Organic matter as key to soil fertility & global warming mitigation?

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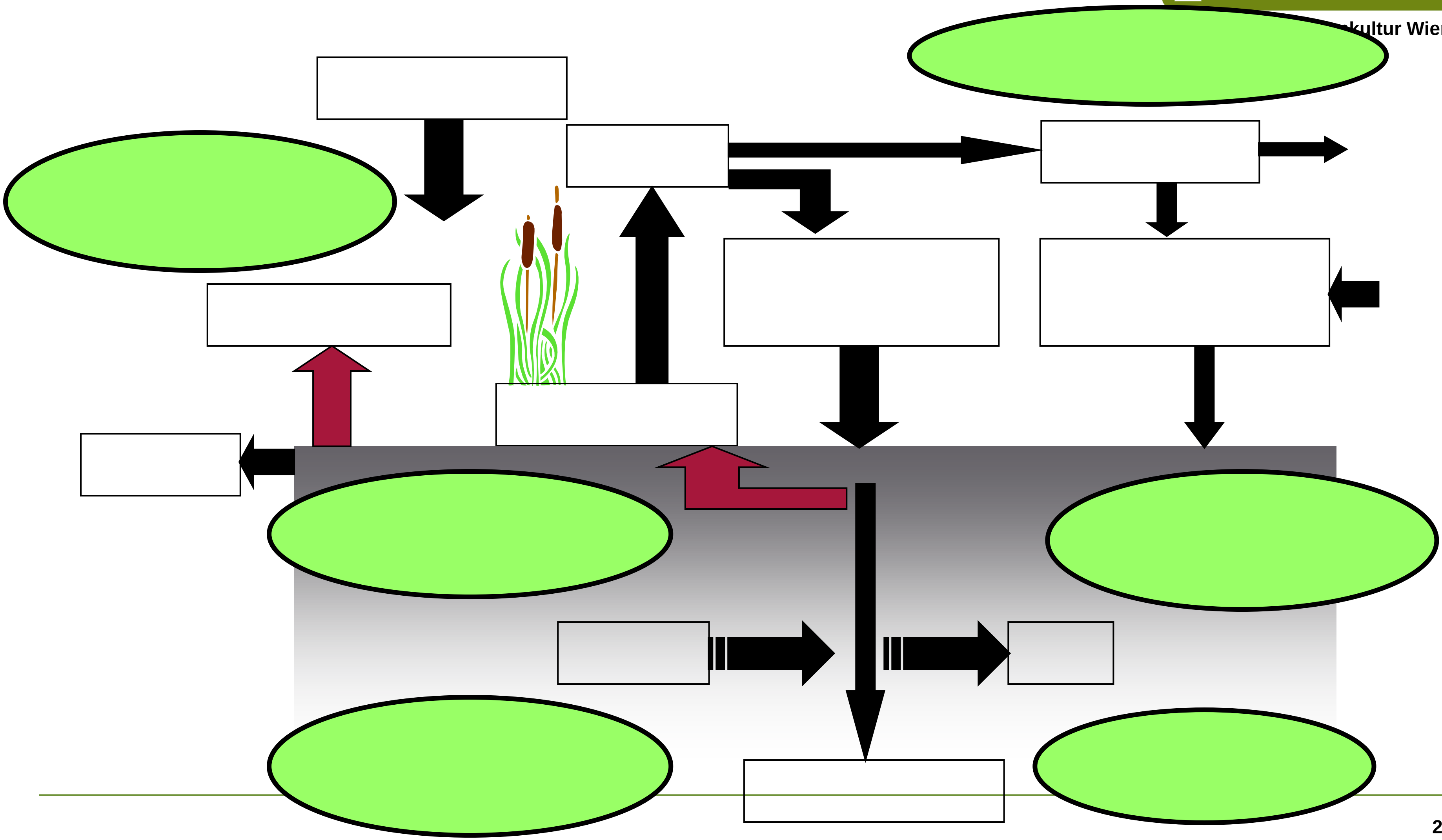
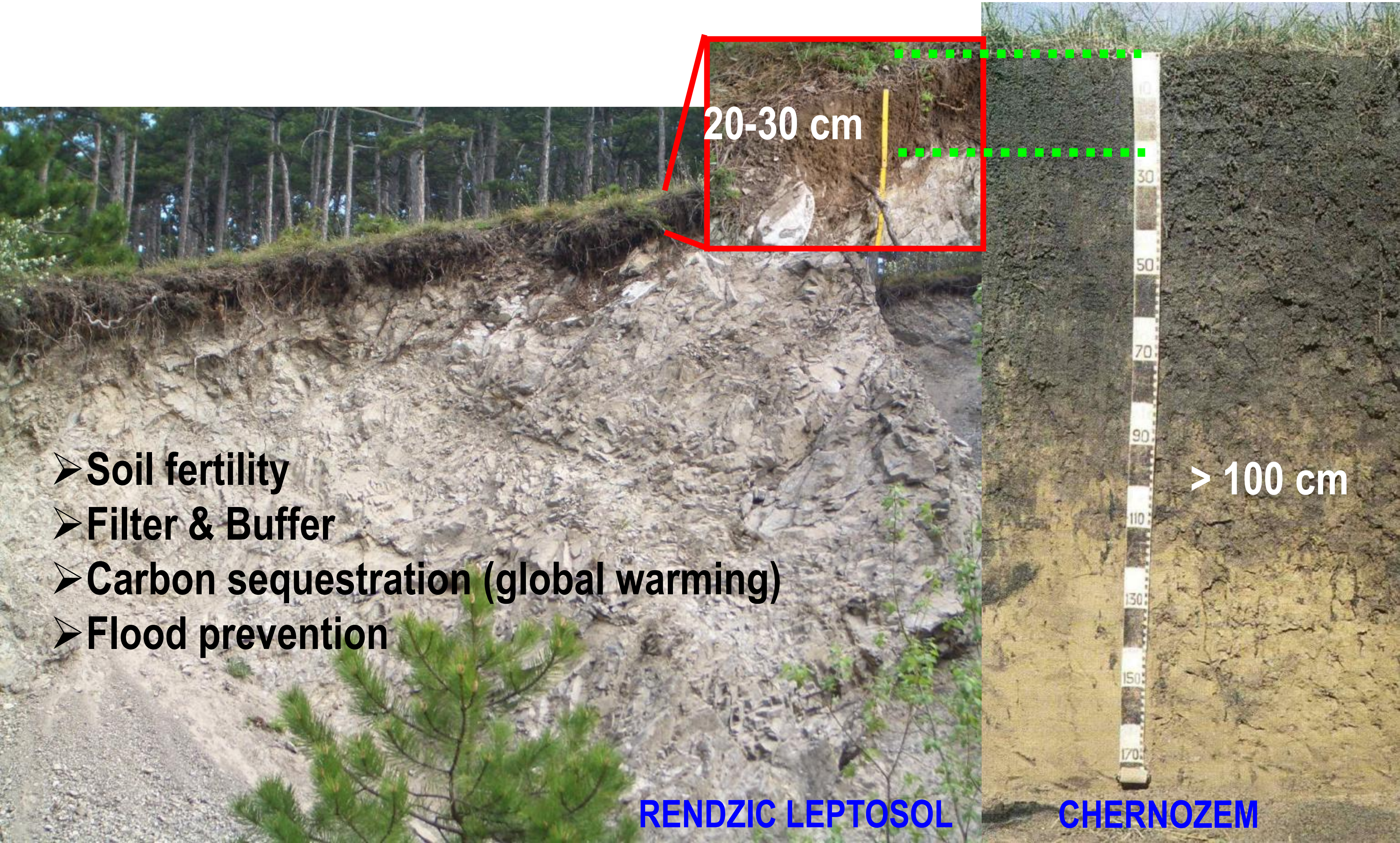
Soil as focal compartment in terrestrial environments



Soil services & organic matter



- Soil fertility
- Filter & Buffer
- Carbon sequestration (global warming)
- Flood prevention

Global carbon stocks

Global carbon stocks in Pg (1 Petagramm = 10^{15} g = 10^{9} t)

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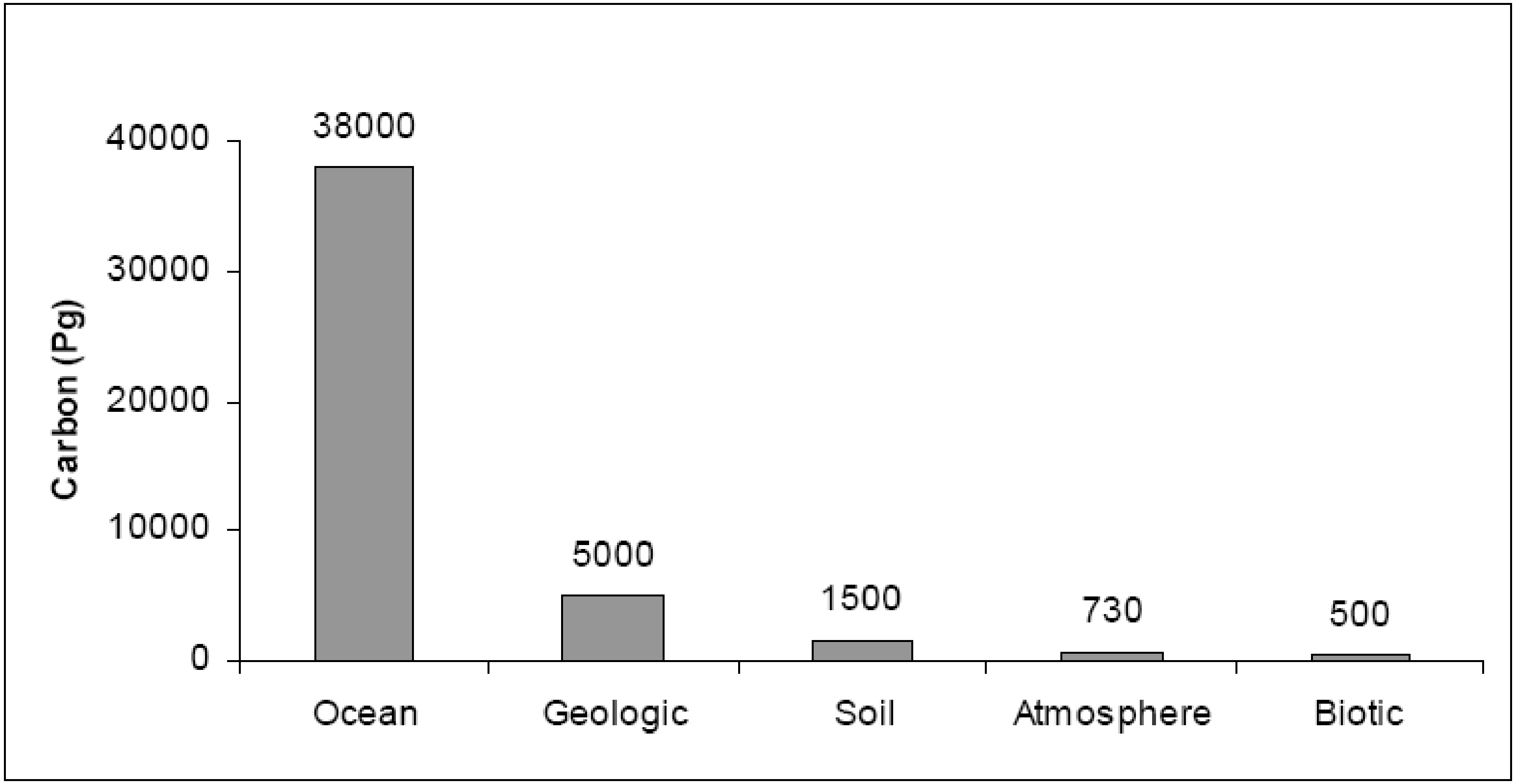
Schils et al. (2008)



Global carbon stocks

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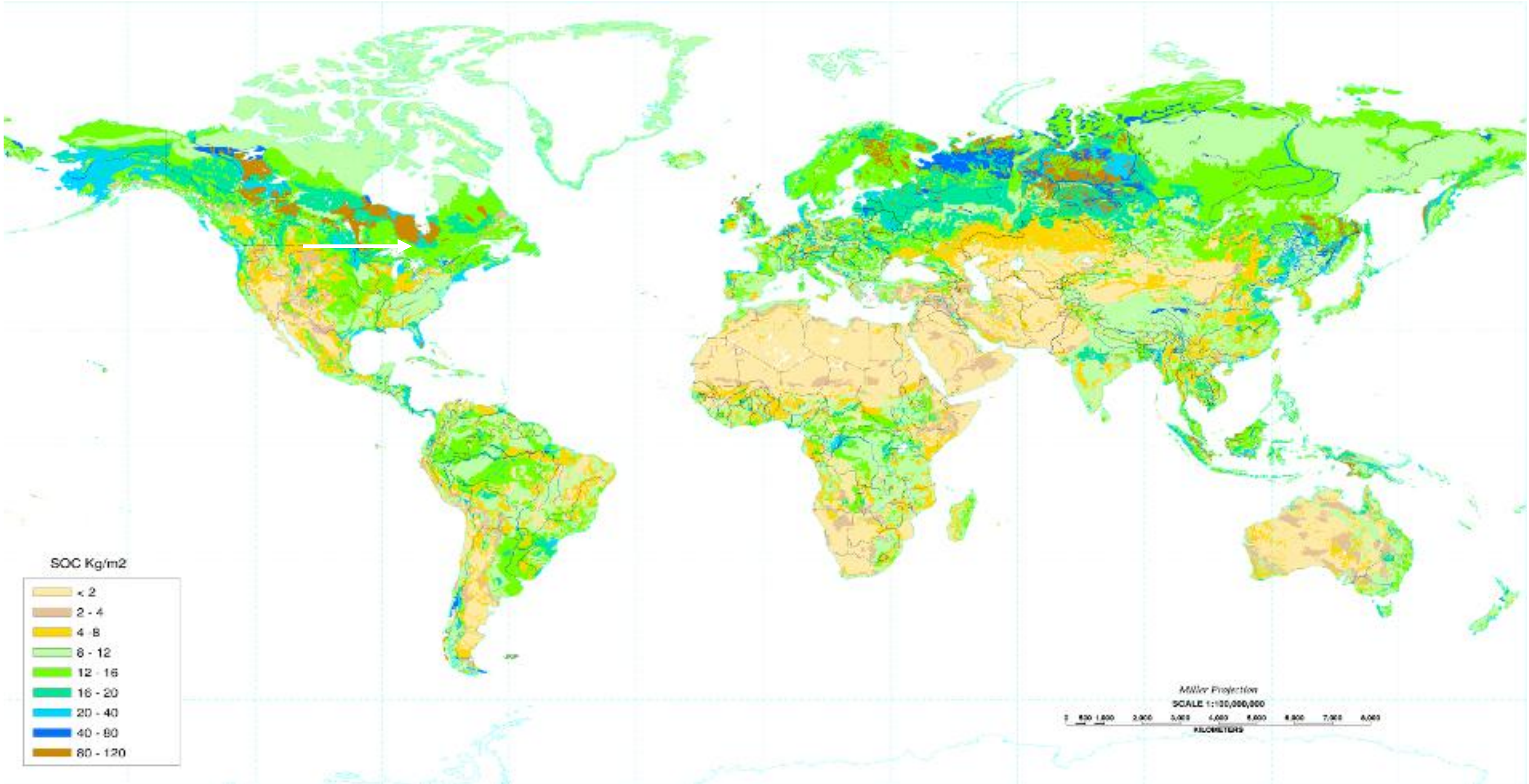

Factors determining SOM

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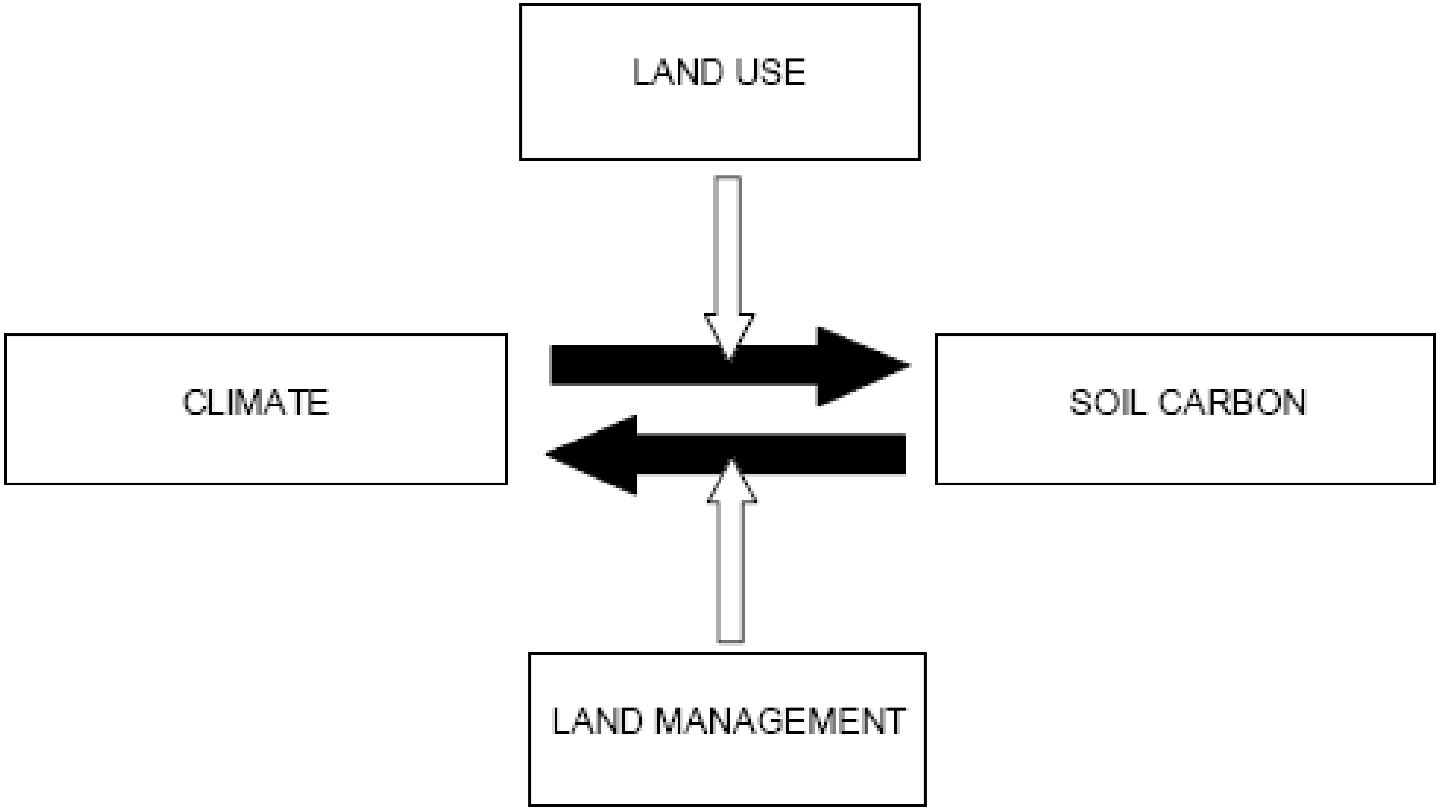
Climate change affects the soil carbon pool and vice versa changes in soil carbon affect the climate. For these relationships, land use and land management are major factors.

Schils et al. (2008)



Novel insights

Molecular structure does not control long-term decomposition of SOM

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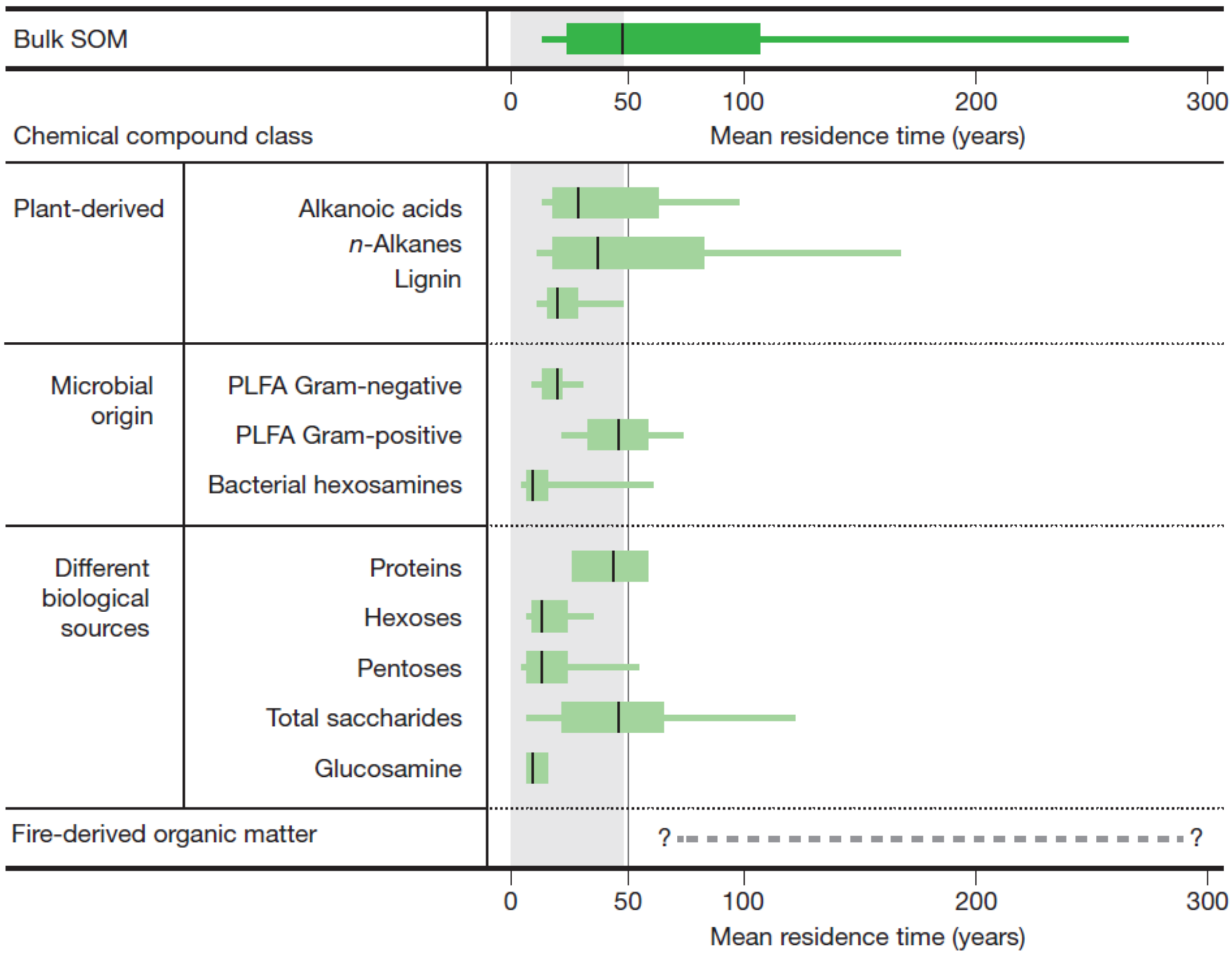
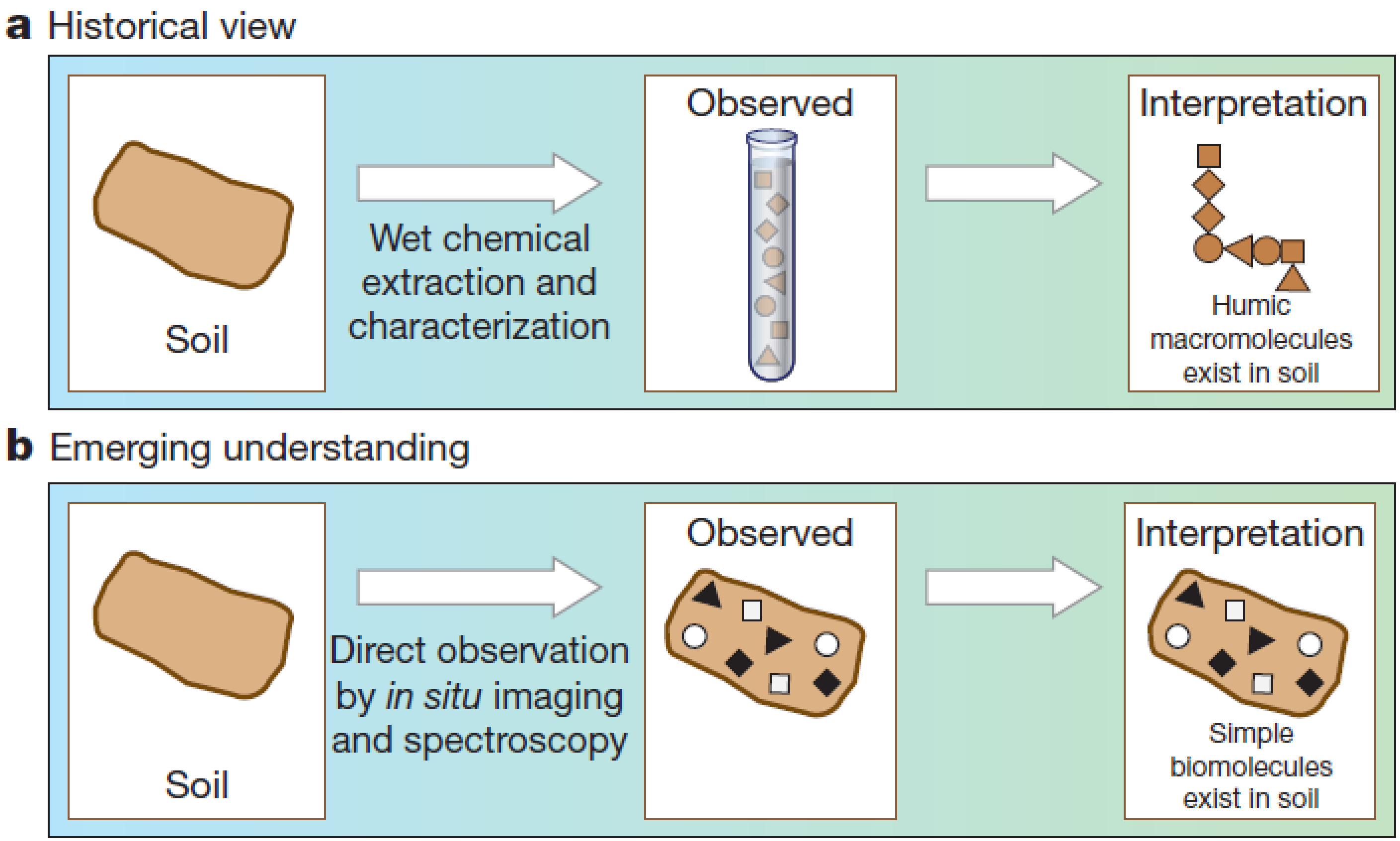


Schmidt et al. (2011)

- Data of surface horizons from 20 long-term field experiments
  - Temperate climate
  - 13C labeling to trace the residence time of SOM and individual molecular compounds
- Relatively persistent components such as lignin appear to turn over faster than the bulk SOM
- Over time, the importance of initial quality fades
- Intially fast-cycling compounds are just as likely to persist as the slow

Novel insights

The existence of humic substances has not been verified by direct measurements



Schmidt et al. (2011)

- **From analysis of extracted materials it was postulated that de novo formation of humic polymers is an important source of recalcitrant SOM**
- **Direct high-resolution observations with non-destructive techniques have recently been able to explain the functional group chemistry of extracted humic substances as relatively simple biomolecules**

Novel insights

Contrasting historical and emerging views of soil carbon cycling

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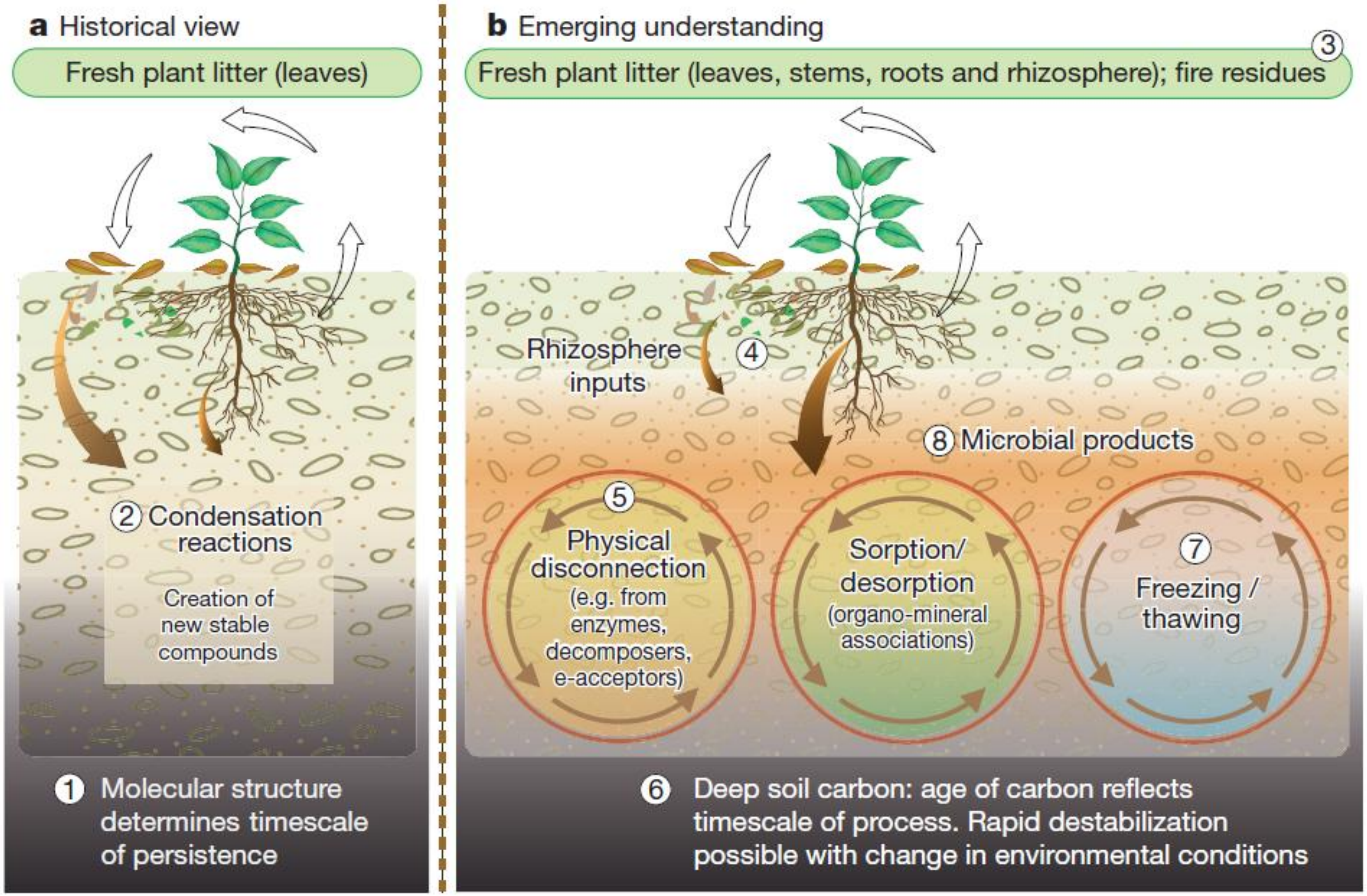
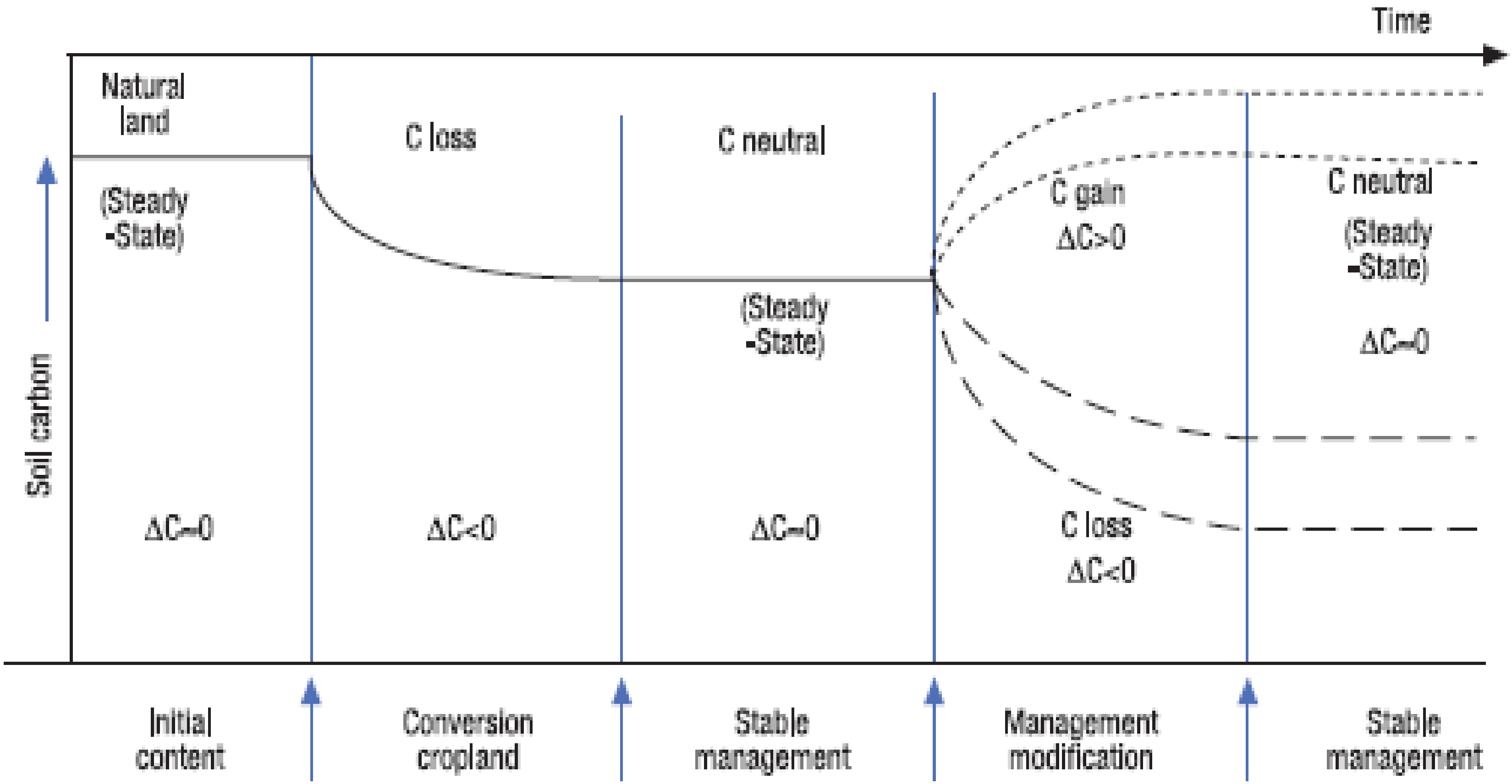
Schmidt et al. (2011)



Historical changes and perspectives



Carbon sequestration & soil management

- Aims:
  - CO_2 sequestration
  - Minimizing losses of OC
- Soil management:
  - Tillage regime ?
  - Fertilization ?
  - Crop rotation ?
  - Cover crops ?
  - Input of organic carbon ?
  - Minimize soil erosion ?

Carbon sequestration & soil management

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Weiseke et al. (2007)

Promising measures for enhancing soil carbon sequestration ?

Measure	Sequestration potential per unit area [t CO_2-eq. ha^{-1} a^{-1}]	Emission reduction potential during first commitment period (EU15) [Mt CO_2-eq. a^{-1}]
Promotion of organic input	1-3	20
Permanent revegetation of set-aside (increased soil carbon; part of afforestation)	2-7	15
Biofuel production on set-aside (increased soil carbon)	2-7	15
Promotion of organic farming	>0-2	14
Promotion of permanently shallow water table on peatland	5-15	15
Zero and/or conservation tillage	>0-3	<9

Conversion factor CO_2 : C = 3.67

Carbon sequestration & soil management

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Realistic C sequestration potential in EU-15 during first commitment period (Mt C y^{-1})

Freibauer et al. (2004)

Cropland management

- 5.5 — Promote organic inputs (crop residues, cover crops, FYM, compost, sewage sludge)
- 3.8 — Organic farming
- <2.5 — Conservation / zero tillage

Grassland management

- 4.1 — Maintain permanent shallow water table and rewett peat soils

Permanent vegetation cover on set-aside land

- 4.1 — Perennial grasses
- 4.1 — Woody bio-energy crops (afforestation, short rotation coppice plantations)

Total: 16-19 Mt C y^{-1}

Carbon sequestration & soil management

Freibauer et al. (2004)
Weiske (2007)

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Potential pitfalls of carbon sequestration policies

Cropland management

More N inputs – more N_2O emissions

Organic farming

Poorer aeration – more N_2O emissions
(1.46 kg N ha y-1 – wives out 50-60% of C sequestration)

Grassland management

Reduced conditions – more CH_4 emissions

Permanent vegetation cover on set-aside land

More animals – more CH_4 emissions

Woody bio-energy crops
(afforestation, short rotation coppice plantations)

Return to previous management (quick loss of C)

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Fine mineral fraction controls potential for SOM sequestration / loss

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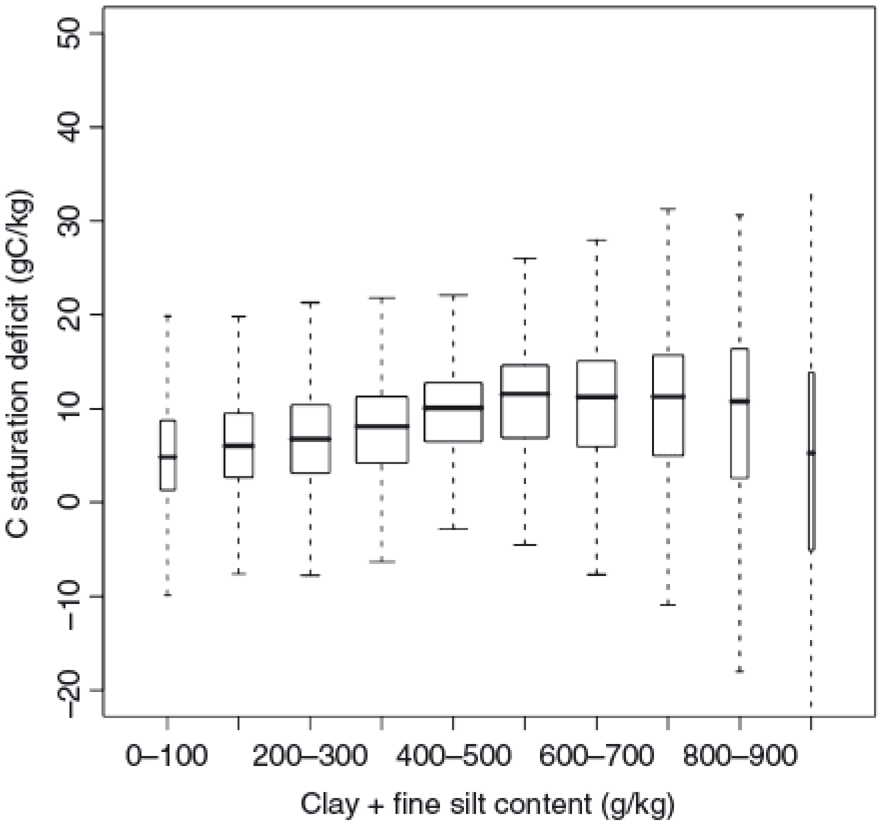
Boxplot statistics (deciles, quartiles and median) of C saturation deficit related to (clay + fine silt) classes.



Angers et al. (2011)

The theoretical value of C saturation (Csat) was calculated according to the equation proposed by Hassink (1997):

Csat = 4.09 + 0.37 (Clay + fSilt)

where Csat is the C saturation (g C ⁄ kg) expressed as the C content of the Clay + fSilt fraction on a whole-soil basis and Clay + fSilt is the clay (0–2 µm particles) and fine silt (2–20 µm particles) contents (% or g ⁄ 100 g for this original equation), respectively.

Mapping carbon saturation deficit as tool for directing policy measures

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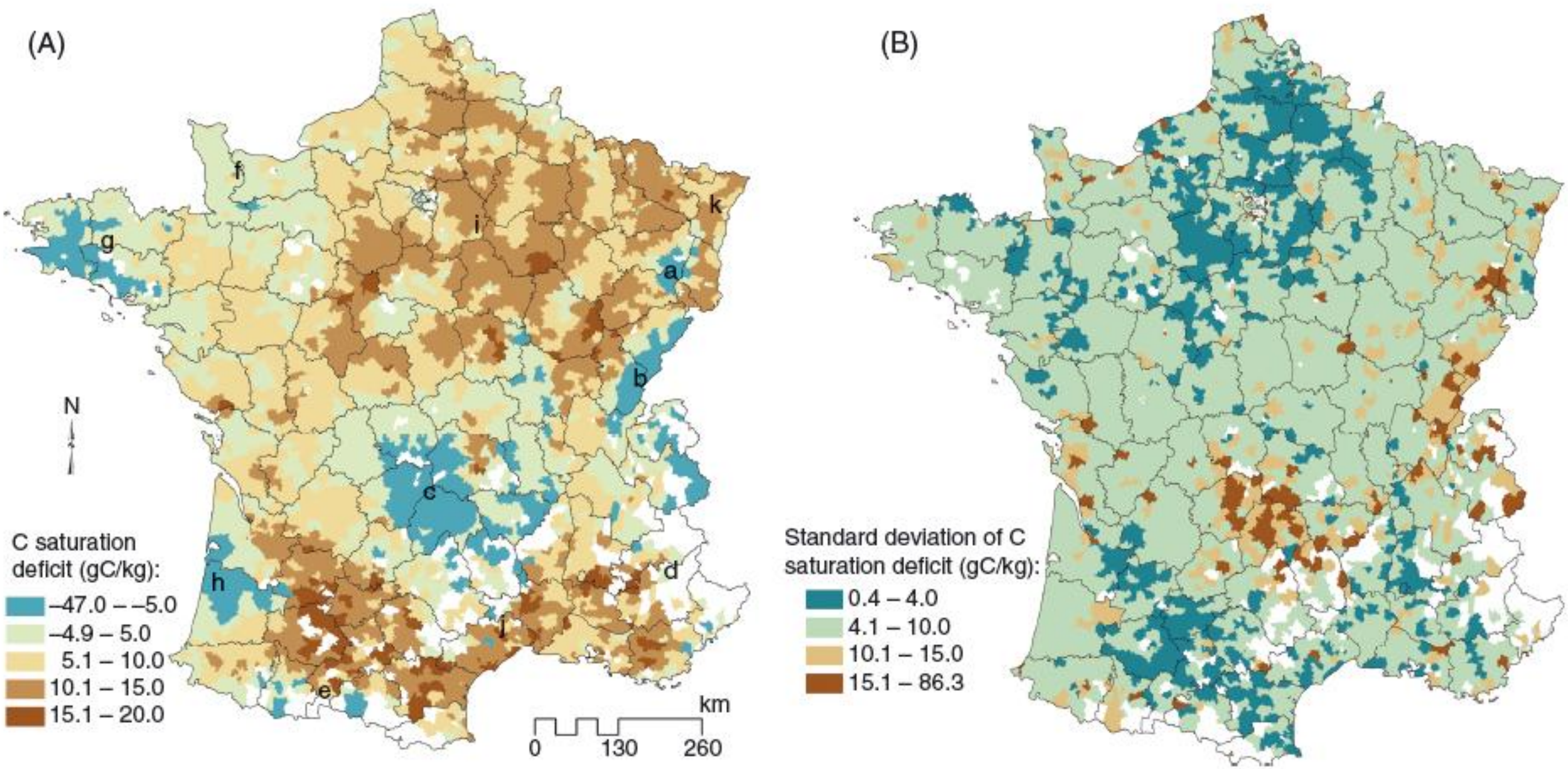
Maps of carbon saturation deficit per canton: (A) mean estimate and (B) standard deviation from 100 Monte Carlo estimations of C saturation deficit. Letters refer to broad regional physiographic units: (a) Vosges; (b) Jura; (c) Massif Central; (d) Alpes; (e) Pyrenees; (f) Normandy; (g) Brittany; (h) Landes of Gascony; (i) Paris Basin; (j) Languedoc-Roussillon; (k) Alsace.

Angers et al. (2011)



Effect of CAP / ÖPUL

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Differences between the medians of SOM in arable soils in the periods 1991-1995 and 2006-2009 in three main crop production regions

AGES (2010)

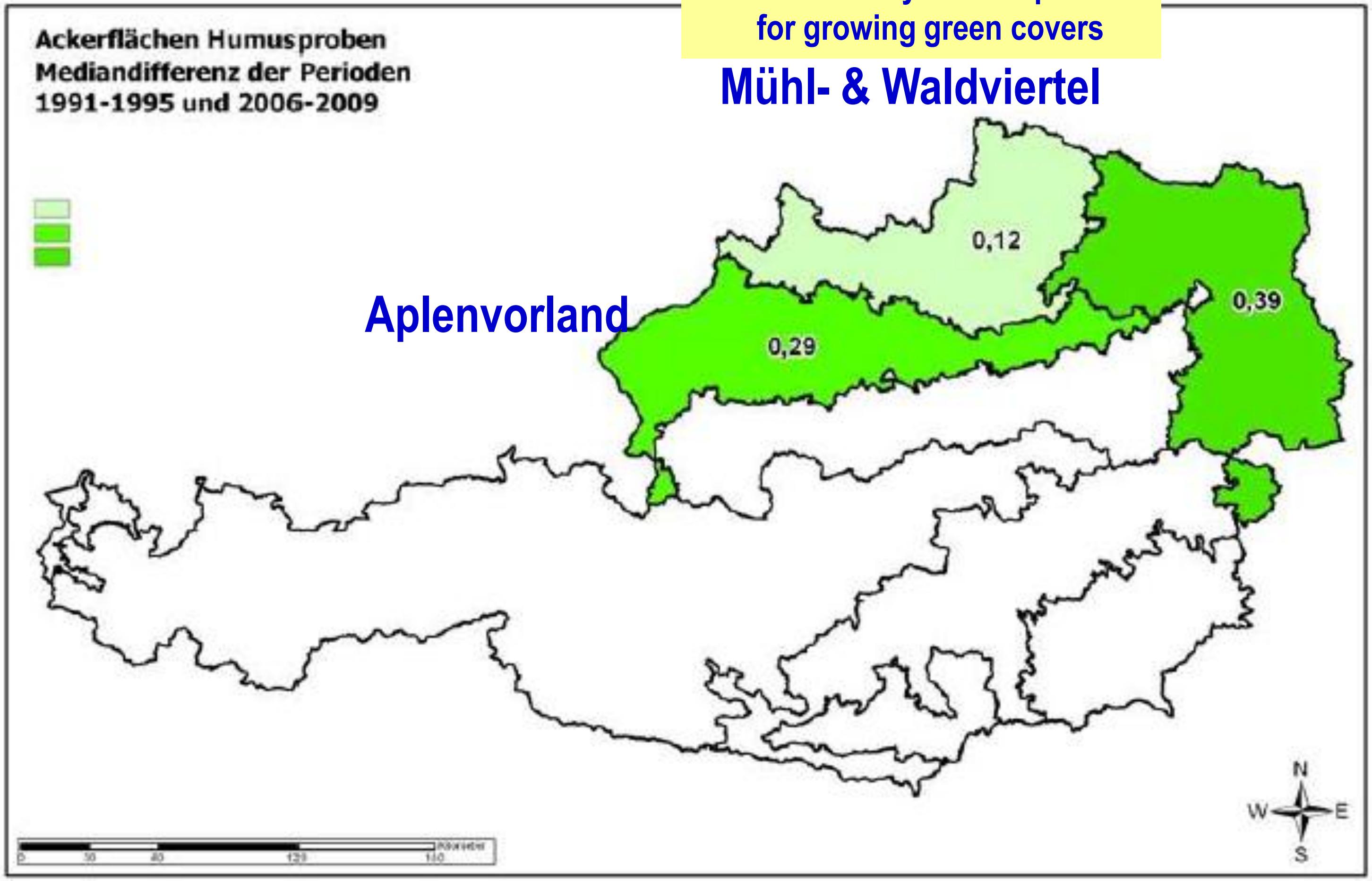
Initially higher SOM saturation
Climatically shorter period for growing green covers

Mühl- & Waldviertel

Aplenvorland

Nordöstliches Flach- & Hügelland & Marchfeld

Initially higher carbon deficit due to intense cropping systems, low organic input
SOM increase by green covers, direct drill…



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