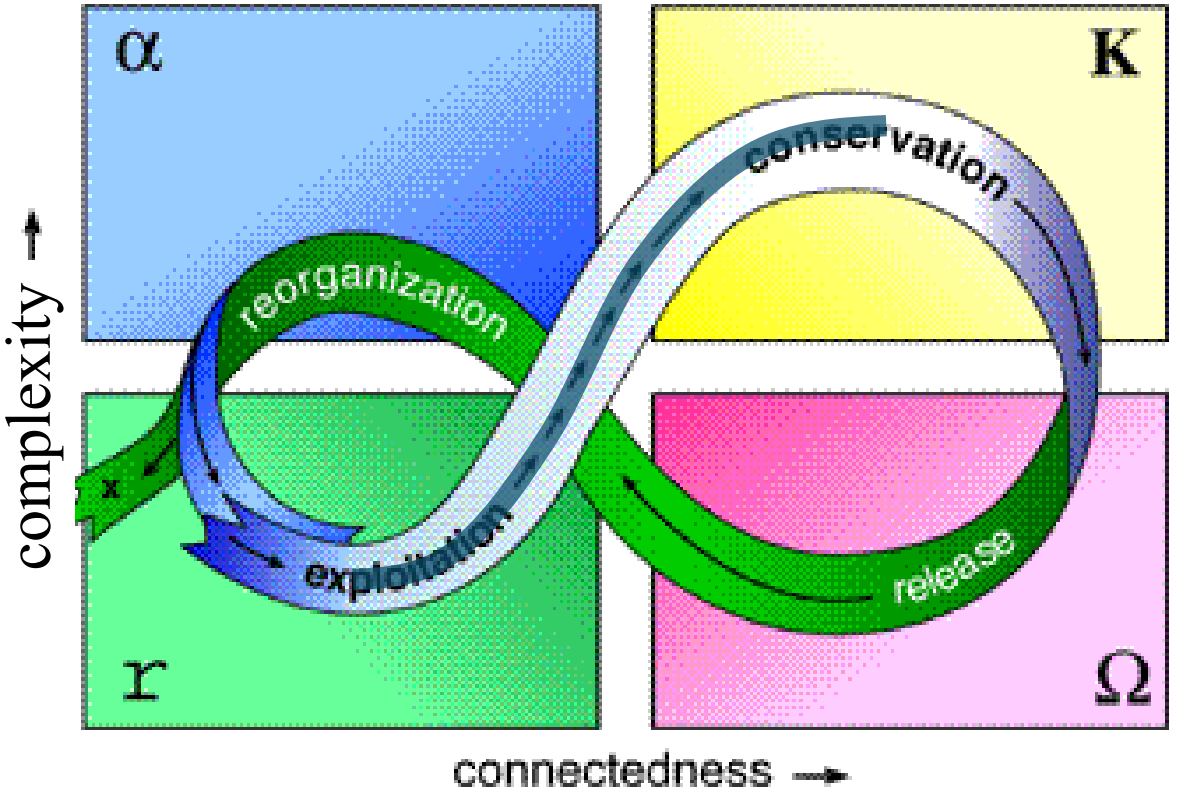



a. During the first year, only the remains of corn plants are seen.

Fig. 25.17 Changes in gross (P_g) and net (P_n) production, respiration (R) and biomass (B) through succession.

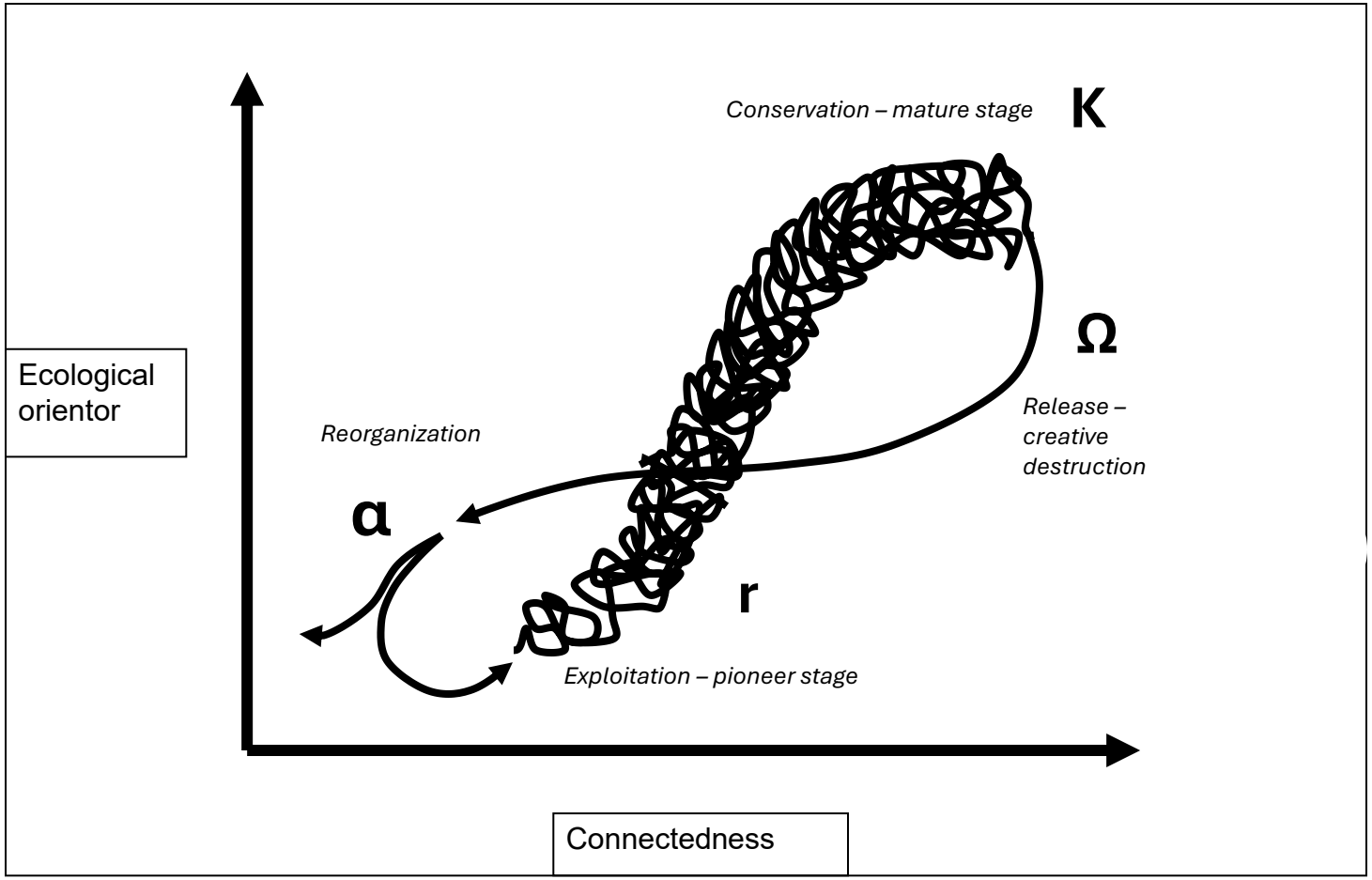
Adaptive Cycle: Ecologist Buzz Holling's 4-stage model of ecosystem dynamics

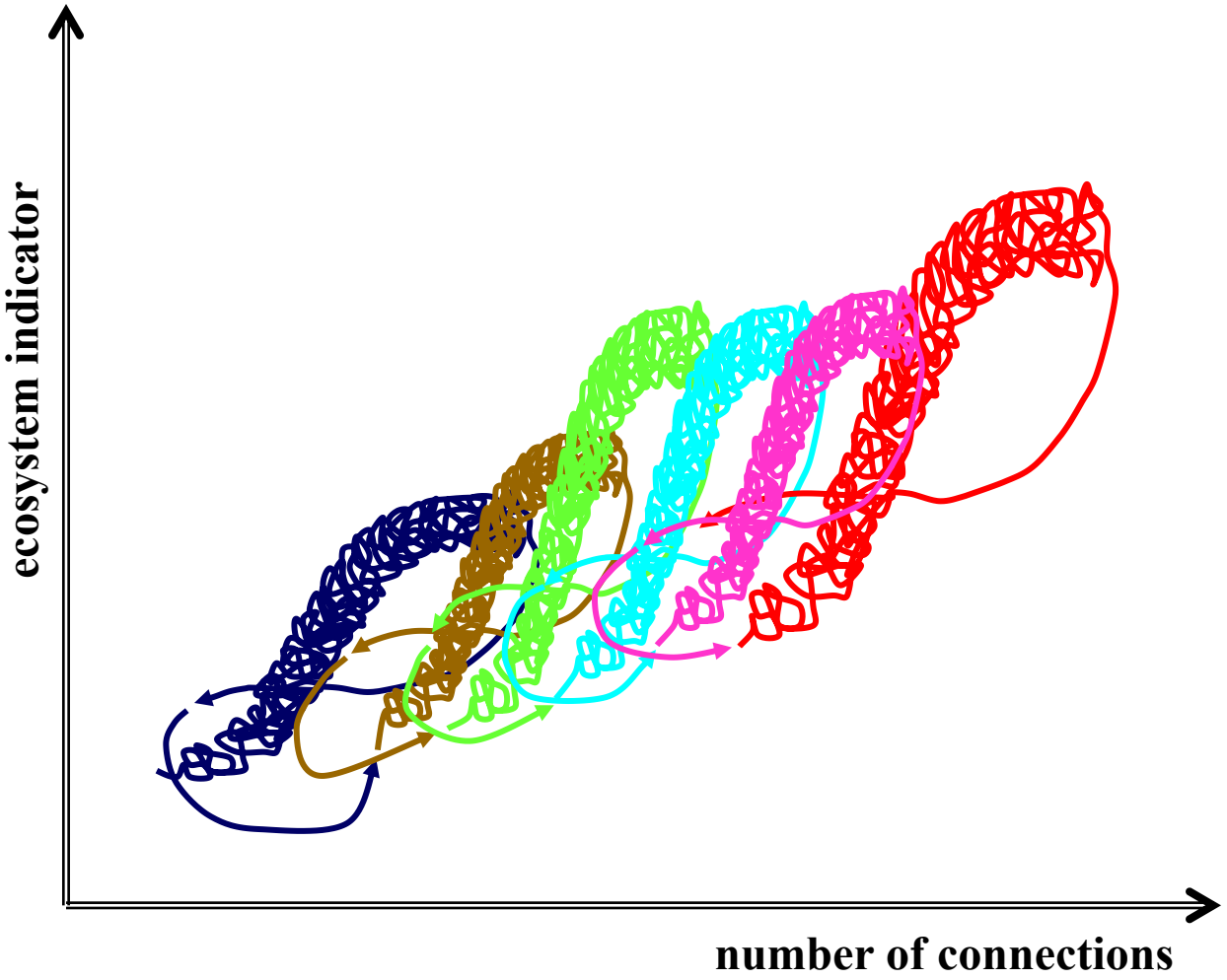
Logistic growth only captures part of the cycle



What is resilience?

Capacity to successfully navigate all stages of the adaptive cycle
Release and renewal are always part of the cycle

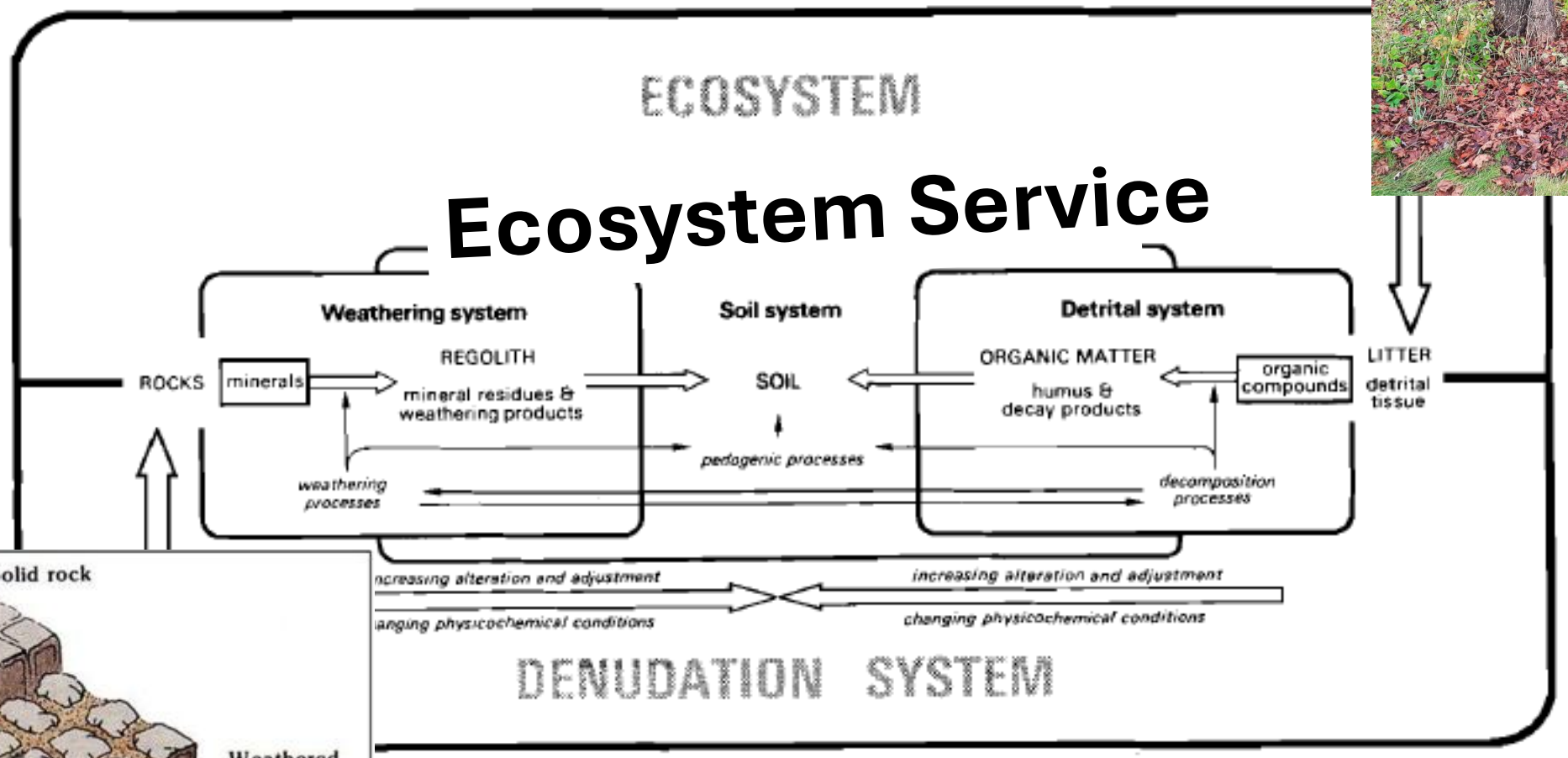


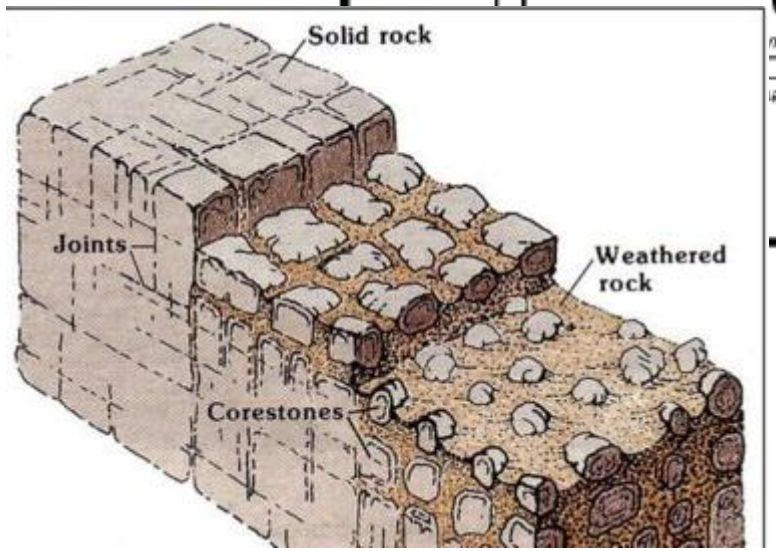


Long-term succession of ecosystems: small-scale disturbances support the overall system development

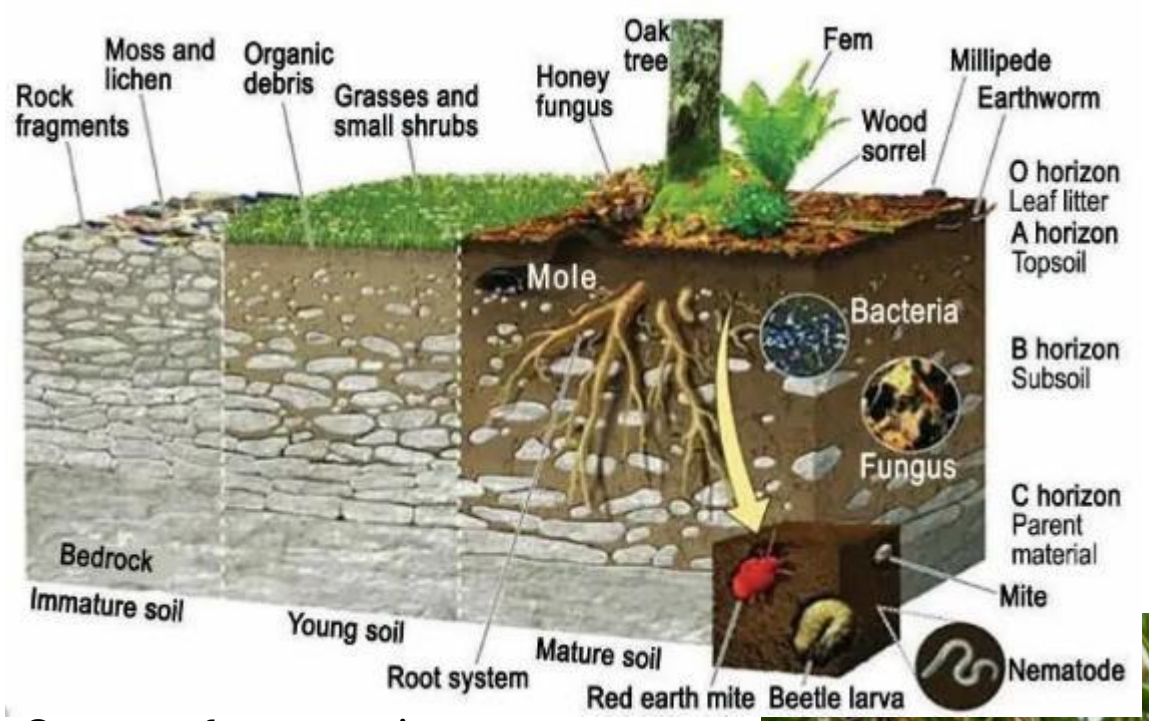
The Soil System

Ecosystem Service



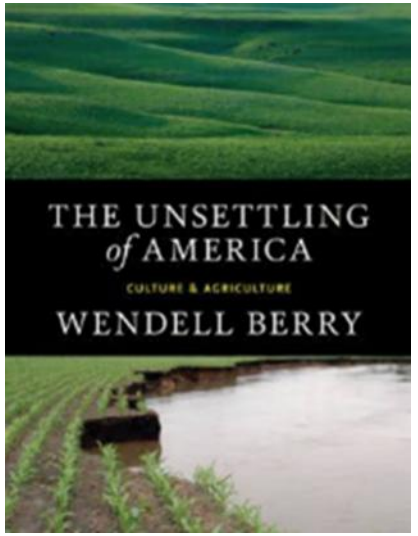


Soil is not a thing but a set of (autocatalytic) relations

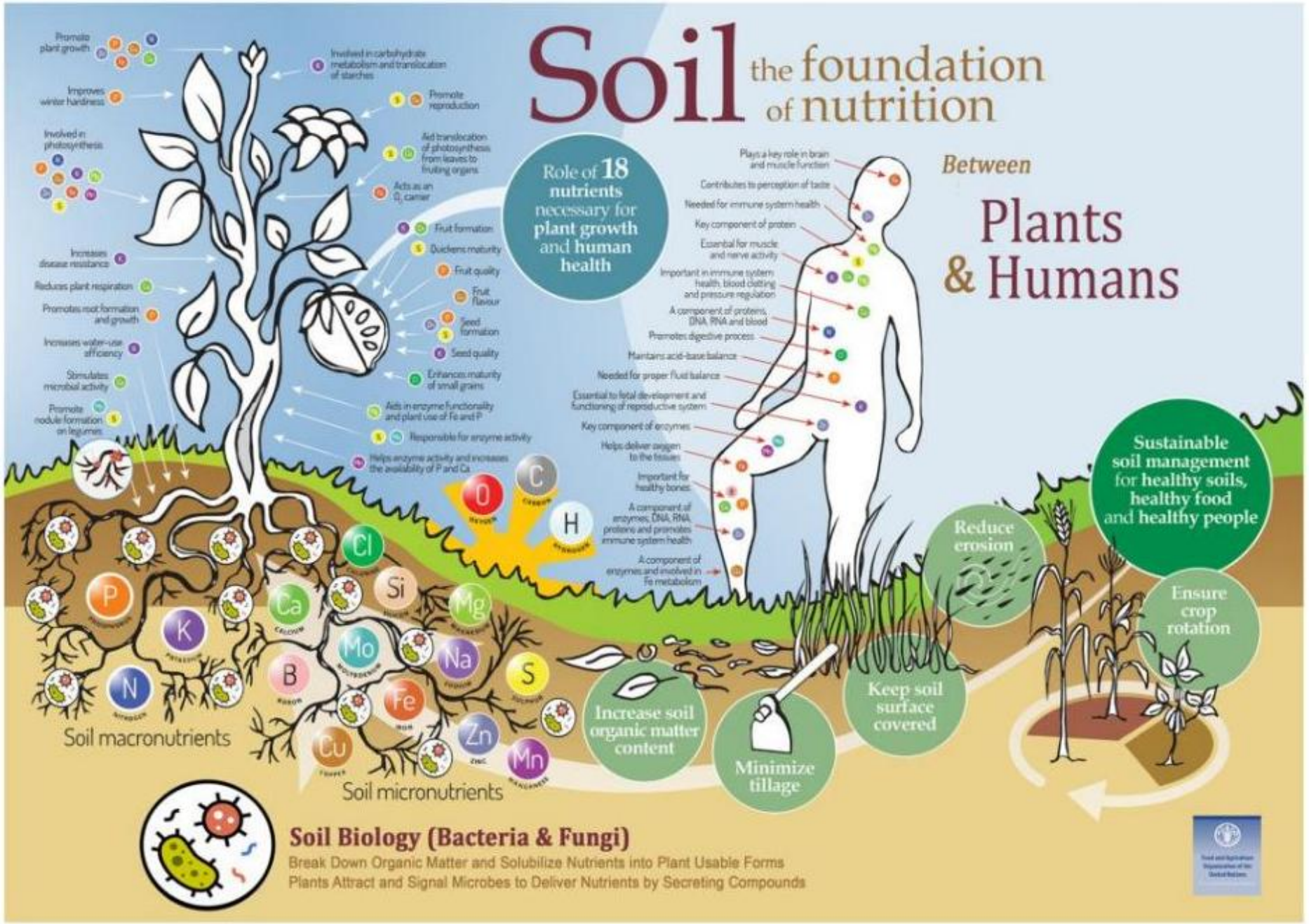


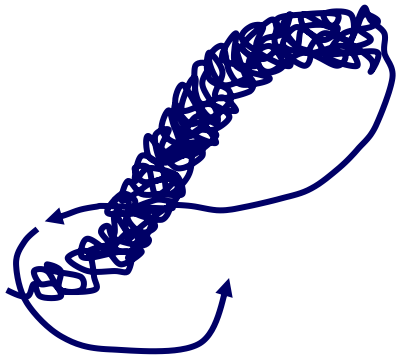
Stages of succession

"Soil is the great connector of lives, the source and destination of all. … It is alive; it is a grave." p.90

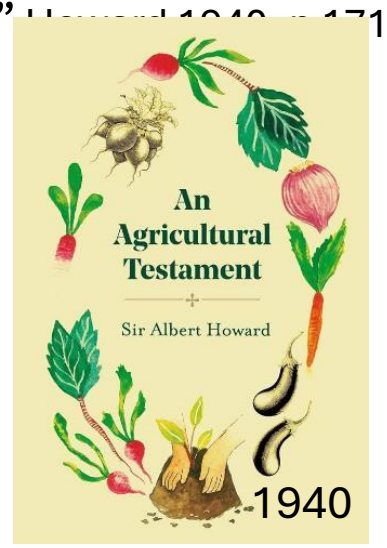


Farming extracts nutrients during growth stage; decomposition replenishes them during collapse stage

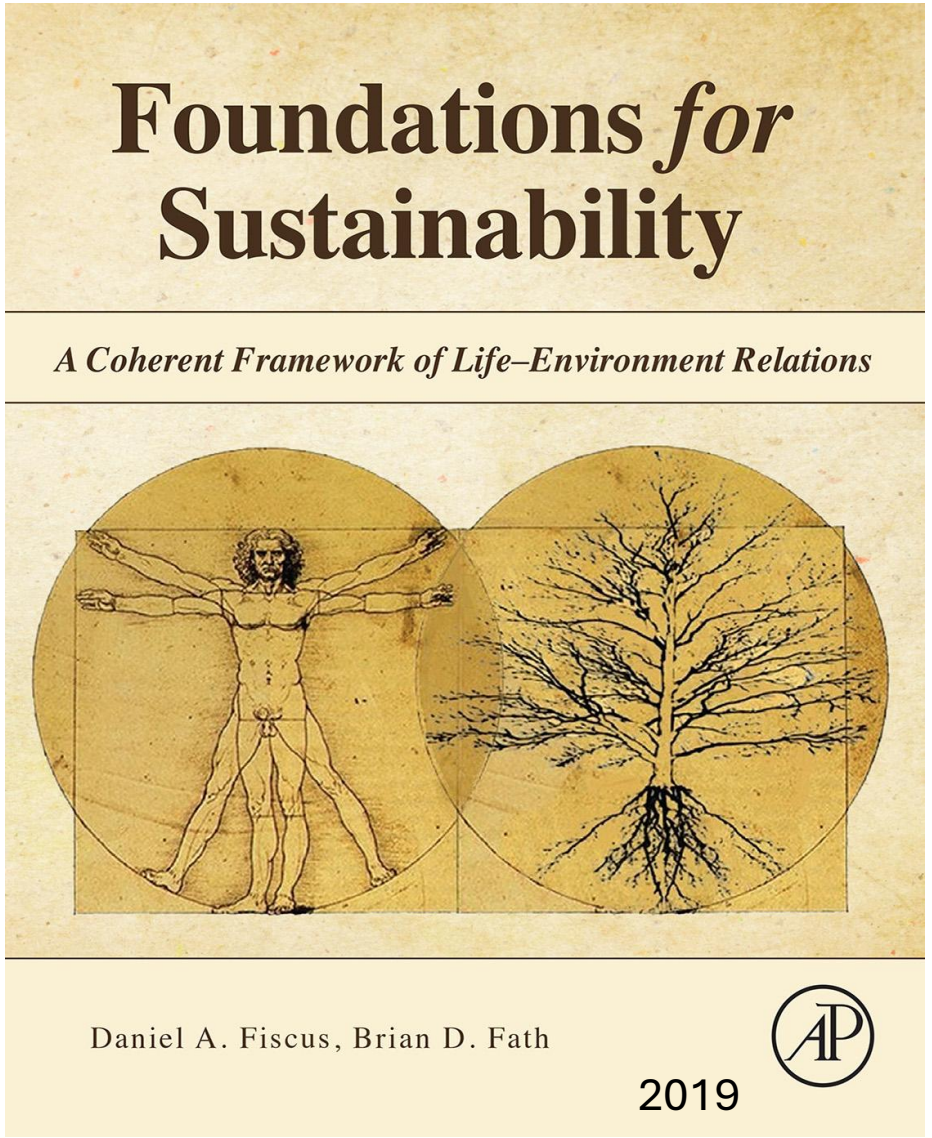




"Except in a few cases, food is not marketed according to the way it is grown. The buyer knows nothing of how it was manured." Howard 1940, p 171



“Feed the soil and let the soil feed the plants.” p. 27



Next steps

- “Farming has become imbalanced. The wheel of life has been left unbridged.” Howard P 219

- [Re] “Establish agriculture upon the same unifying cycle that preserves health, fertility, and renewal in nature by which ‘Death supersedes life and life rises again from what is dead and decayed’ ” Berry 1971

Take home

- We “borrow” the environment for a short time
- Ecosystem dynamics follow a cycle of growth→development→death→renewal
- Soils are generative places of living and dying

"Growth has been speeded up, but nothing has been done to accelerate decay" (Howard 1940)

Thank you for your attention!