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**Greenhouse gas budget of soils under changing
climate and land use:
experience from Cost Action 639 "Burnout"**

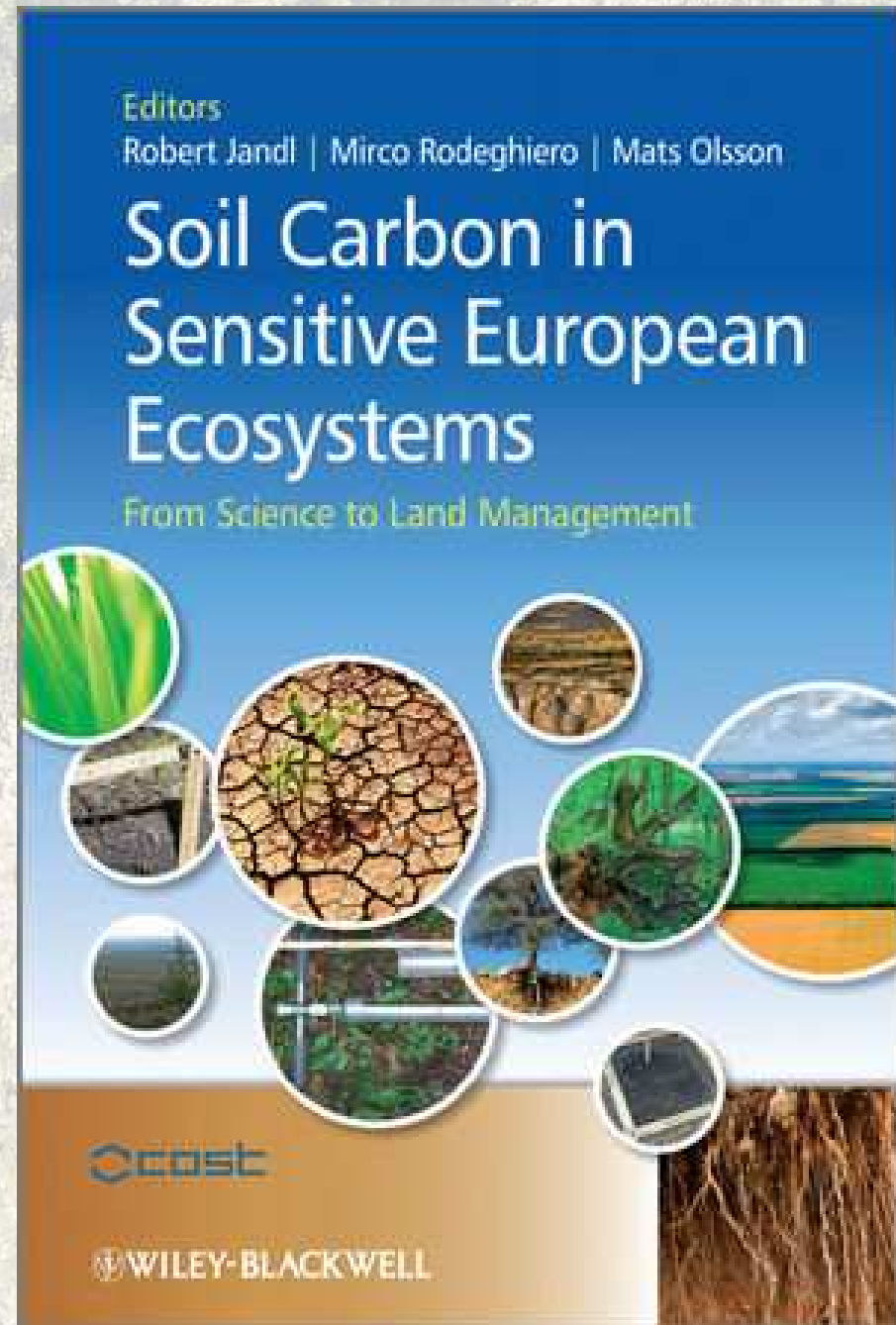
JRC technical workshop on LULUCF issues under the Kyoto Protocol (21/11/11)

COST Action 639

Greenhouse gas budget of soils under changing climate and land use (2006-2010)

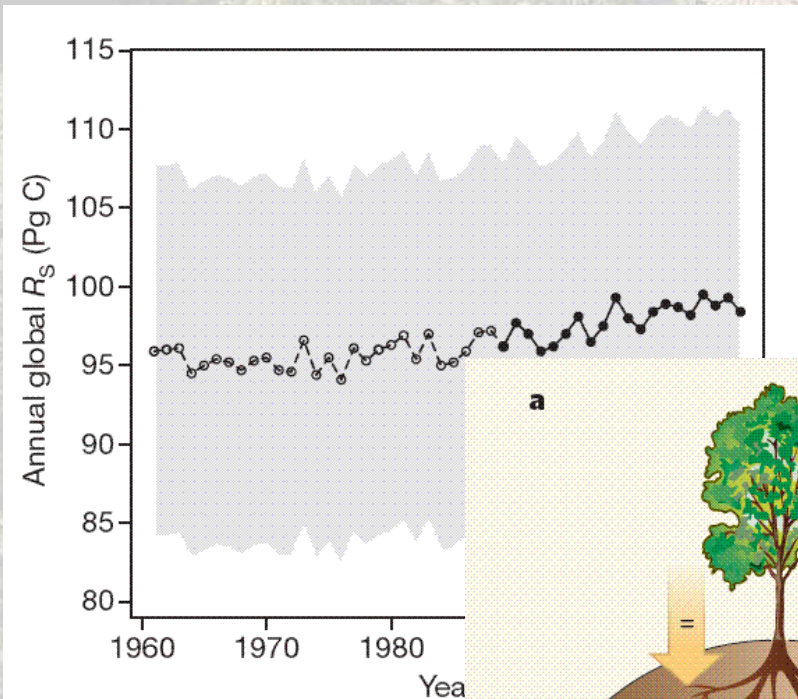
Sensitive ecosystems (patchy occurrence and underrepresented in systematic assessments):

- Mountain ecosystems
- Peatlands
- Mediterranean ecosystems

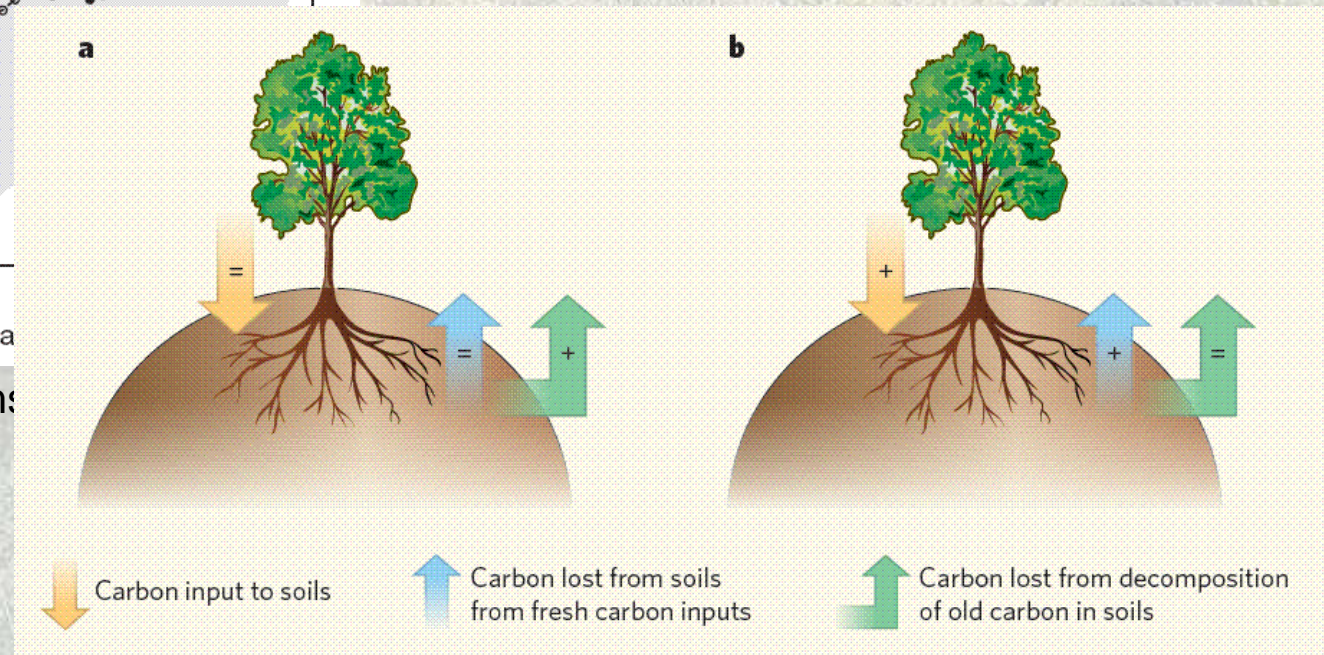


Introduction

The ongoing climate change is affecting the soil carbon processes



Bond-Lamberty & Thomas



Smith & Fang, 2010

Soil carbon balance

Evaluation methods:

- 1) **Flux approach**: indirectly, by determination of all carbon fluxes entering and leaving the soil over a certain time period.
- 2) **Repeated inventory approach**: directly, by repeated measurements of SOC stocks at the same location over a period of time (>10 yrs).
- 3) **Modeling approach**: application of process based models.

Flux approach

Net soil carbon change
(Hanson *et al.*, 2000)

$$\Delta C \text{ (g C m}^{-2} \text{ y}^{-1}) = (L_A + L_B) - (R_S + R_R)$$

Example:

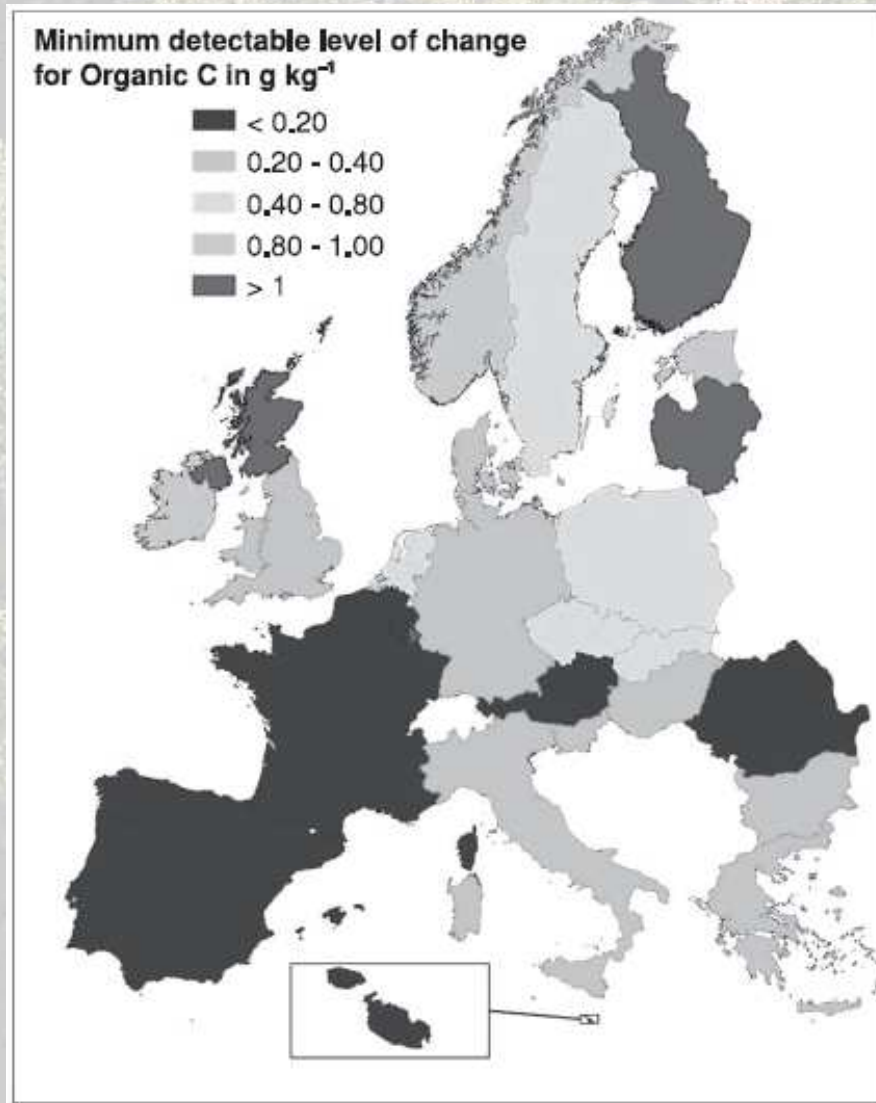
$L_A = 205.0$	Aboveground litter
$L_B = 88.0$	Belowground litter
$R_S = 510.0$	Total CO ₂ efflux
$R_R = 264.0$	Root respiration

$$\Delta C = 47.0 \text{ g C m}^{-2} \text{ y}^{-1}$$

Carbon in European soils

- ✓ Main European soil inventories: EC/ICP Forest Level I; FOREGS (GEMAS); LUCAS.
- ✓ LUCAS and GEMAS will give representative SOC estimates for the different land uses.
- ✓ At the moment there are problems in soil C changes detection from repeated Inventories (Funding! Bd, Stones, Spatial variability, hot spots).

Carbon in European soils



Arrouays et al. (2008)

- ✓ A density of 57628 plots needed to detect a relative change of 5% in the national mean of topsoil carbon.
- ✓ A density of about one million sites required to detect a relative change of 1% at EU level.

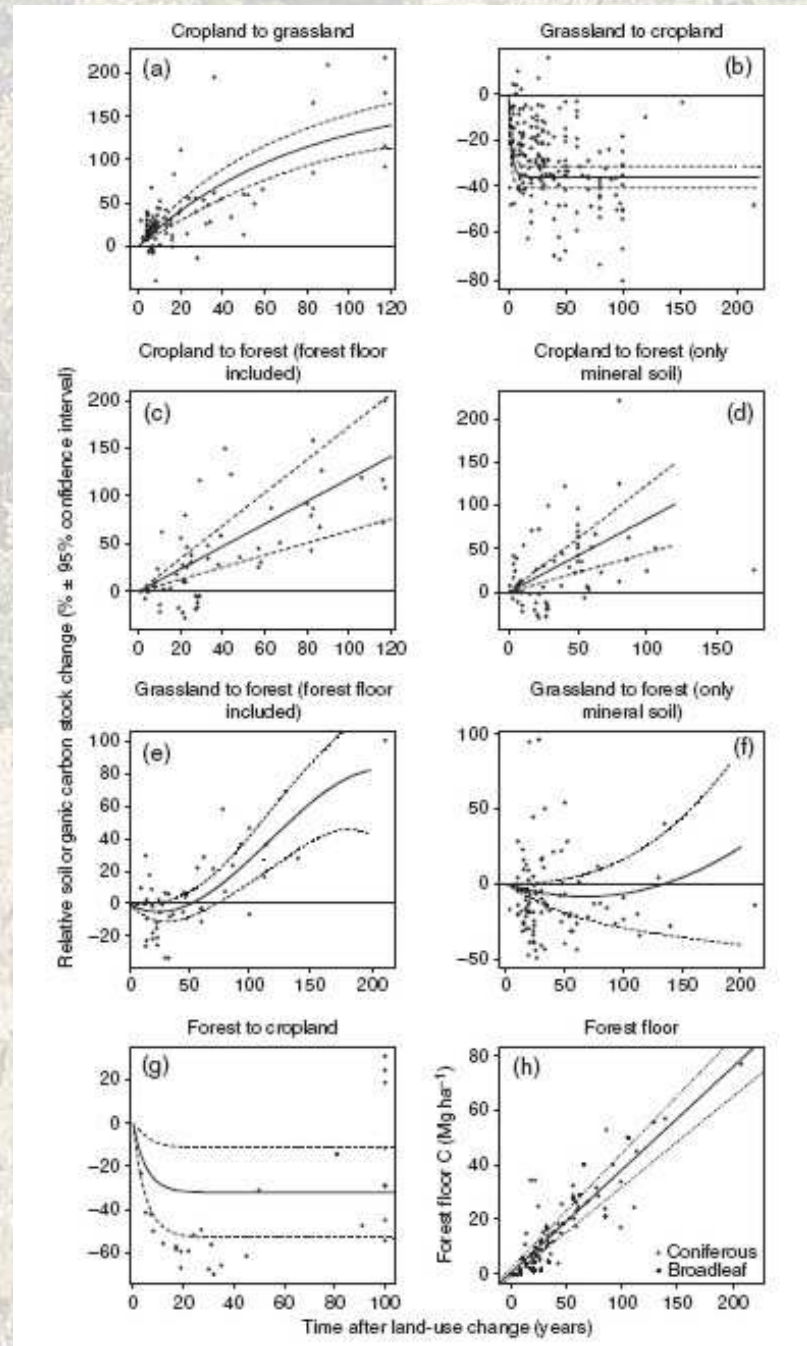
Reporting requirements (Art. 4 (1a), UNFCCC)

- ✓ For forest land remaining forest land most countries (17 out of 30) apply the default method for mineral soils which assumes **no carbon stock changes**.
- ✓ Many countries are still not able to report on soils and dead organic matter.
- ✓ Most countries apply Tier 1 method cause country specific data based on large scale representative data collections are missing.
- ✓ Where countries apply specific methods they are difficultly comparable. Estimation of the uncertainty of reported values is even more complicated.
- ✓ Even in case of declared “**not source**” there can be sources of C (e.g. sensitive ecosystems hot spots).

Carbon response functions

- ✓ The functions were derived from a global dataset of studies performed in chronosequences or paired plots.
- ✓ IPCC default factors underestimate SOC change for CL to FL and CL to GL.
- ✓ Temperature, precipitation and soil texture should be included in future reporting guidelines.

(Poeplau et al., 2011)



Process based models vs. Soil Inventories

- ✓ Q model (Hyvonen & Agren, 2001); Yasso07 (Tuomi et al., 2008).
- ✓ The Swedish NFSI estimated an avg. national change in SOC stocks between 1994 and 2000 of -2 ± 4 (CI) TgC y⁻¹.
- ✓ The corresponding estimate with the Q model was $+4 \pm 9$ TgC y⁻¹ whereas the Yasso07 model estimated -1 ± 8 TgC y⁻¹.

Forest management vs. soil C sequestration

(Jandl et al., 2007)

- ✓ Aims of forest management: secure a high productivity of the forest and avoid as much as possible soil disturbances.
- ✓ A trend towards nature-oriented silviculture and continuous cover forestry will reduce the relevance of site preparations and clear cuts.
- ✓ Old growth forests can have impressive rates of soil C sequestration but beyond a certain age they are susceptible of disturbances.
- ✓ Avoid soil disturbances is important for the formation of stable organo-mineral complexes which are crucial for C sequestration.
- ✓ Maintaining a high stand density would maximize the C pool but would also bear a considerable risk of disturbance.

Forest management vs. soil C sequestration

Tier 1 Implementation

- ✓ Forest Inventories hardly found robust relationships between vegetation features (e.g. growth, biomass production, diameter of trees, age etc.) and soil carbon accumulation (Rodeghiero et al., 2010).
- ✓ More frequently (e.g. for Sweden) positive relationships were found between forest age and forest floor thickness (but accumulation of carbon does not necessarily mean stabilization).
- ✓ This could be reasonably due to the very different turnover times of vegetation (tens to hundred years) and soil carbon (>thousand years).
- ✓ Therefore an approach based on soil C carrying capacity (Gupta & Rao, 1994) (+additional variables) could be a possible alternative to demonstrate that a soil is not a source of C.

Conclusions

- ✓ The international reporting rules for GHG emissions put a high demand on data quality.
- ✓ Existing guidelines (IPCC, 2006) are interpreted by governments in a national context. The default emission factors listed in the Emission Factors Database of the AFOLU guidelines may need updating by providing a dynamically growing data pool.
- ✓ Repeated national soil inventories are likely to be the only data source to quantify the soil C pools for GHG inventories for land under forest management. Soil monitoring in agricultural lands are difficult due to the restrictions of private owners.
- ✓ Existing Tier 3 approaches according to the UNFCCC reporting guidelines are still rare and if available combine soil carbon inventories with soil carbon models.