Soil biodiversity as driver for multiple ecosystem services on cropland





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Take home message

- Farmland soils threatened by poor, intensified and short-sighted management
- Soil biodiversity contributes to benefits for farmers and society (ecosystem services)
  - Soil structure, soil fertility
  - Positive organisms for crop production
- Soil ecosystem services must be managed well with long-term perspectives to fully utilise their potential benefits

Soil is an asset in agriculture

What makes soil valuable?

- Value of soils recognized already in antiquity
- Land the source of wealth in classical economics
- Important part of natural capital
- Why? – Food is central to societies everywhere

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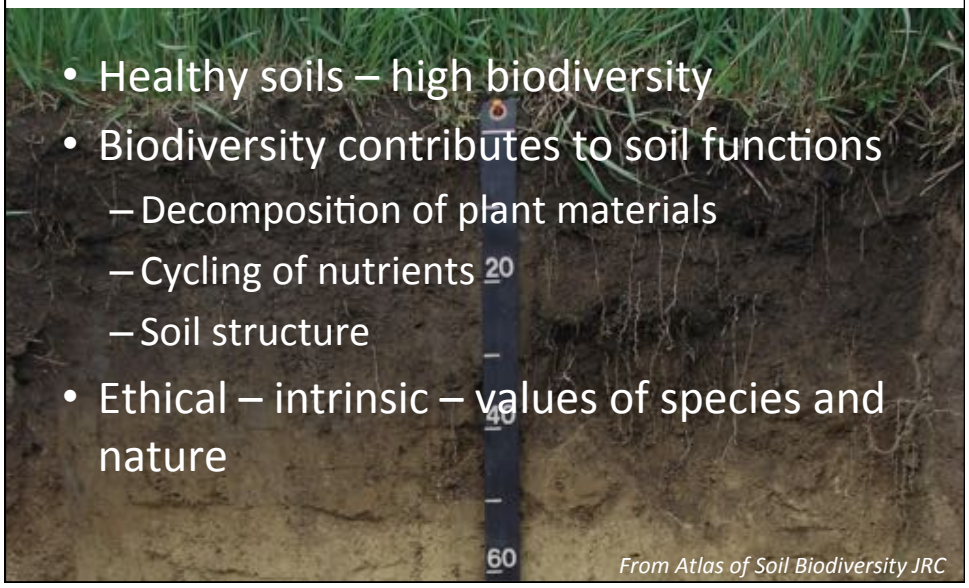
… When the roots of the plants and the trees cease to nourish their mother, the result is that the soil grows lean … because of our own lack of energy our cultivated lands yield a less generous return … we may reap greater harvests if the earth is quickened again by … manuring (Columella ≈70 AD)

Natural capital, in the form of land … including "the soil, …" (Malthus,1853), … has a core position in classical economic analysis (Gomez-Baggethun 2010)

The economic function is one of many vital functions of land. It invests man's life with stability; it is the site of his habitation, a condition of his safety; it is the landscape and the seasons." (Karl Polanyi 1944)

Why is soil biodiversity important?



- Healthy soils – high biodiversity
- Biodiversity contributes to soil functions
  - Decomposition of plant materials
  - Cycling of nutrients
  - Soil structure
- Ethical – intrinsic – values of species and nature

From Atlas of Soil Biodiversity JRC

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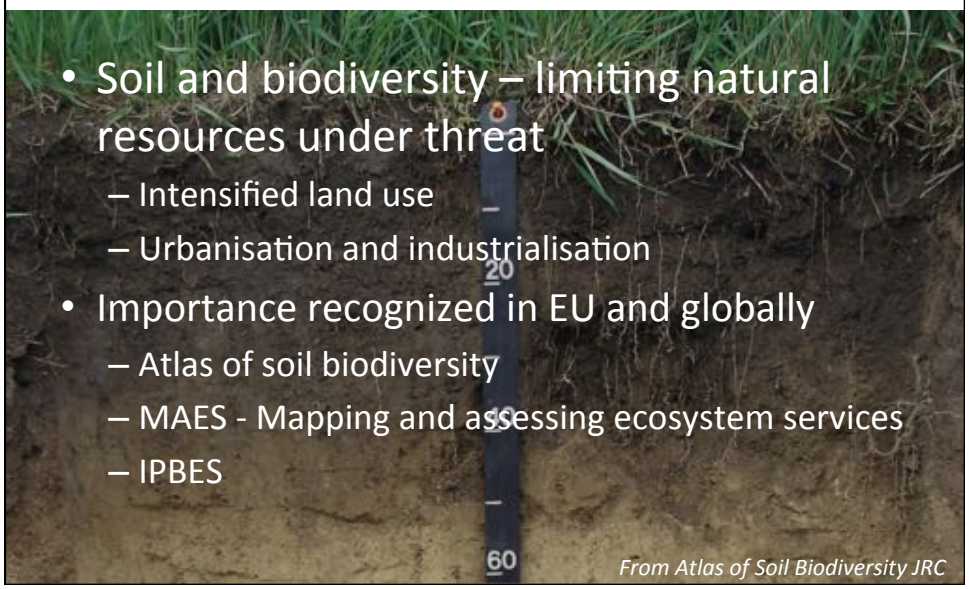
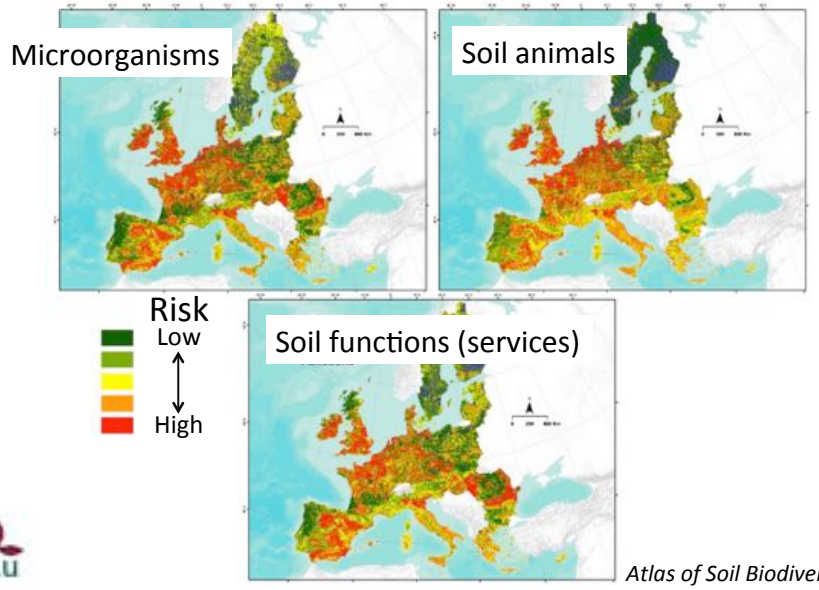


- Soil and biodiversity – limiting natural resources under threat
  - Intensified land use
  - Urbanisation and industrialisation
- Importance recognized in EU and globally
  - Atlas of soil biodiversity
  - MAES - Mapping and assessing ecosystem services
  - IPBES

From Atlas of Soil Biodiversity JRC

Soils in Europe are under threat



Atlas of Soil Biodiversity JRC

Ecosystem services?

”The conditions and processes through which *natural ecosystems* and the species that make them up, sustain and fulfil human life”
(Daily 1997, Nature’s services)

”The benefits human populations derive directly or indirectly from *ecosystem functions*” *(Costanza et al. 1997)*

Ecosystem services

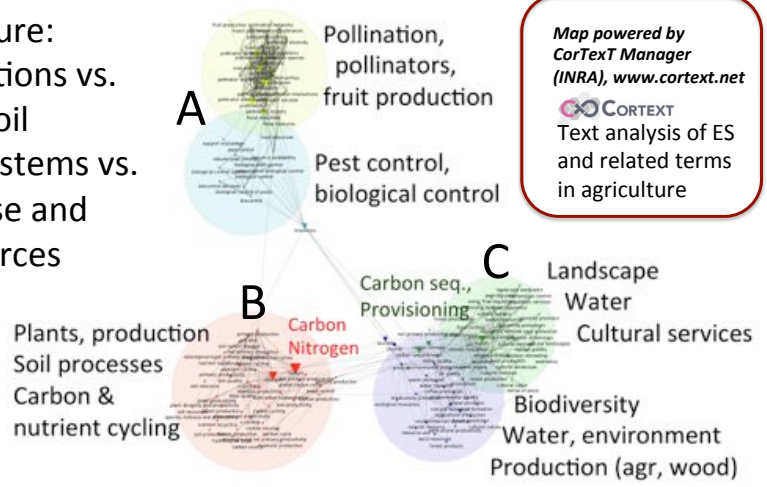
- Ecosystem processes and functions that benefit humans/society
- Earlier also called environmental or soil services
- IPBES: Natures contributions to people (NCP)

Examples

- Crop yield – provisioning service
- Pollination, biological control, soil fertility – regulation and maintenance
- Recreation – cultural services

Ecosystem services

- Studied by different disciplines
- Agriculture:
  Populations vs.
  Plant-soil ecosystems vs.
  Land use and resources



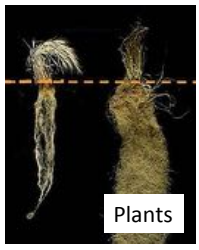
Map powered by CorTexT Manager (INRA), www.cortext.net

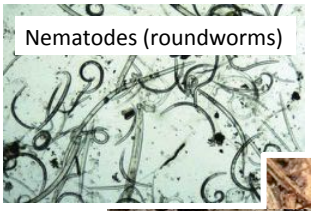
CORTEXT
Text analysis of ES and related terms in agriculture

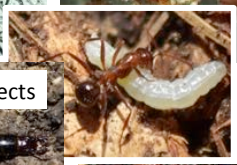
From Barbier, Bengtsson et al. TempAg report (2016)

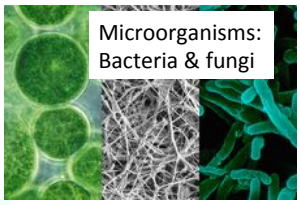
What is soil biodiversity?

- Many different organisms









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What is soil biodiversity?

… connected in food webs that function as wholes

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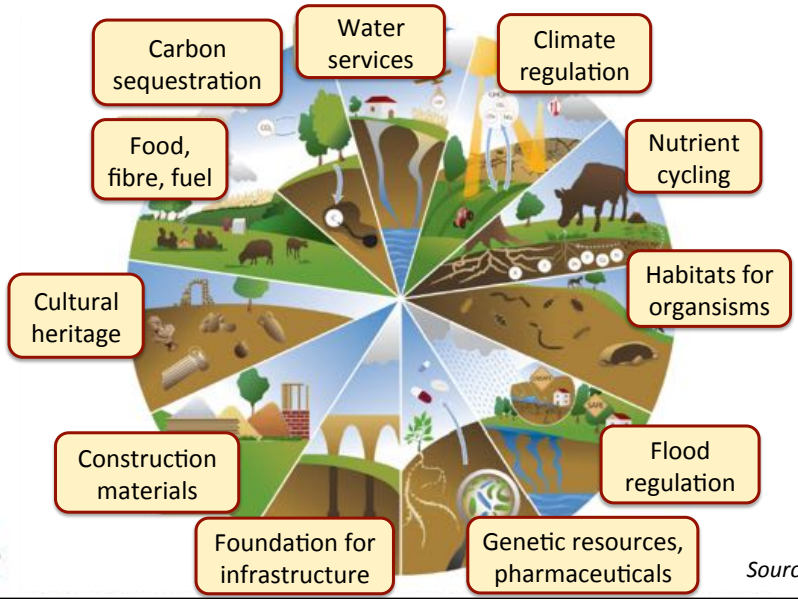
Soil ecosystem services

- Ecosystem functions in soils
- Produced by organisms performing biological and ecological processes
  - Fixing carbon, using nutrients, eating, growing, & dying

  i.e. carried out by soil biodiversity

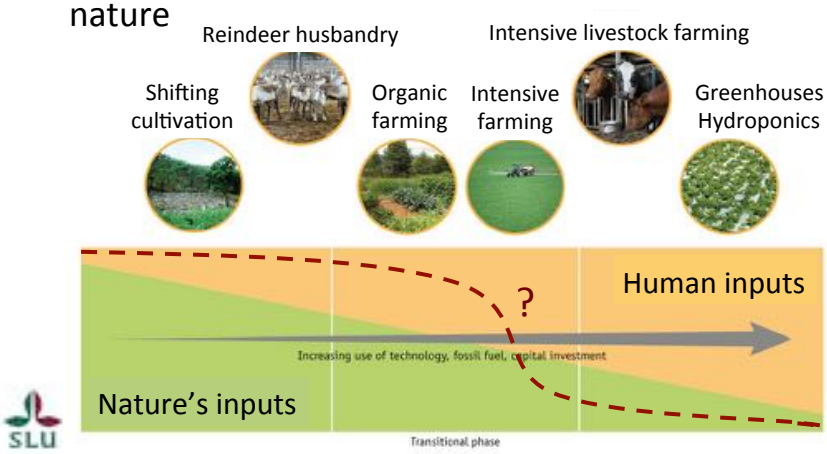
Soil ecosystem services and resources



Source: FAO

Soil ecosystem services

- Are not ”nature’s contributions to people” or society
- They are managed – co-produced – by humans and nature



Figs from Rist et al 2014

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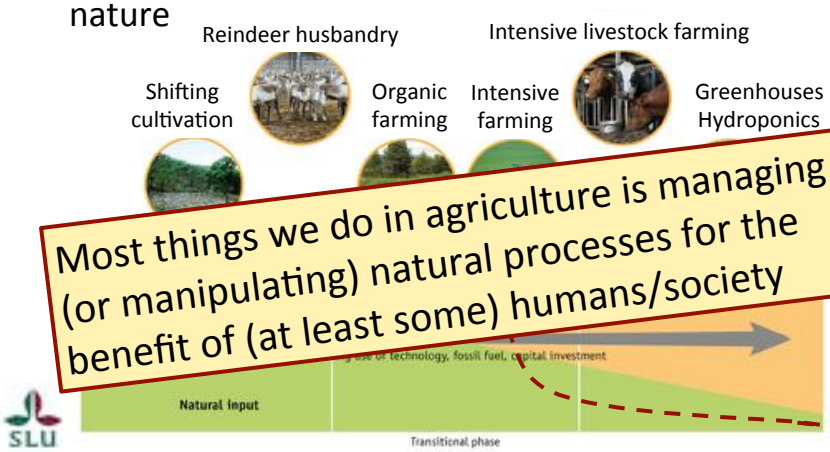
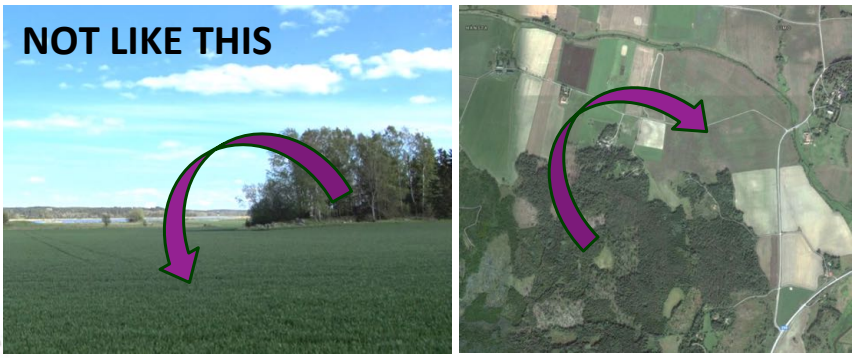


Figs from Rist et al 2014

The mental picture in (much) ecosystem services research is wrong

- Ecosystem services in production systems need
  - Management in agriculture, forestry …
  - ES produced locally in/close to managed habitat



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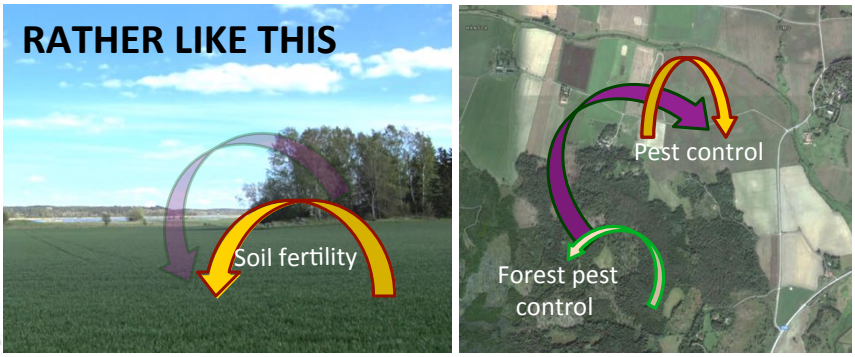

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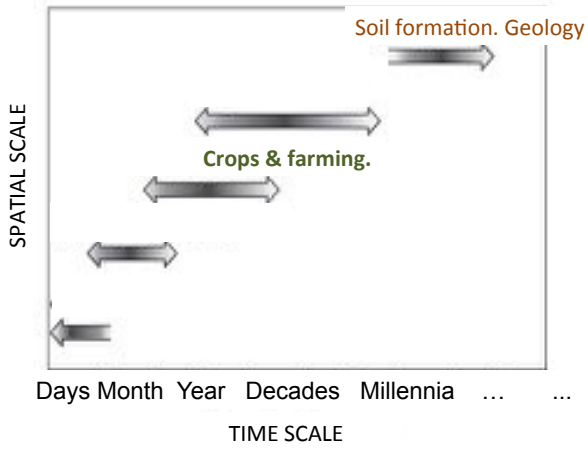
The short term and the long term

- Soil ecosystem services are managed and replenished on different time scales
- Crop yield, farming
  - Years (max 20)



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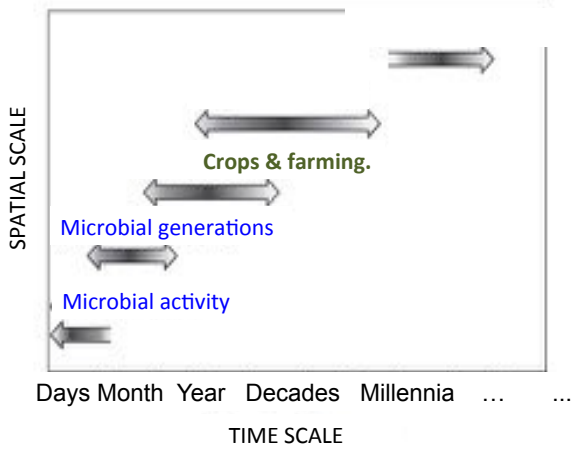

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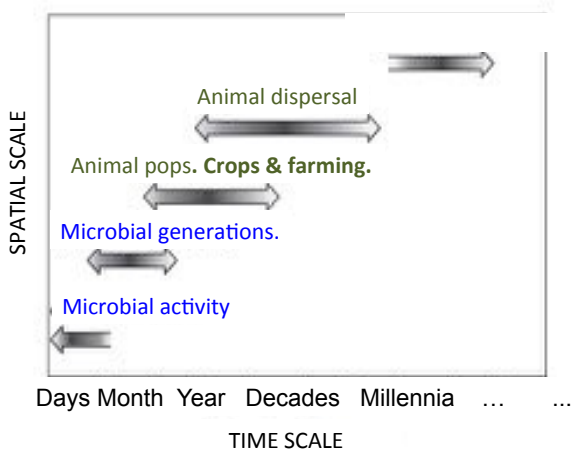

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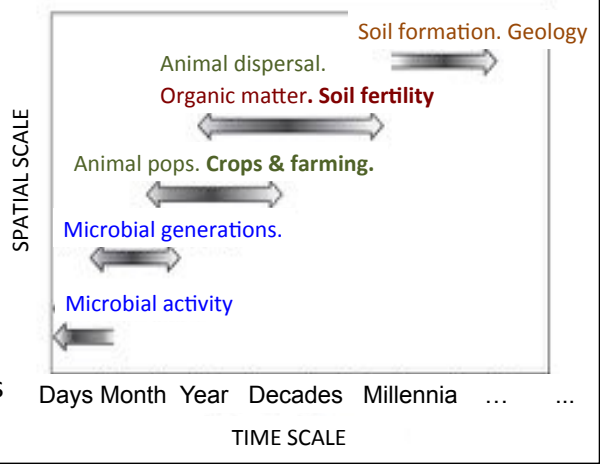
- Soil fertility, SOM
  - Decades - centuries



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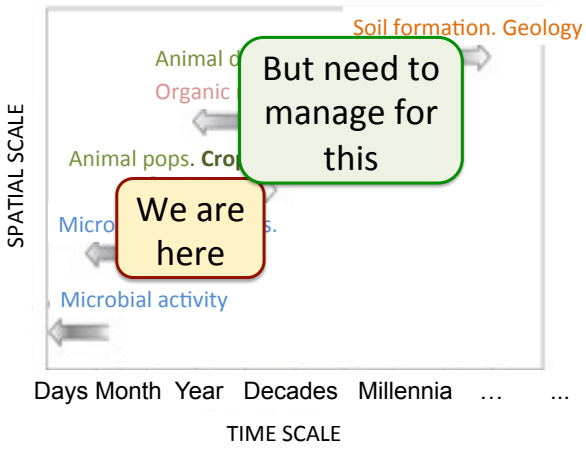


Soil biodiversity & ecosystem services – a wicked problem

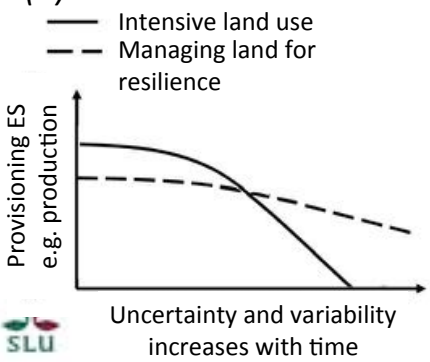
Mismatches

- Fast microbial vs. plant growth vs. slow organic matter processes → crop production
- Farmer's economical time scales vs. time scales for soil fertility and sustainability
- How value essential slow, long-term processes? – managing for soil fertility

Soil biodiversity & ecosystem services – a wicked problem

- Resilience and recovery of soil ecosystem services requires the long time frame
  – And may never be possible in intensive agriculture

(a) Resilience



After Puettman 2011

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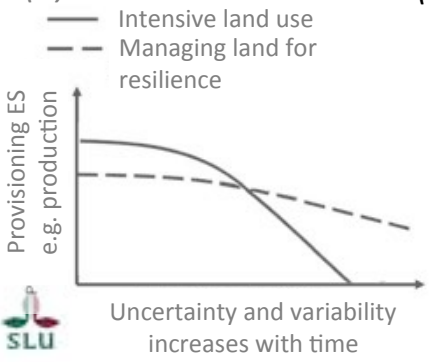
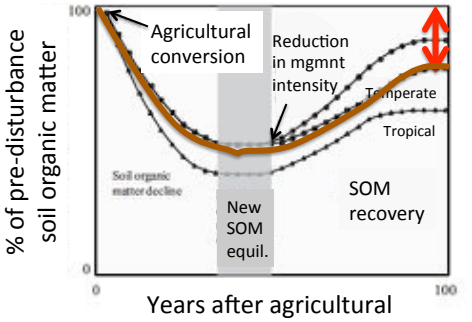


(b) Soil organic matter restoration



Grandy et al. 2012

Trade-offs between ecosystem services

- Provisioning (production) and other ES

  "… emphasis on provisioning services to meet the increased need for food, fibre, water and energy, has resulted in degradation of many …. ecosystems and … many regulating, supporting and cultural services"

- Agricultural intensification vs. other services
- Crop yield vs. Biological control
  Biodiversity *(Geiger et al. BAAE 2010)*
  Soil fertility

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Trade-offs between ecosystem services

- You can't get everything
- Example: No-till, earthworms & yields

Tillage  No-tillage

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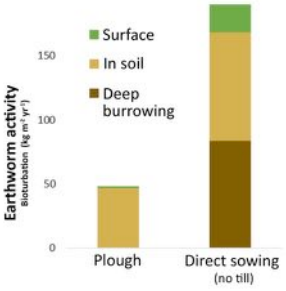
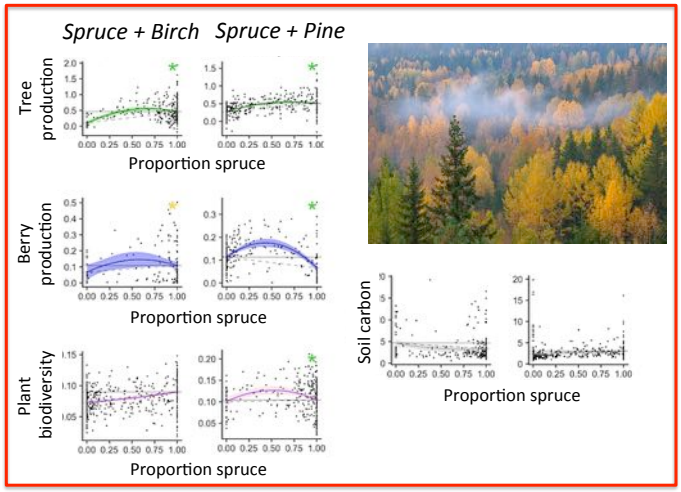


Torppa, Taylor et al. in prep.

Trade-offs between ecosystem services

- Good management can enhance multiple services = synergies
- A forest example



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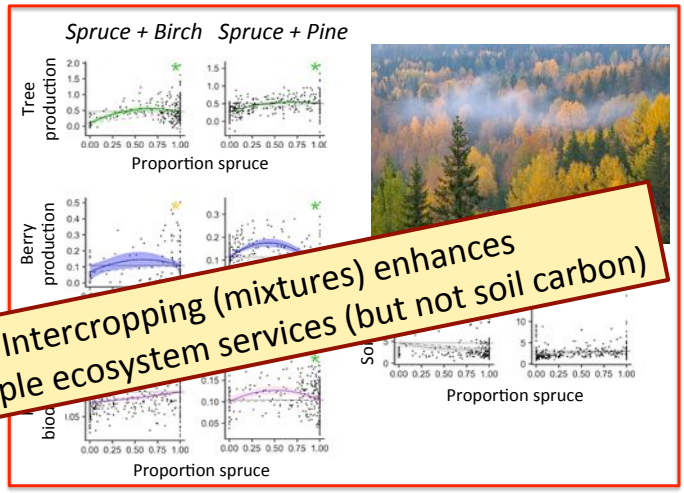

Maintaining and restoring soil biodiversity and ecosystem services

- Future agriculture depands on healthy productive soils
- Short term actions to support soil ecosystem services
  - Policies and science for
    - maintaining and restoring soil organic matter
    - supporting positive interactions among soil biota
    - finding management practices targeting ES synergies that can be adopted by farmers now
- Long term actions
  - Policy instruments for maintaining and restoring soil fertility
  - Targeting soils and long term sustainability in future CAPs