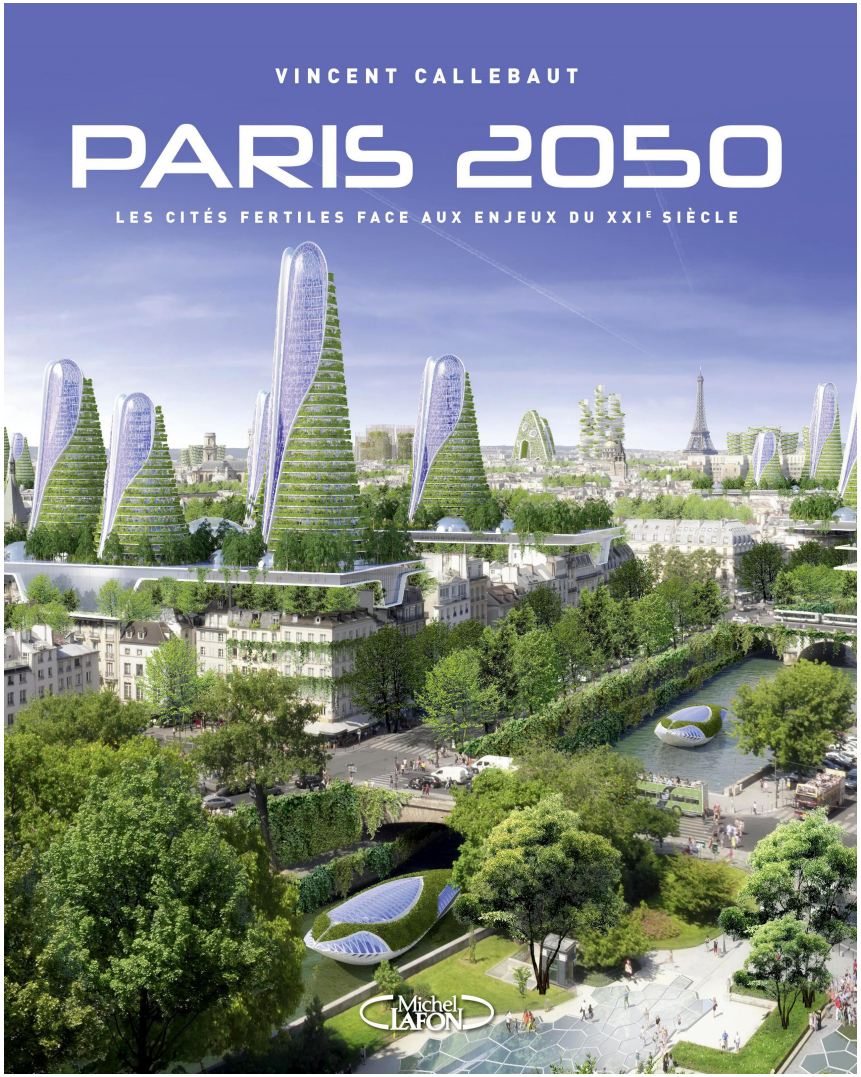
Agricultural-Ecological Mutualism: Feeding People and Planet

bmarron

Agricultural-ecological mutualism



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from the US Congress...

Sec. 3103. Definitions.
(19) The term "sustainable agriculture" means an integrated system of plant and animal production practices having a site-specific application that will, over the long-term-
(A) satisfy human food and fiber needs;
(B) enhance environmental quality and the natural resource base upon which the agriculture economy depends;
(C) make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
(D) sustain the economic viability of farm operations; and
(E) enhance the quality of life for farmers and society as a whole.
7 U.S.C. Sec. 3103(19)

Important Questions

- How can we design low-impact, low-input, robust, sustainable food production systems at the landscape scale that simultaneously maximize regional agricultural and ecological productivity? Is agricultural-ecological mutualism possible?
- Why do some agro-ecological practices work and some don't?
- Can virtuous agricultural and ecological cycles be generated by 'tuning' landscape scale disturbance regimes like agriculture?
- What is the parsimonious set of state variables required to adequately assess the degree of agricultural-ecological mutualism for different agro-ecological landscape patterns?

Agricultural-ecological mutualism

Agricultural-ecological mutualism – the set of complex linkages and relationships that provide for mutually beneficial transfers of matter, energy, and information between the agriculturally-organized and the naturally-organized components of a multi-functional landscape.

(The Landscape Institute, 2016)

Agricultural-ecological mutualism

Ecological Monographs, 55(1), 1985, pp. 119–140

INTERACTIONS OF BACTERIA, FUNGI, AND THEIR NEMATODE GRAZERS: EFFECTS ON NUTRIENT CYCLING AND PLANT GROWTH[1]

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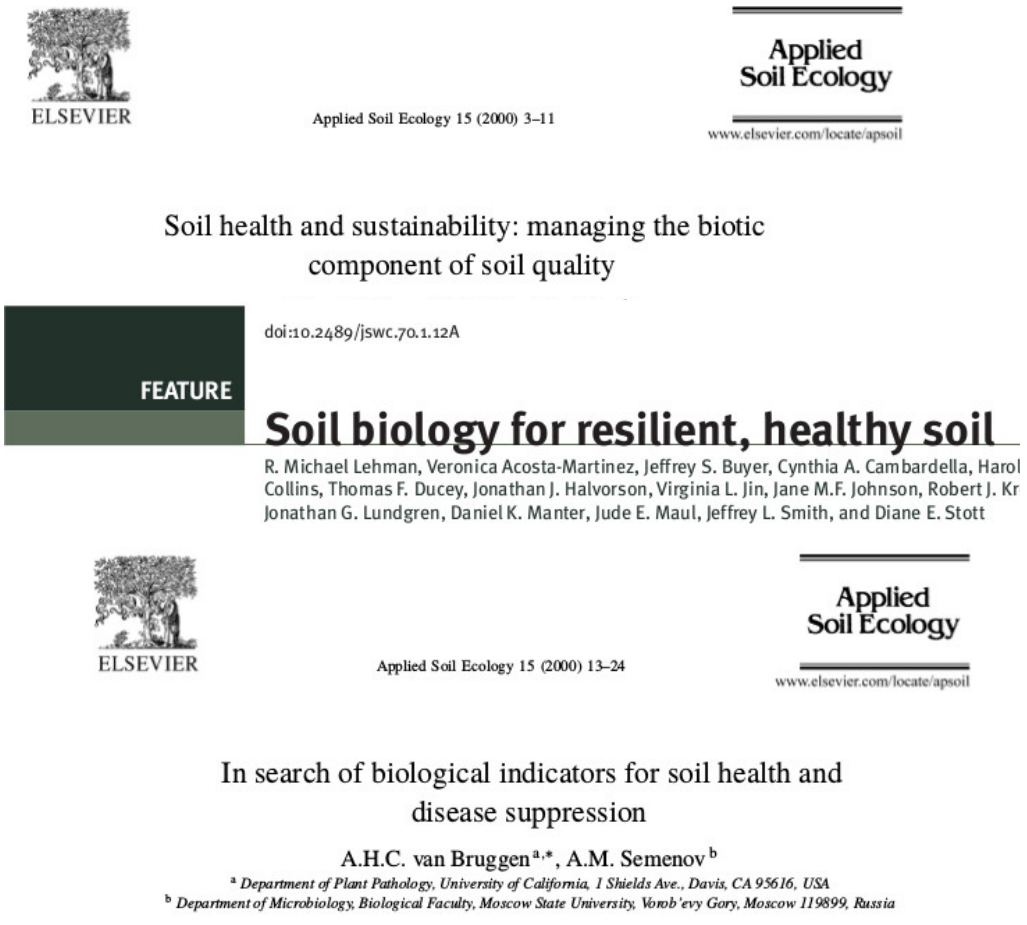

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Applied Soil Ecology 15 (2000) 3–11

Applied Soil Ecology

www.elsevier.com/locate/apsoil

Soil health and sustainability: managing the biotic component of soil quality

FEATURE

doi:10.2489/jswc.70.1.12A

Soil biology for resilient, healthy soil

R. Michael Lehman, Veronica Acosta-Martinez, Jeffrey S. Buyer, Cynthia A. Cambardella, Harol Collins, Thomas F. Ducey, Jonathan J. Halvorson, Virginia L. Jin, Jane M.F. Johnson, Robert J. Kr Jonathan G. Lundgren, Daniel K. Manter, Jude E. Maul, Jeffrey L. Smith, and Diane E. Stott

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Applied Soil Ecology 15 (2000) 13–24

Applied Soil Ecology

www.elsevier.com/locate/apsoil

In search of biological indicators for soil health and disease suppression

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PERSPECTIVES

ESSAY

The role of ecological theory in microbial ecology

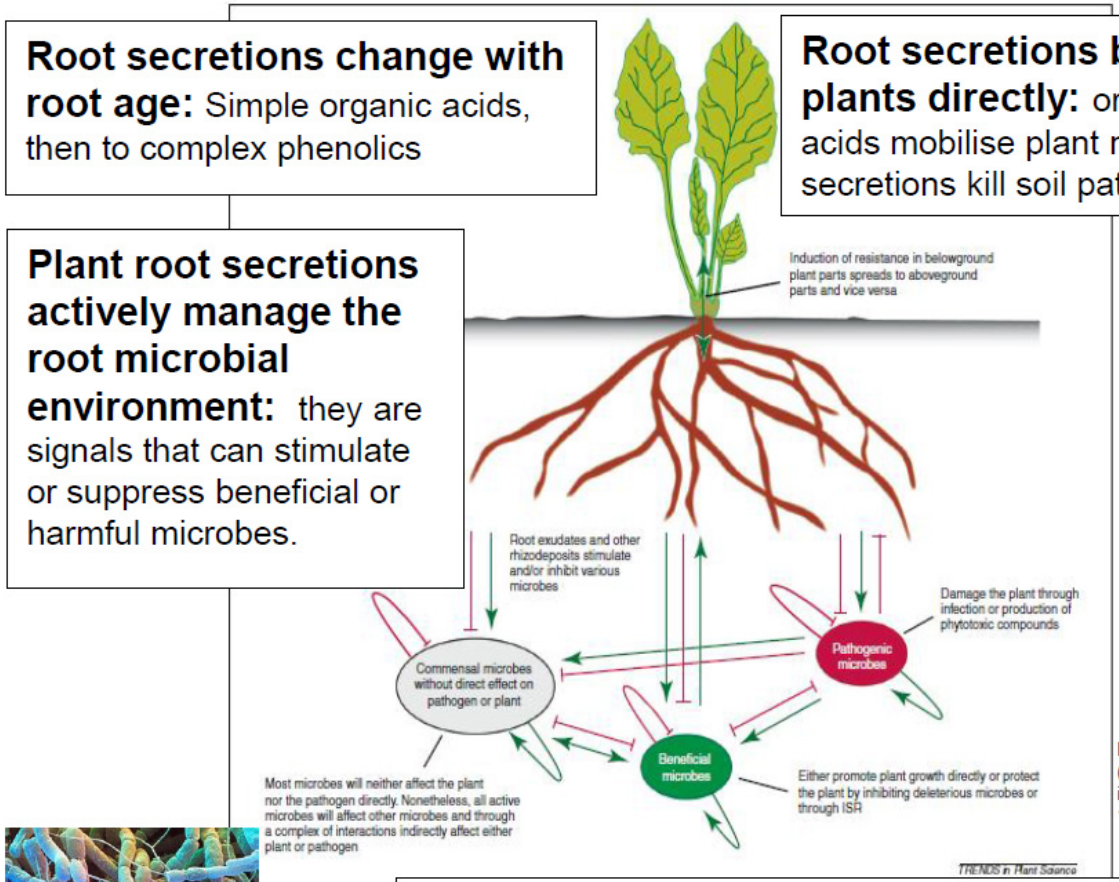
James I. Prosser, Brendan J. M. Bohannan, Tom P. Curtis, Richard J. Ellis, Mary K. Firestone, Rob P. Freckleton, Jessica L. Green, Laura E. Green, Ken Killham, Jack J. Lennon, A. Mark Osborn, Martin Solan, Christopher J. van der Gast and J. Peter W. Young

Agricultural-ecological mutualism

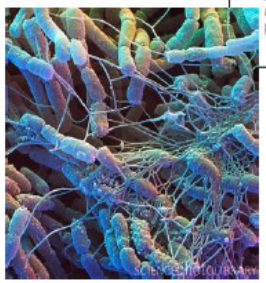
Root secretions change with root age: Simple organic acids, then to complex phenolics

Root secretions benefit plants directly: organic acids mobilise plant nutrients, secretions kill soil pathogens.

Plant root secretions actively manage the root microbial environment: they are signals that can stimulate or suppress beneficial or harmful microbes.



Berendsen et al (2012), Trends in Plant Science 17, 478-86.



Rhizosphere soil compared to bulk soil: up to 40% of plant carbon photosynthates are secreted into soil via roots, so there can be abundant food for microbes and fungi here compared to bulk soil.

Agricultural-ecological mutualism

Life In The Soil Class, Session 12 2/17/15

(Ingham, 2015)

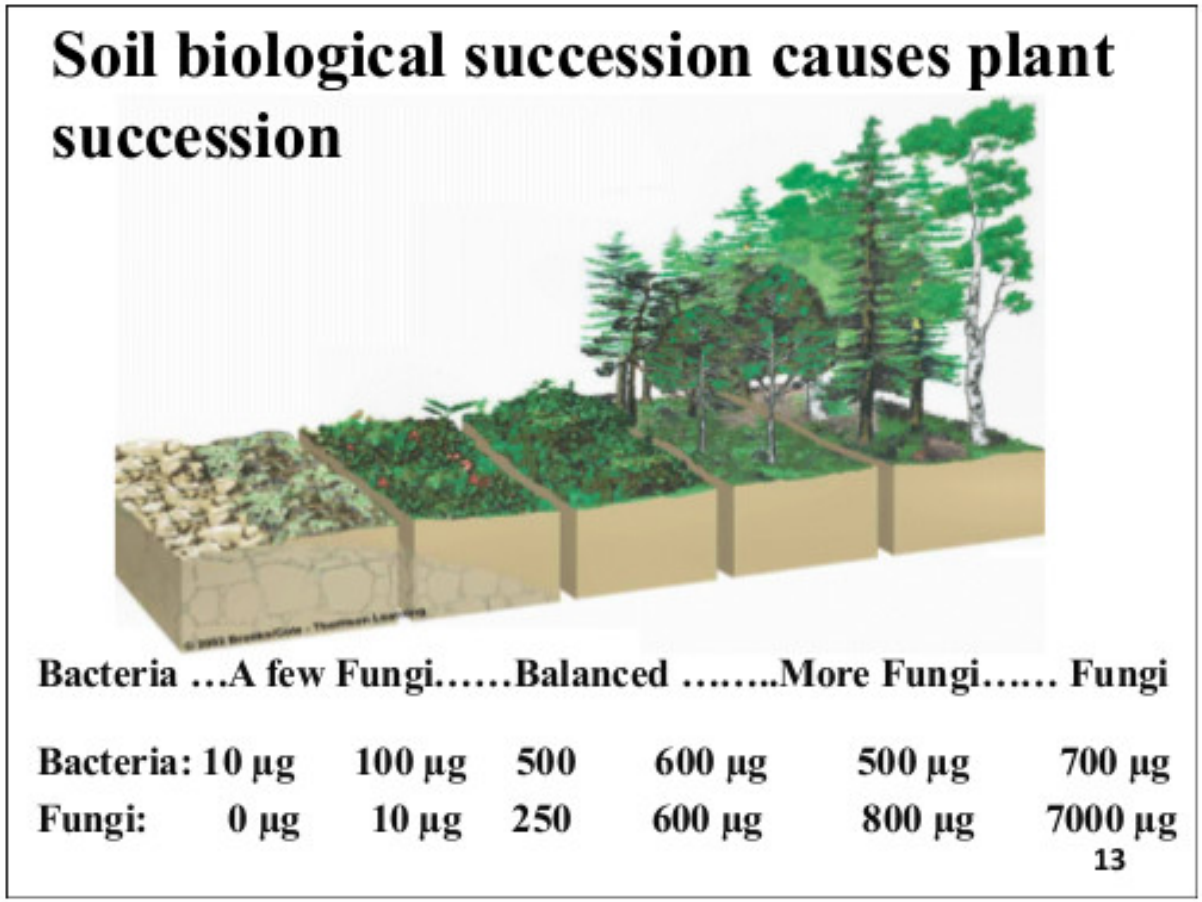


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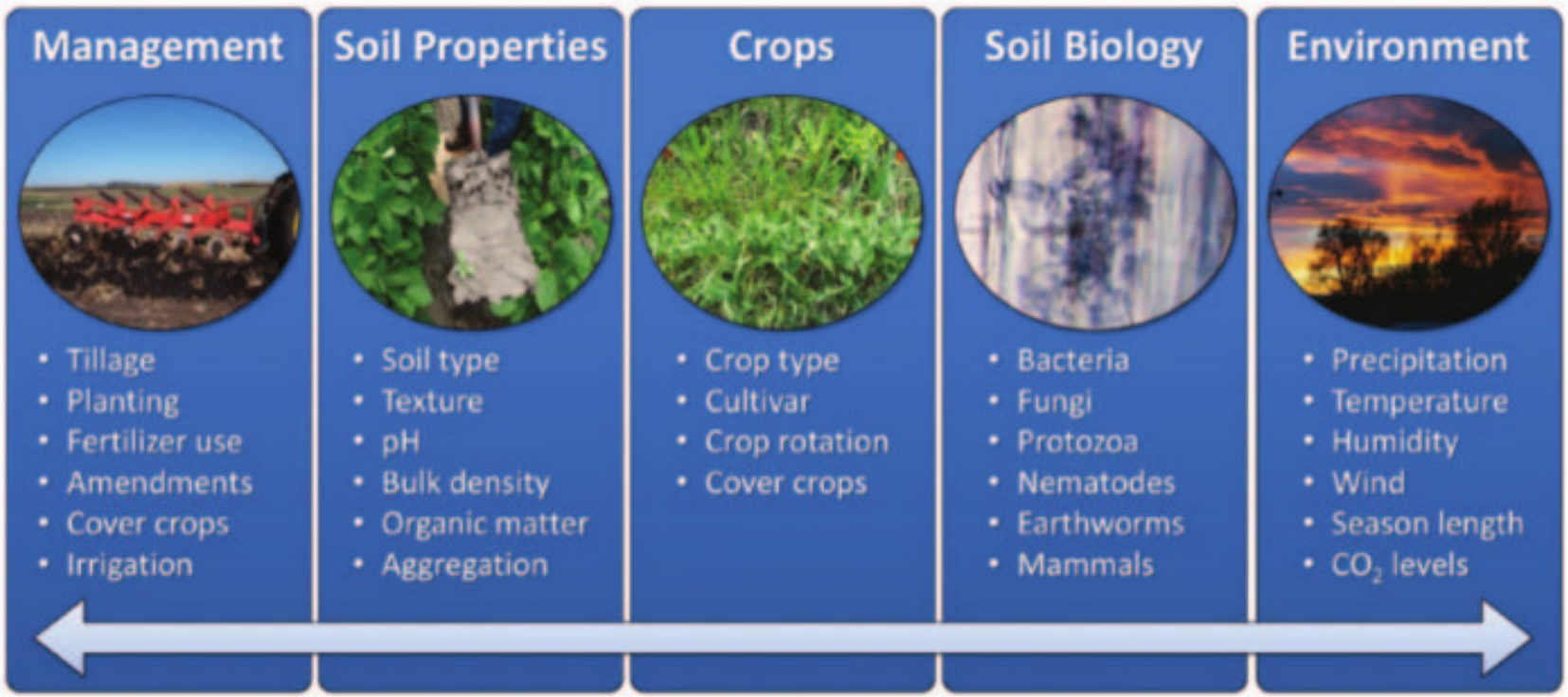
Figure 2

Selected factors affecting soil functions and the provision of ecosystem services. The arrow represents interactions between factors and within each factor.



(Lehman et al., 2015)

Soil food web typologies may provide the theoretical as well as the applied basis for agricultural-ecological mutualism.

If it is the energetic (trophic) and biochemical transformations brokered by rhizospheric fungal/bacterial/protozoa assemblages that are primarily responsible for soil nutrient cycling and there are readily identifiable rhizospheric fungal/bacterial/protozoa assemblages fueled by root exudates that constitute functional soil food webs, then different natural successional stages should have unique soil food webs and outcomes of interactions in the rhizosphere should ultimately affect plant and soil community dynamics at the ecosystem scale and maximizing the nutrient retention (SOM) and trophic energy capture capabilities of any given landscape may require a set of successionally derived, soil food webs.

Next steps in my research agenda

1. Assessment of soil food web typologies by field sampling (optical microscopy) for the major successional stages of successionally developed agroecosystems in the Yucatán Peninsula of Mexico.

2. Correlation of soil food web typologies to agricultural and ecological productivity using literature-derived data and the Yucatán field sample data.

3. Construction of a LANDIS-II model of a successionally developed agroecosystem.

4. Experimentation with the LANDIS-II model to evaluate ANPP of various agroecological landscape patterns driven by coupled, agricultural and ecosystem disturbance regimes.