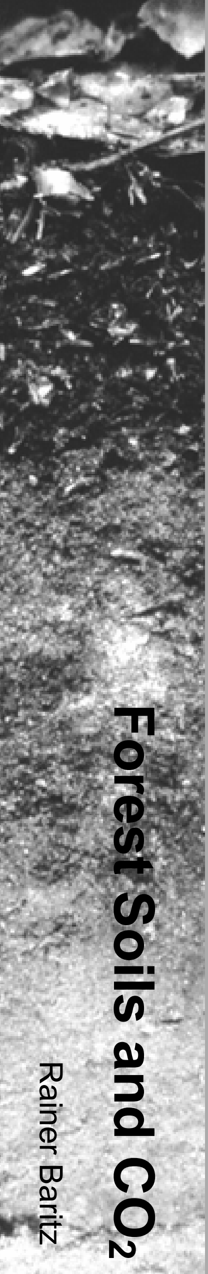
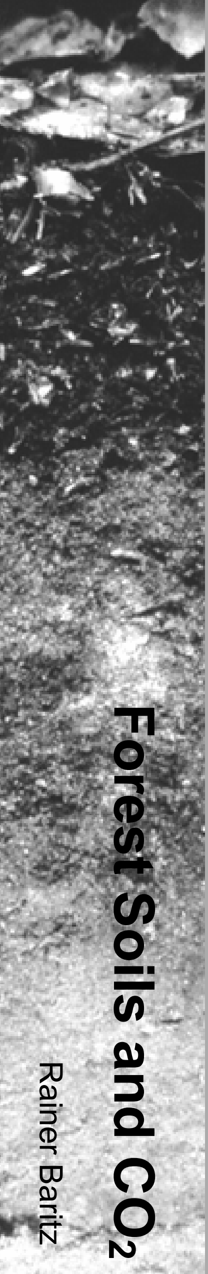


CO_2 and other GHG gases, factors determining forest soil emissions and implications for landscapes

Rainer Baritz

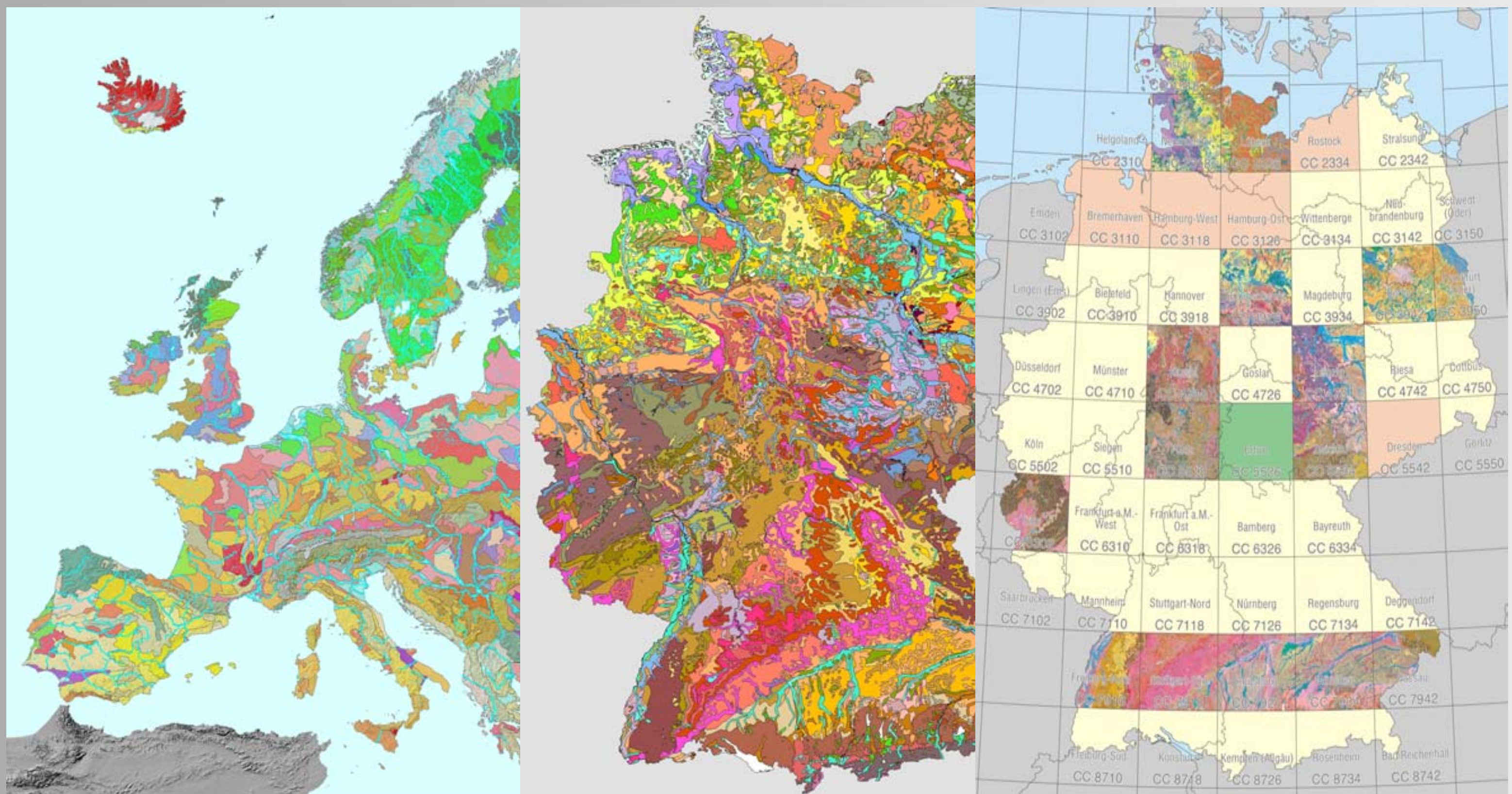
Federal Institute for Geosciences and Natural Resources (BGR)

Bordeaux, 2004



< 02.2004 EU Commission Joint Research Centre – Climate Change Unit

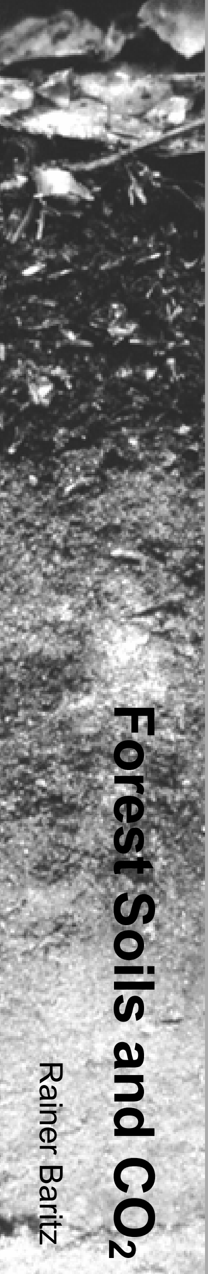
> 02.2004 Federal Institute for Geosciences and Natural Resources (BGR → ESB Steering C.)



Forest Soils and CO_2

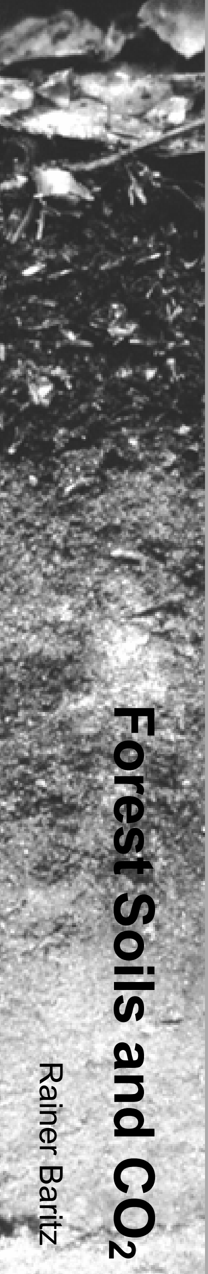
Rainer Baritz

BGR



Project Background

BGR



CarboInvent (→ FP5 CarboEurope cluster)

Multi-source inventory methods for quantifying carbon stocks and stock changes in European forests (FP5)

EU Joint Research Centre

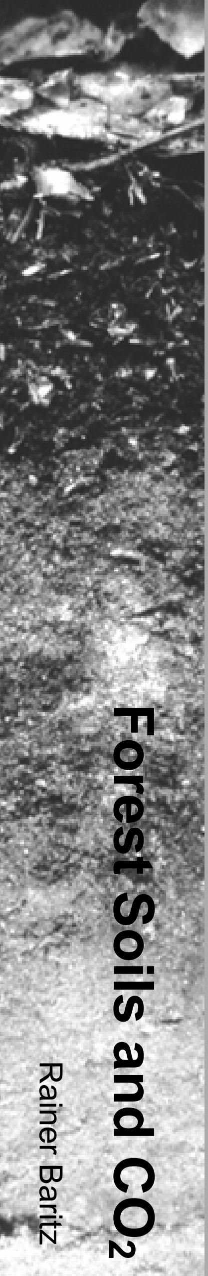
Data Quality System for greenhouse gas emissions and sinks

CarboEurope IP (→ FP6)

Work Package 4.2. Land Carbon Inventories (baseline for forest soil C)

IPCC Greenhouse Gas Inventory Programme

Good Practice Guidance LULUCF 2003



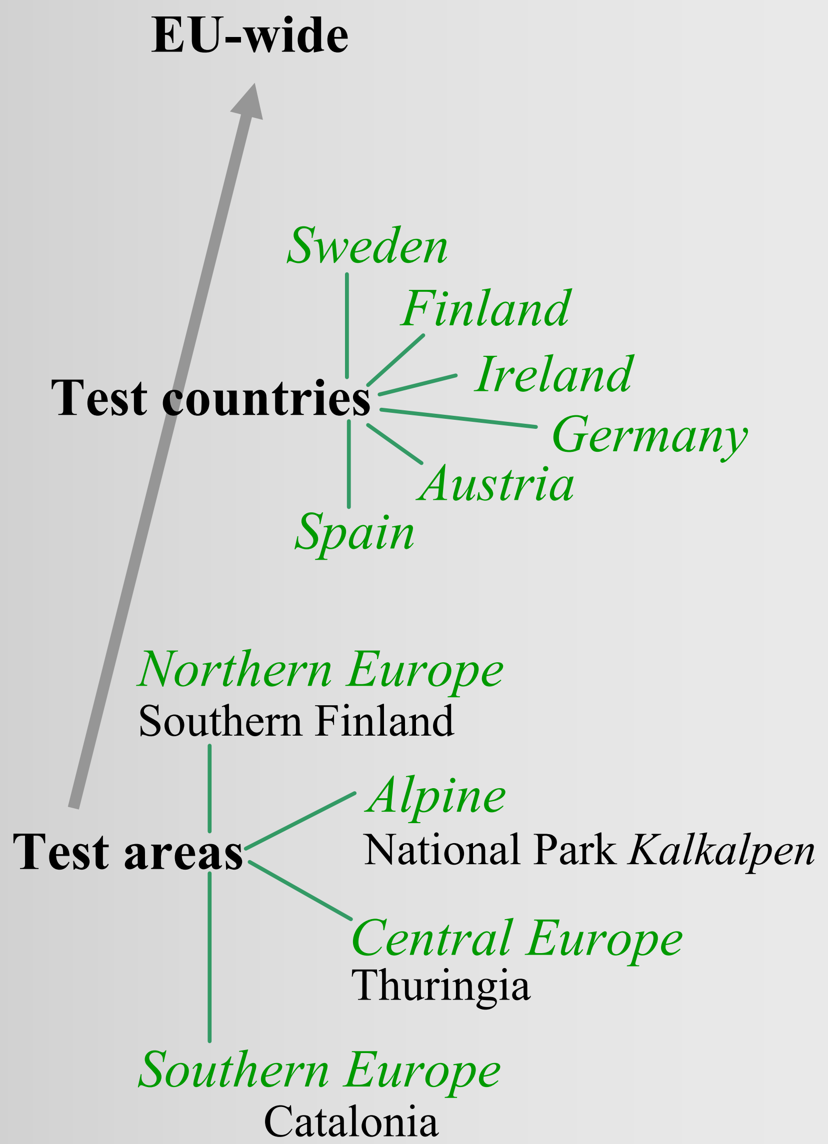
EU Joint Research Centre

- QA/QC of EU GHG Inventory
- independent verification

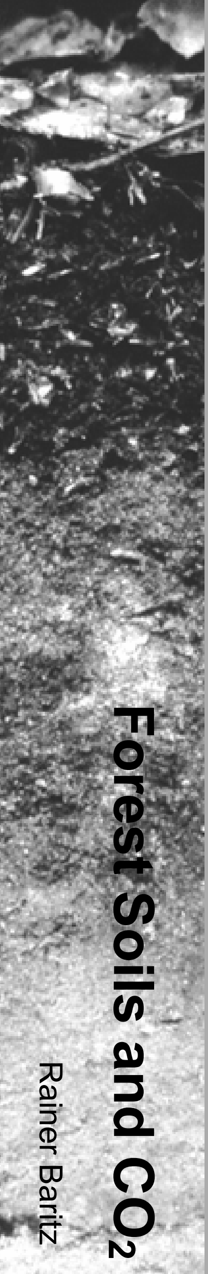
CarboInvent

- Quantification of **regional soil C budgets** at various scales
- Assessment of <u>plot level</u> and <u>regional-level</u> **uncertainties**

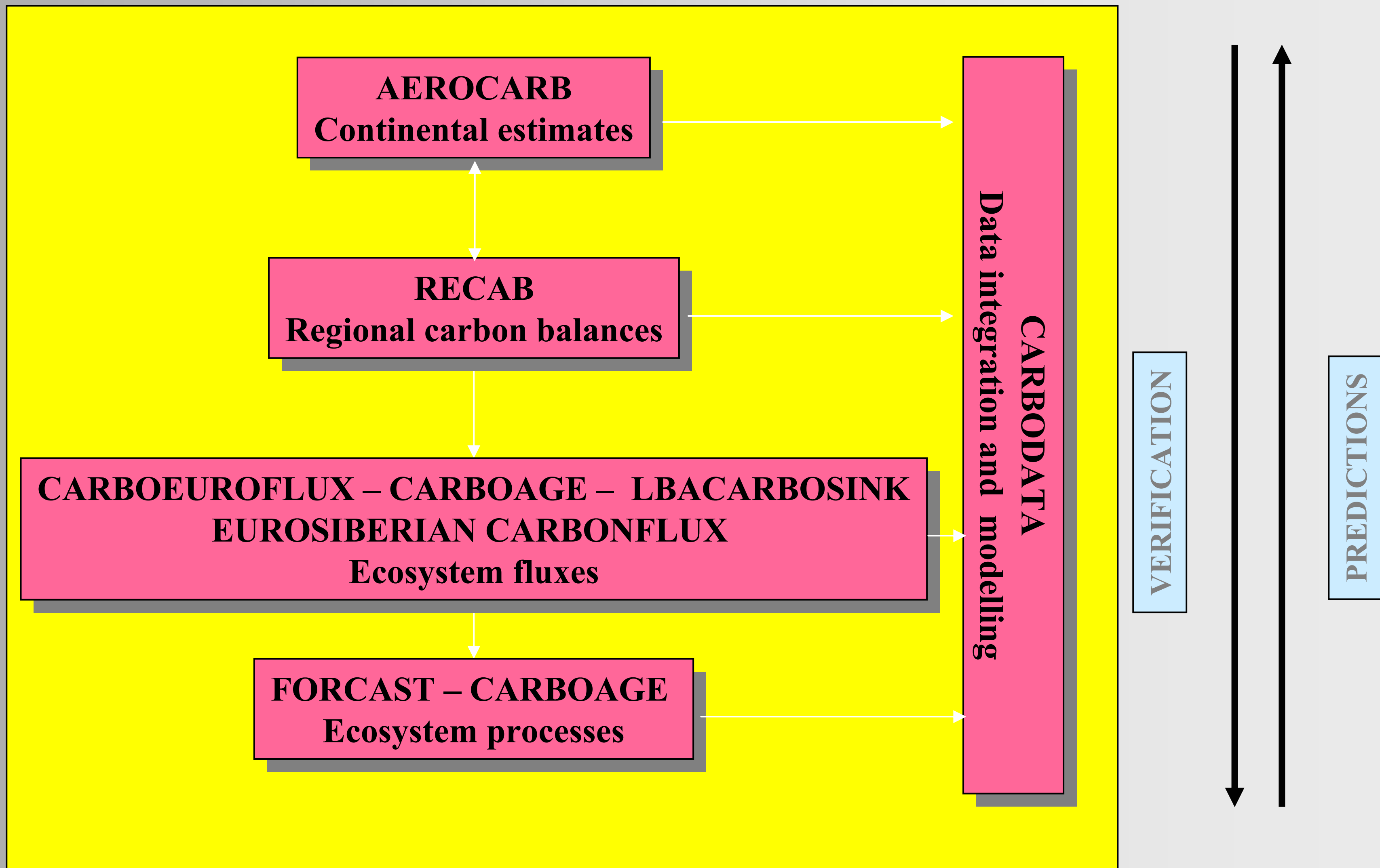
CarboEurope IP



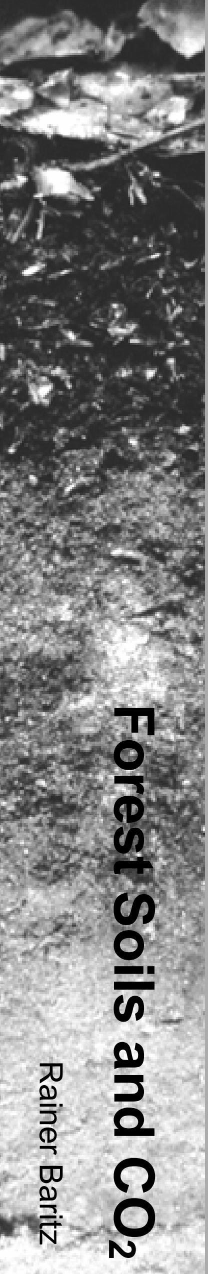
BGR



CARBOEUROPE



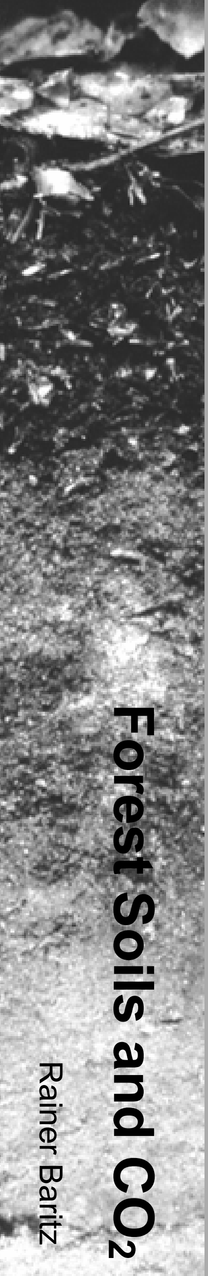
Compiled by Matteuchi 2002

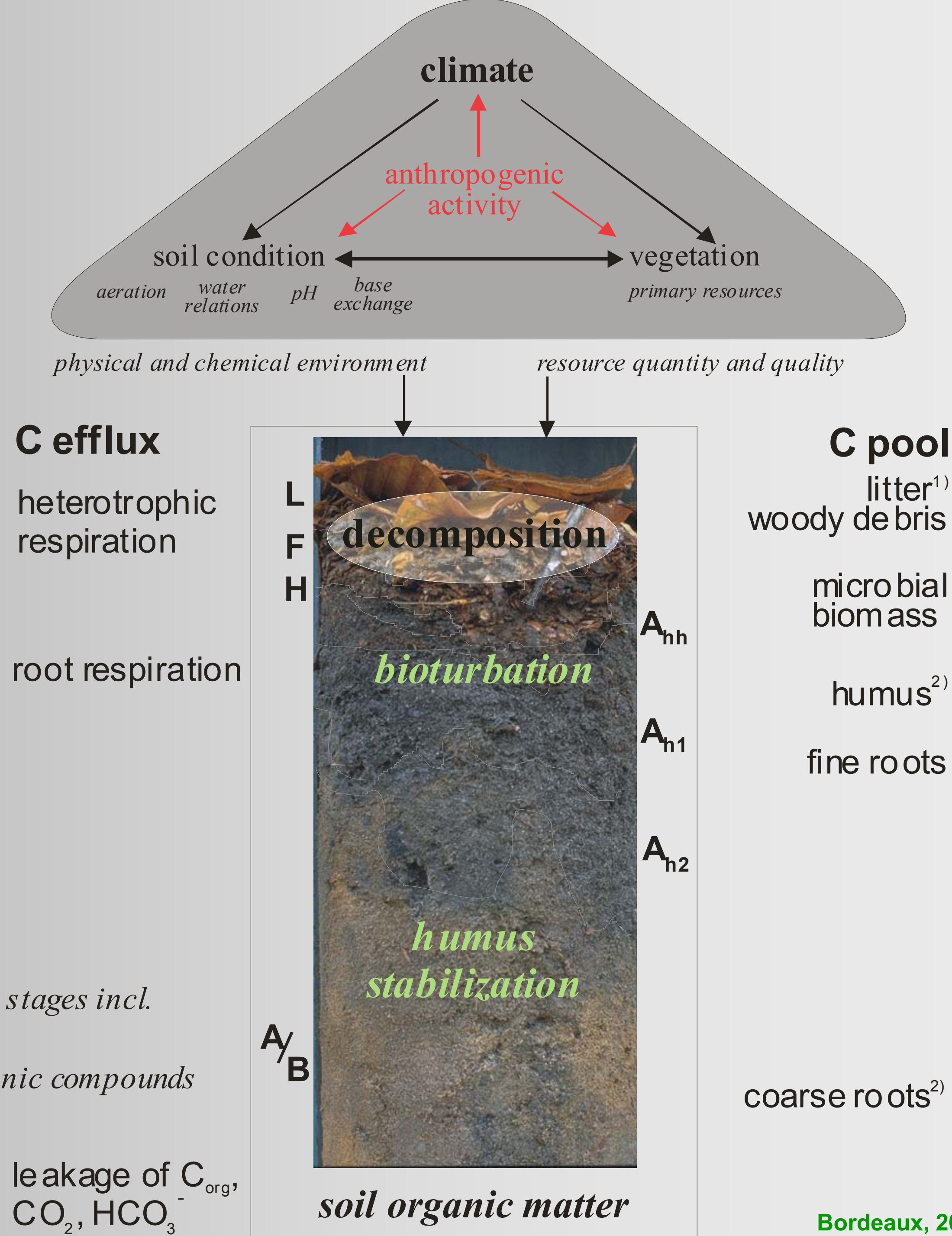


Soil Carbon

Forest Soils and CO_2

Rainer Baritz





[1)] *plant residues of various decompositional stages incl. carcasses and faeces of soil animals*

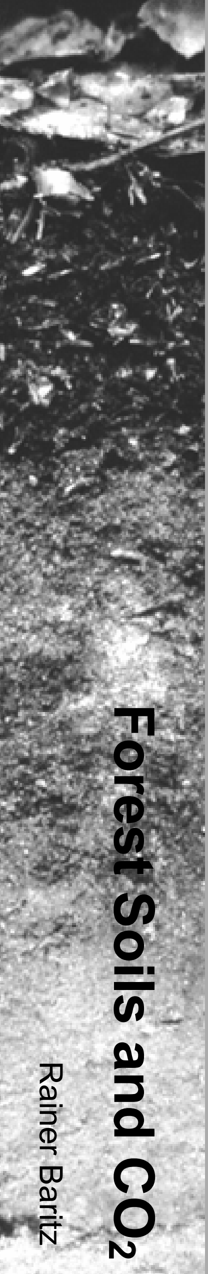
[2)] *humus: re-synthesized and stabilized organic compounds*

[3)] *usually counted as standing tree biomass*

BGR

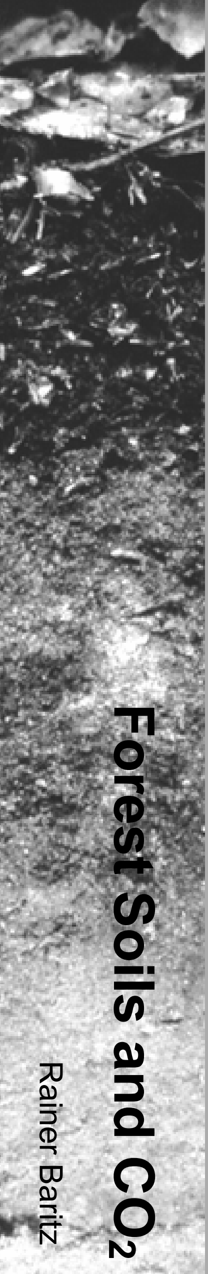
Bordeaux, 2004

- **to measure fluxes…**
  (few sites)
- **to measure pools…**
  (more sites - depends on which pool/fraction**)**
- **to measure process drivers…**
  (frequent: basisdata for pedo- transfer functions, models, etc.)



- **to measure for which purpose … ?**

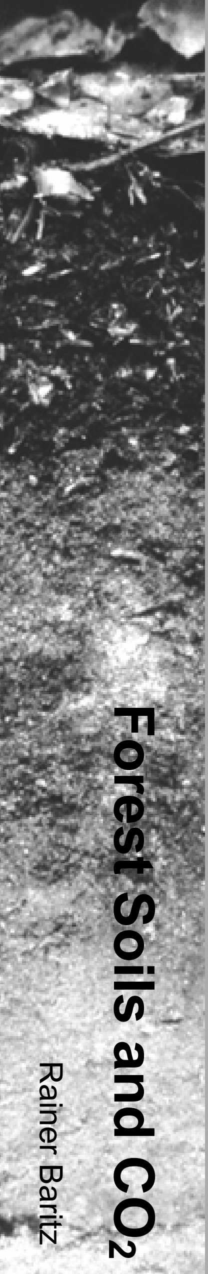
- *C (N) cycle – sinks and sources for greenhouse gases*
- *detecting the drivers (with regard to C dynamics) helps to identify positive and negative management effects, as a basis for setting political incentives*
- *plot/process → landscape for regional/country-level estimates*



➢ Global view

	80'ies	90'ies
atmospheric increase	3.3±0.1	3.2±0.1
emissions (fossile fuels)	5.4±0.3	6.3±0.4
ocean - atmosphere flux	-1.9±0.6	-1.7±0.5
land - atmosphere flux	-0.2±0.7	-1.4±0.7
a) land use change	1.7 (0.6 to 2.5)	not available
b) remaining terrestrial sink	-1.9 (**-3.8 to 0.3)**	not available

IPCC Third Assessment Report (TAR) [PgC/a]

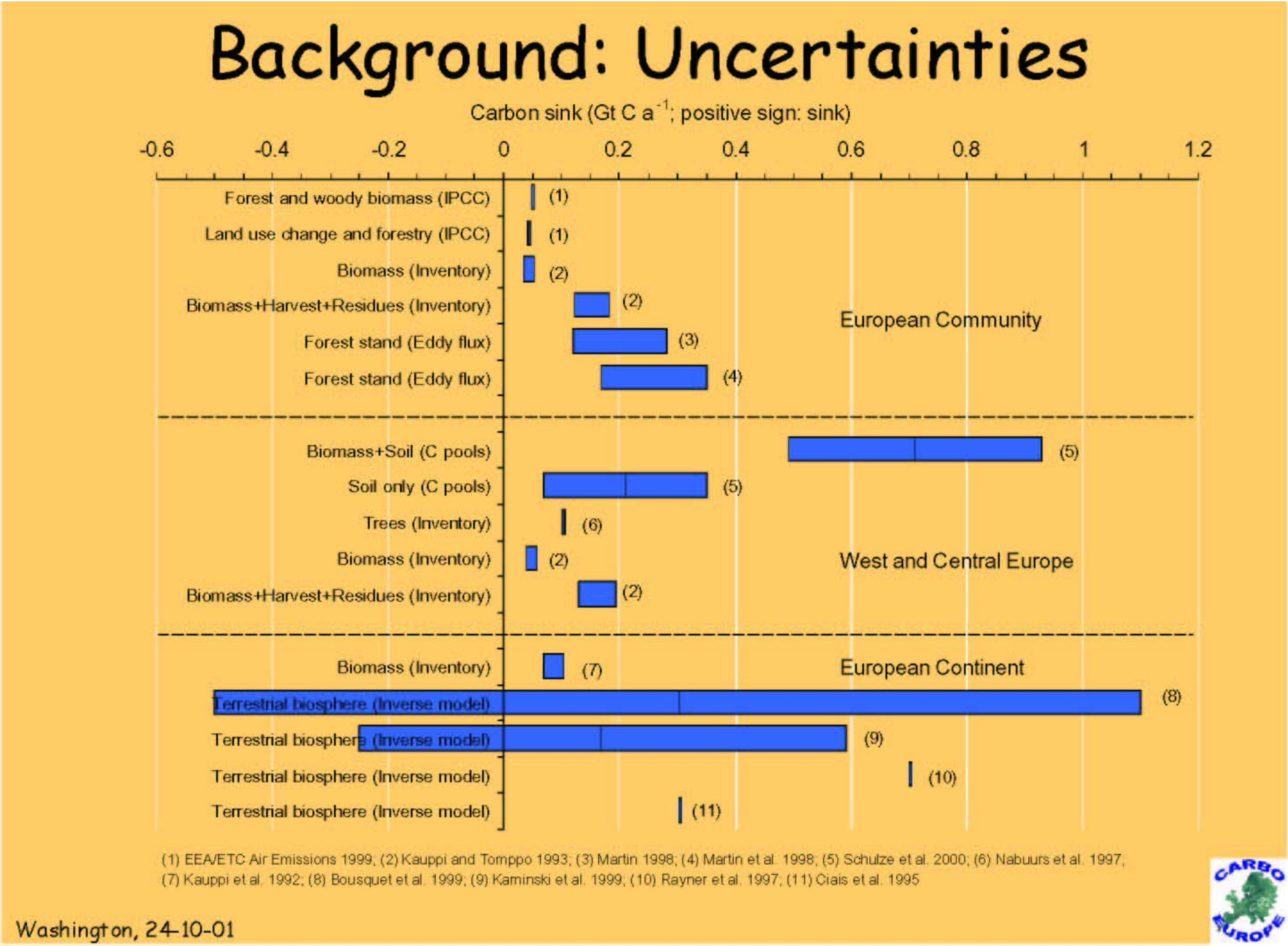


➢ Soils

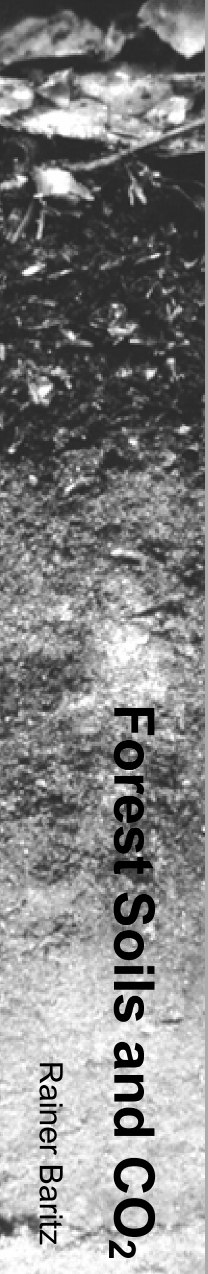
- **soils globally** contain two to three times more carbon than terrestrial biomass does (Bouwman 1990; Schlesinger 1990)
- high **uncertainties** exist about the contribution made by soils to the terrestrial carbon pool and carbon flux (Post et al. 1990; Dixon & Turner 1991).
- lack of knowledge/data and high uncertainties endanger the environmental integrity of the **Kyoto Protocol**

BGR

➢ Sink estimates for terrestrial carbon (LULUCF) in Europe



Source: H. Dolman (2001)



Data Need: Environmental Policy

European Climate Change Programme

ECCP was established in June 2000 to help identify the most environmentally friendly and cost-effective measures enabling the EU to meet its Kyoto target

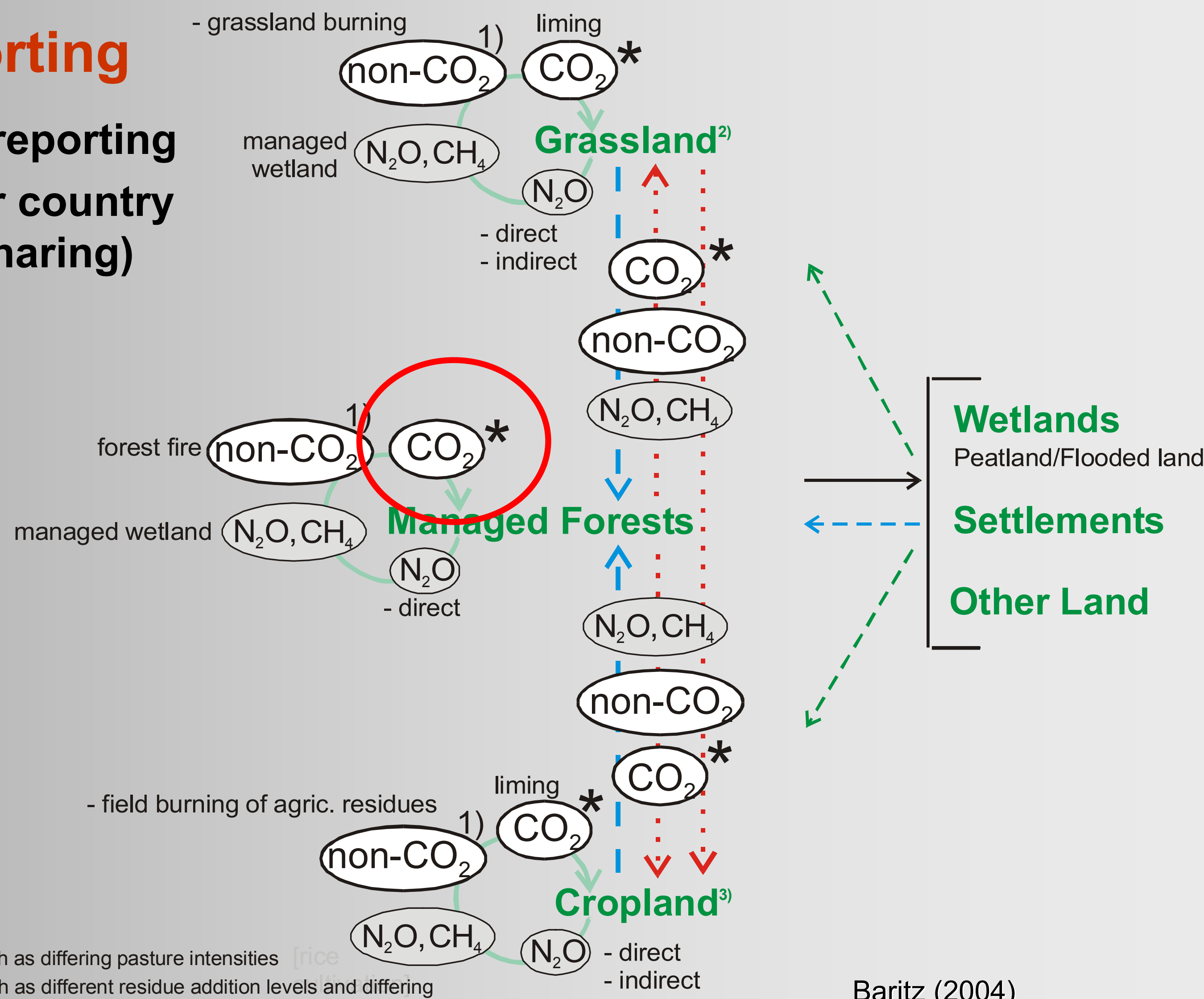
Working groups, relevant for soils:

- Forest related carbon sequestration
  final report available at
  http://europa.eu.int/comm/environment/climat/forestrelatedsinks.htm
- Carbon sequestration in agricultural soils
  final report available at
  http://europa.eu.int/comm/environment/climat/agriculturalsoils.htm

- The 8% reduction target for EU15 corresponds to 336 Mt CO_2eq
- Considering only activities with clearly positive environmental co-benefits (e.g., on soil protection, biodiversity), the technical potential for carbon sequestration by the 1st CP in 2010 is about 60-70 Mt CO_2eq for agricultural soils and 33 Mt for forests.
- 12 Mt will be achieved through reduced N_2O emissions (by-product of CAP reform and cross compliance with environmental legislation like nitrate directive)
- Globally, management of forests is expected to sequester carbon to offset 12-15 % of projected fossil fuel emissions (next 60 years; *Cannell 1995)*

➢ Political Reporting

Greenhouse Gas reporting (UNFCCC, KP) per country and EU (burden sharing)



Baritz (2004)

* **C Stocks in 5 Pools**
above-ground biomass
below-ground biomass
dead wood
litter
soil carbon

[1)] non-CO_2: CH_4, N_2O, NO_x, CO (NMVOCs)

[2)] includes agricultural management categories such as differing pasture intensities [rice

[3)] includes agricultural management categories such as different residue addition levels and differing tillage systems and agricultural use of organic soils

no land-use change

Unresolved in the present greehouse inventory guidelines

proposed for further revision of GHG guidelines (GPG completed)

Land-use change

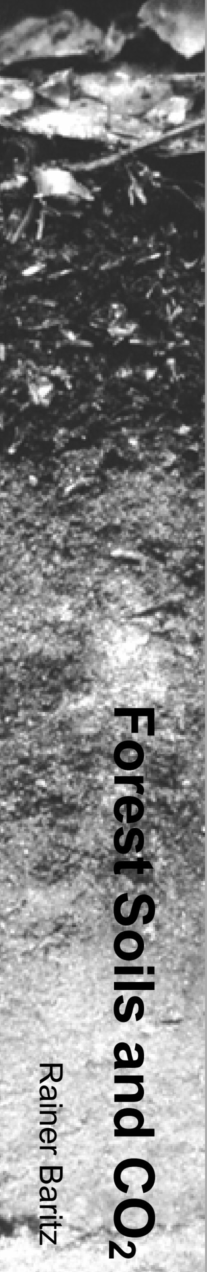
Afforestation, reforestation, abandonment of managed land (incl. natural revegetation of fallow land and agricultural set-aside

Forest and grassland conversion (includes **deforestation** and clearing of native vegetation e.g. wetlands)

Forest Soils and CO_2

Rainer Baritz

BGR



C sinks in the Kyoto Protocol

Sinks form “RMU’s”: tradable, but not “bankable”

Art. 3.3
Afforestation, deforestation, reforestation (ARD activities)
Land use change, avoided deforestation?, biodiversity?

Art. 3.4
Management of domestic land
- Forest land management: 3.3-sources and CAP
- Cropland, grazing land management, revegetation: “NET-NET”

Ancillary effects, biodiversity?

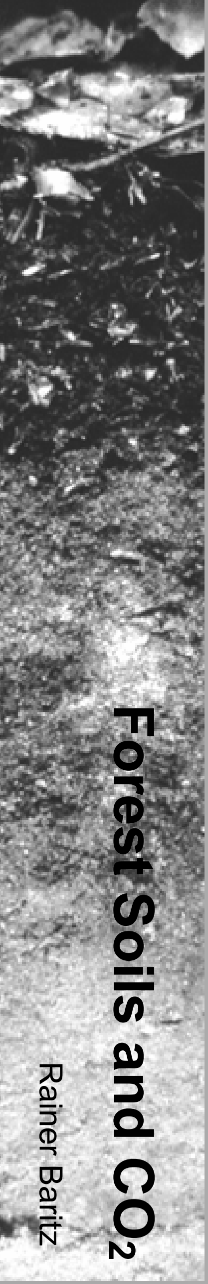
Art. 6 Joint implementation
activities: human-induced, additional?

Art. 12 CDM
only ARD: human-induced, additional, baseline?
only plantations, no protection of existing forests

Compiled by Freibauer 2003

➢ UN ECE Ministerial Conference on the Protection of Forests in Europe (MCPFE)

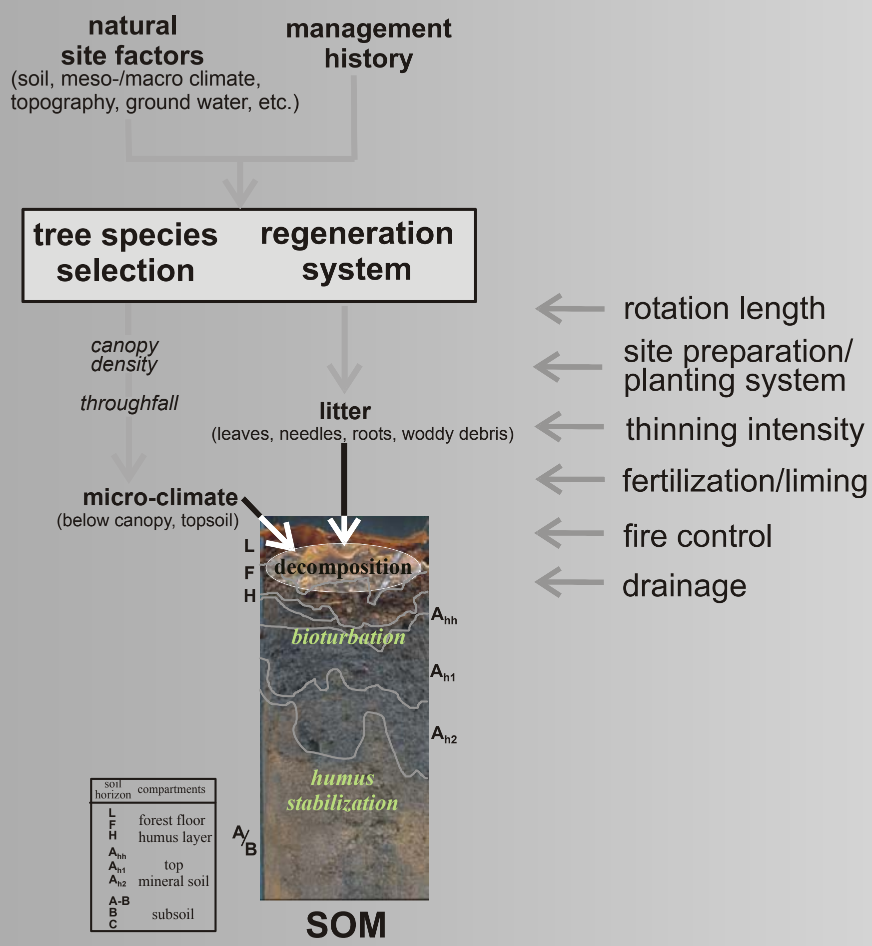
Criteria and indicators



BGR

EU Soil Protection Policy: Soil Thematic Strategy

- **e.g.: Soil Organic Matter and Soil Biodiversity** (all land uses)

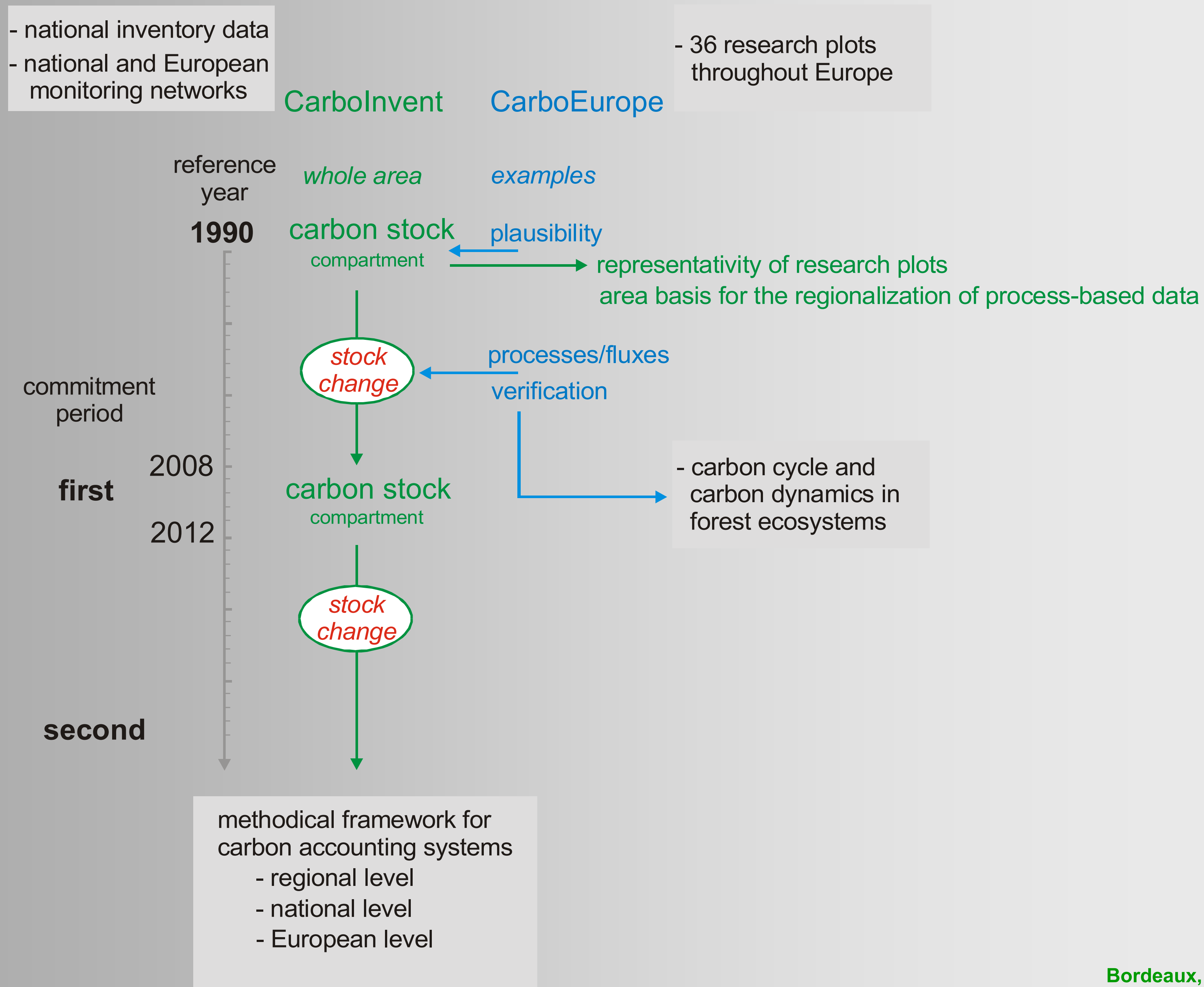


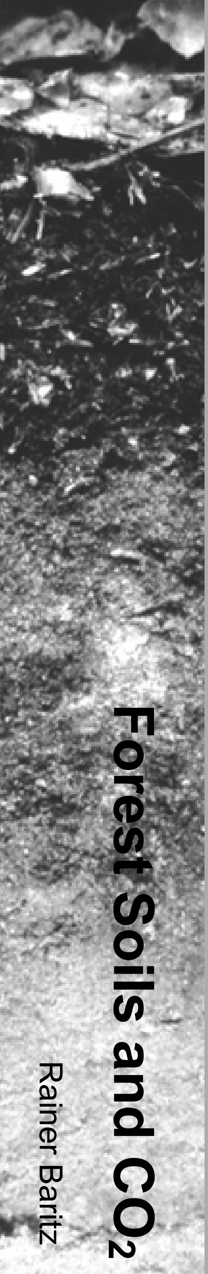
Requirements:

- **Cross-country** soil monitoring data
- Common **baseline** (soil GOOD STATUS)
- **Comparable** and **verifiable** data
- Coverage of soil **threats** (hot spots, landcapes)
- Relationship to **management**
- etc.

Rainer Baritz

➢ Research to provide data to policy





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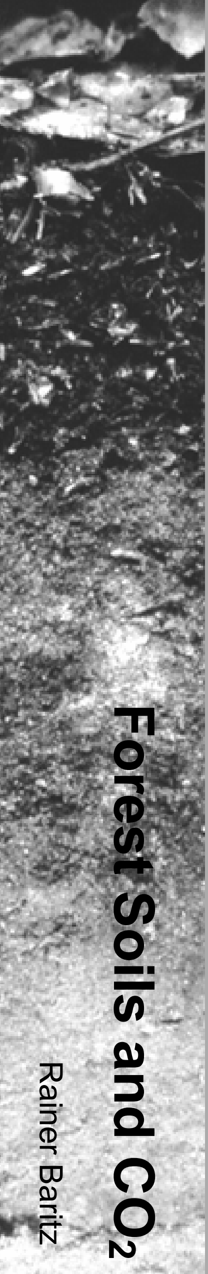
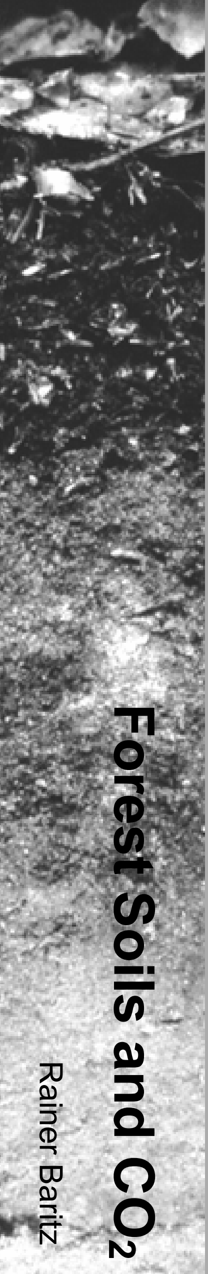
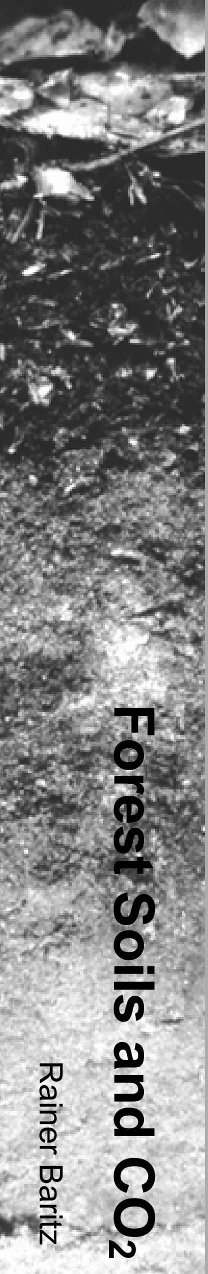


Research Response



➢ enumerous projects….



➢ CO_2 - dynamics

CO_2 - sinks photosynthetic CO_2-fixation

Drivers soil moisture, temperature, CO_2 (atmosphere), nutrient availability, pollutant input, solar radiation, soil pysical and soil chemical properties, forest management

CO_2 - sources auto- and heterotrophic respiration

Drivers soil moisture, temperature, CO_2 (atmosphere), nutrient availability, pollutant input, physical and chemical soil properties, forest management

Problems
- measurement intensive and expensive
- not representative
- high spatial and temporal variability
- lack of regional estimates
- DOCs not fully considered (depth gradient)
- root dynamics not fully considered
- long-term measurements required

BGR

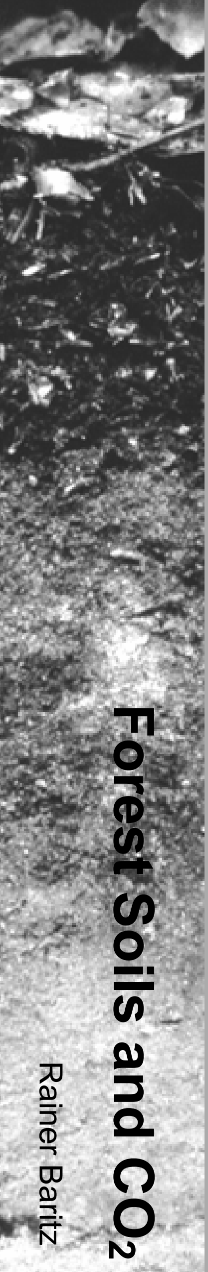
➢ CO_2 - dynamics

C - pool C concentration, C stocks (C content, C density)

Drivers
- same as for CO_2 sinks and sources
- analysed inventory data are controversial

Problems
- environmental gradients not always clear (e.g., temperature northern Europe, elevation)
- also not representative
- also high spatial and temporal variability (forest floor, litter)
- not all pools can be reliably measured (e.g., roots)
- high systematic error in soil inventories prevents reliable estimates
- lack of data on DOC prevent complete soil C estimates
- data availability for model input insufficient (e.g., labile vs. stable organic fractions)

- many models can meanwhile predict topsoil C densities fairly well, but not in deeper soil horizons (Yasso, CoupModel, ROMUL) (therefore soil C changes cannot be predicted, especially for Podzols)



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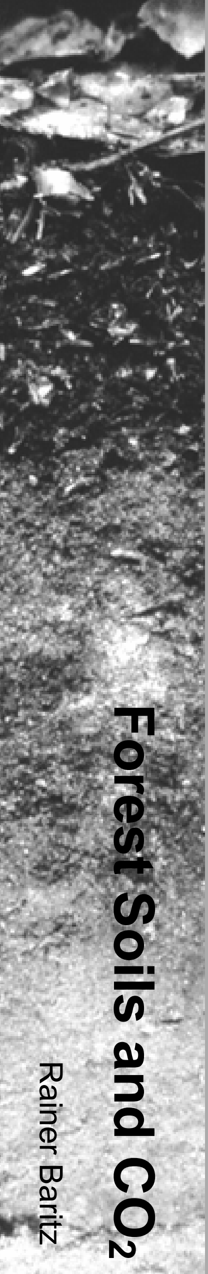
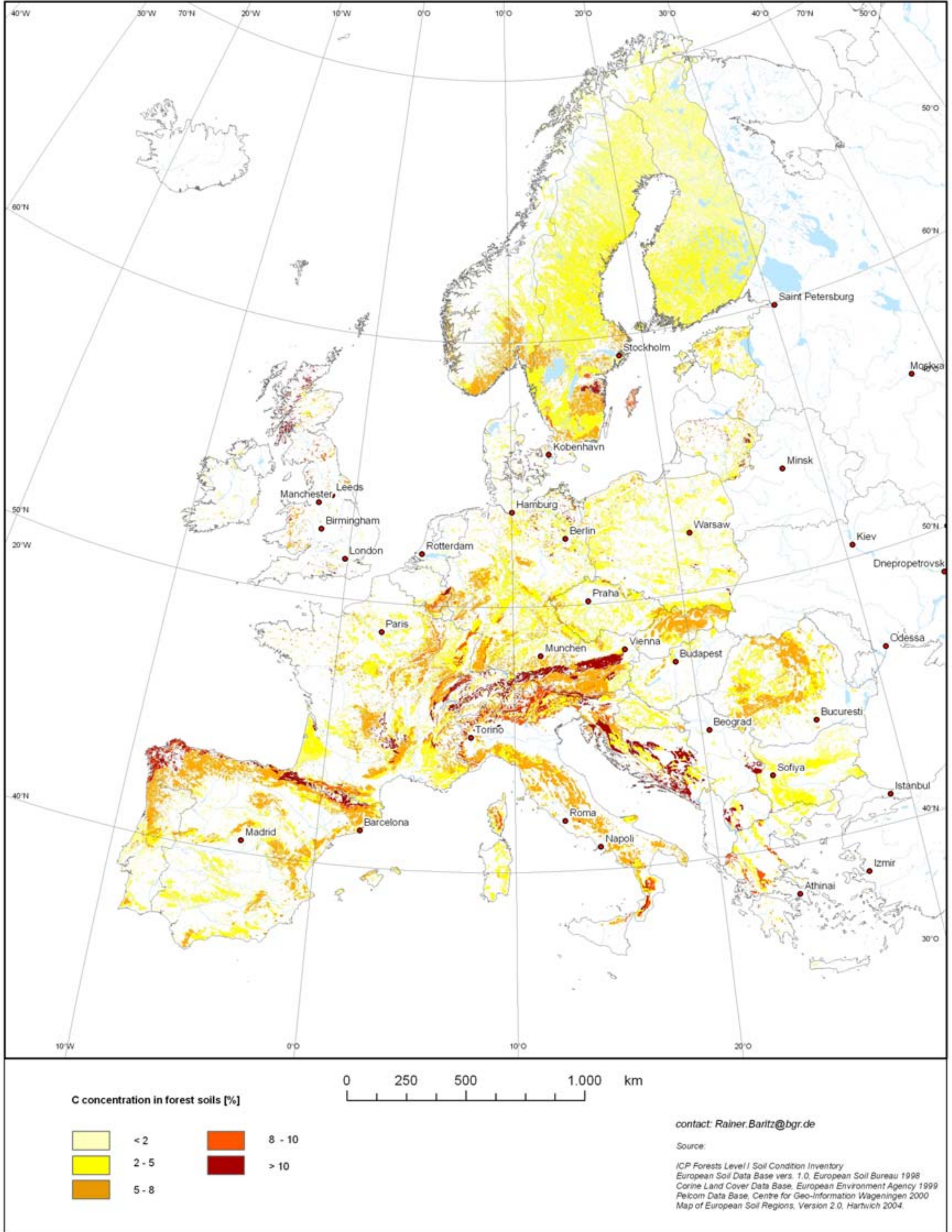
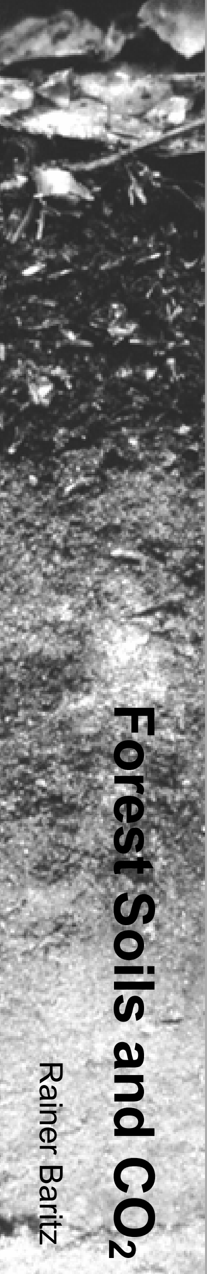


Forest Soils and CO_2

Rainer Baritz



forest soil C %
topsoil
(0-5/0-10 cm)



Forest Soils and CO_2

Rainer Baritz

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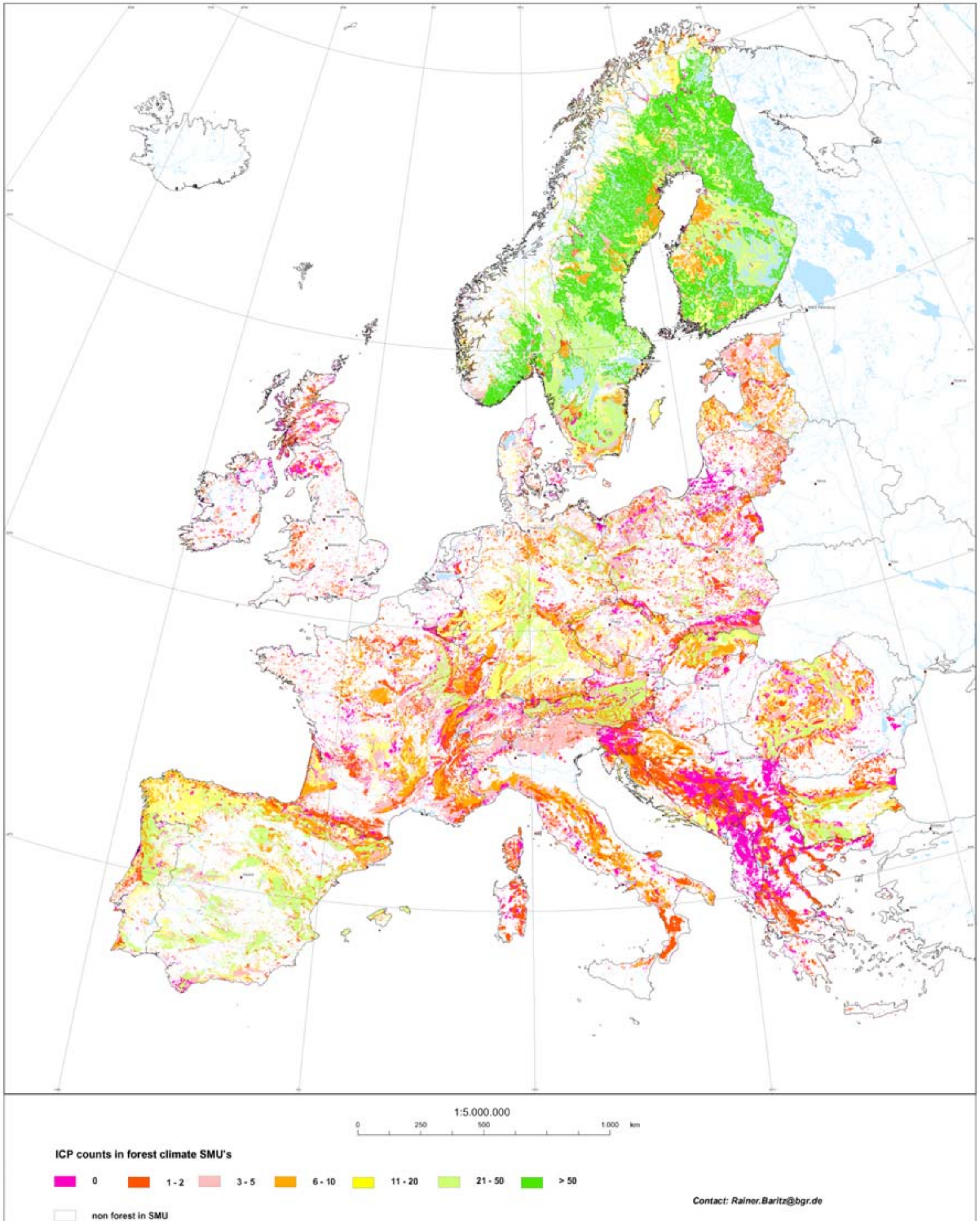
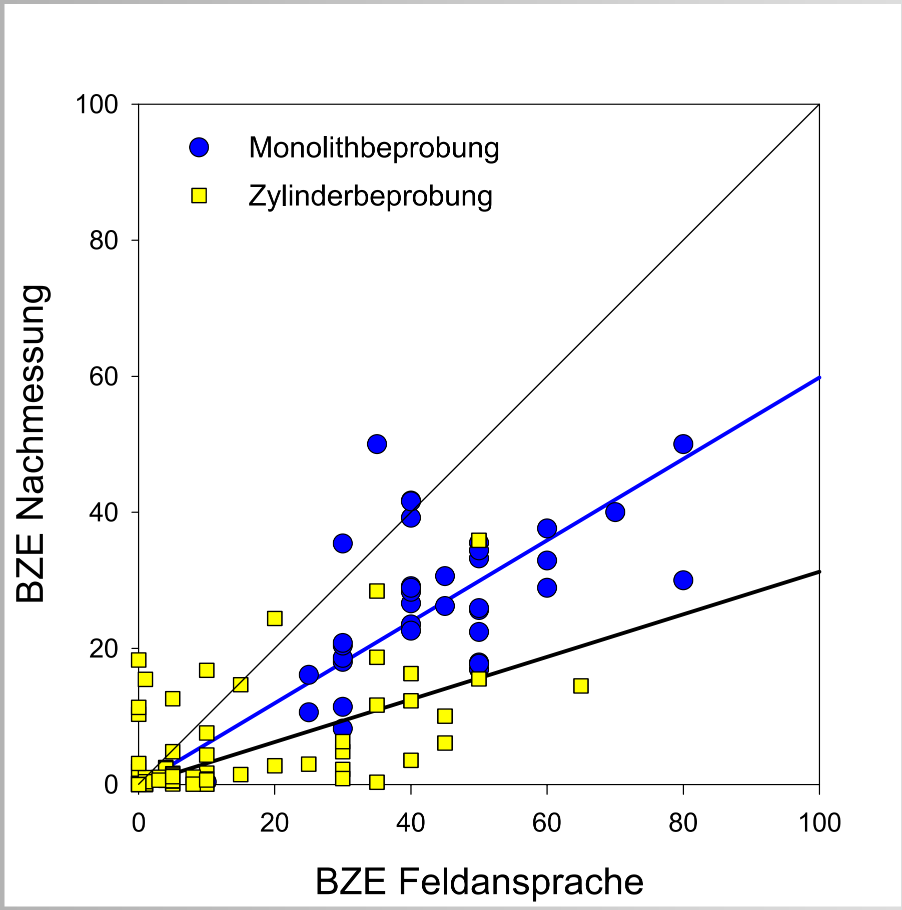
“Representativity”



➢ Systematic error

Example: Stones



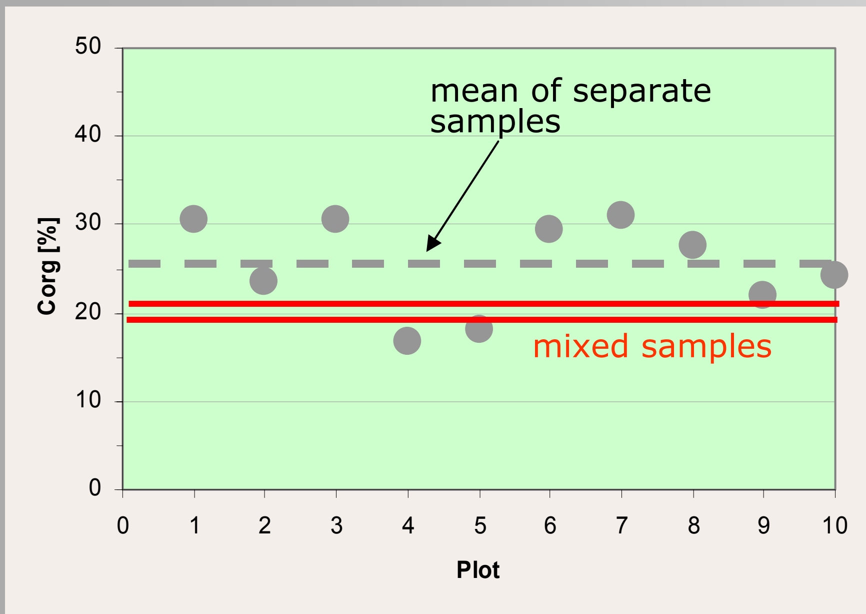
Wirth et al. 2003

Forest Soils and CO_2

Rainer Baritz

➢ Systematic error

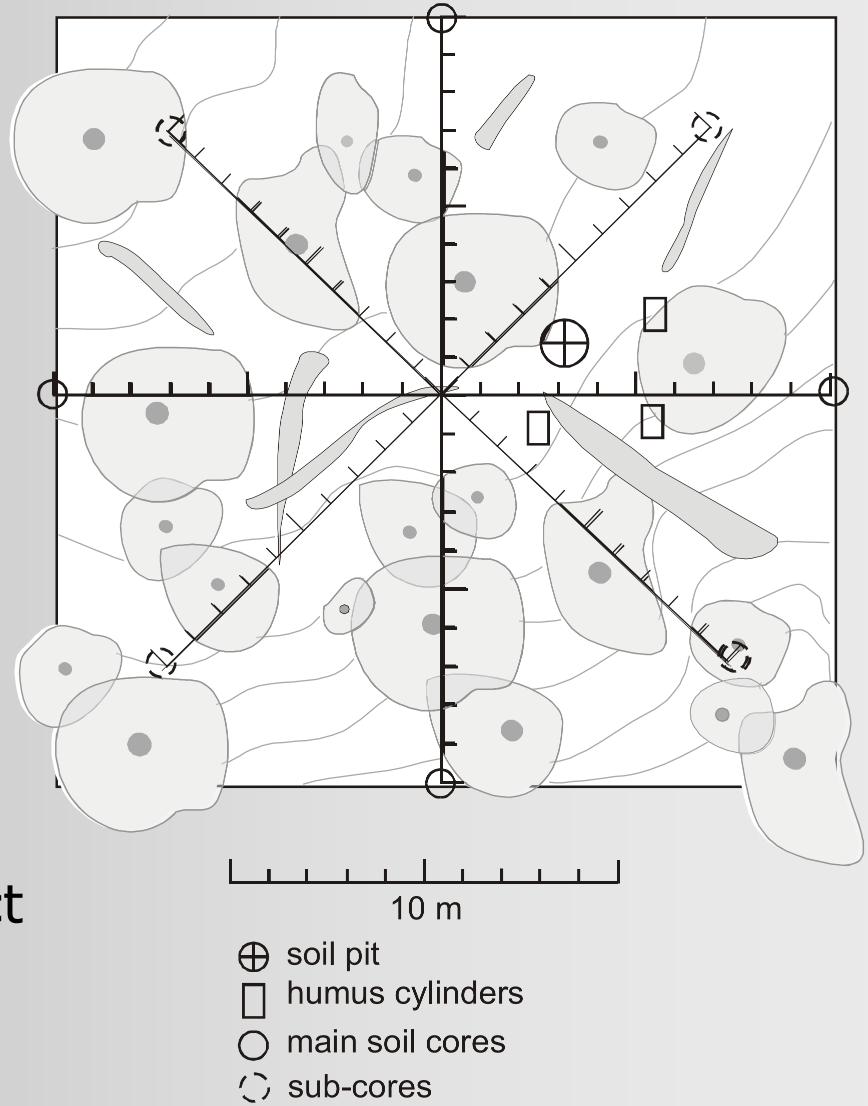
Example: representative, plot level sampling design

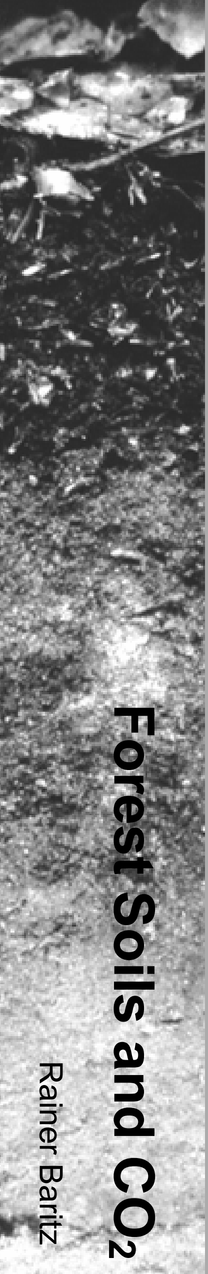


Baritz (2003, unpublished)

Spatial variability in 10m transect

Corg [wet oxidation], H horizon





➢ Climate change

Temperature: increase by 1.4 to 5.8°C until 2100

Soil moisture: increase of weather extremes (summer drought, floods, fire)

CO_2 (atmosphere): 540 to 970 ppm until 2100

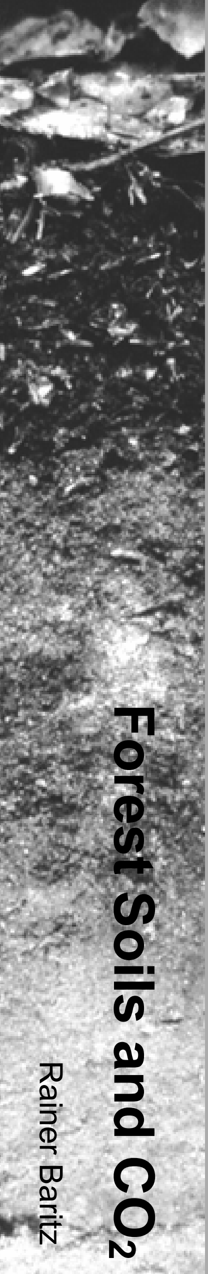
Calamities

Disturbance

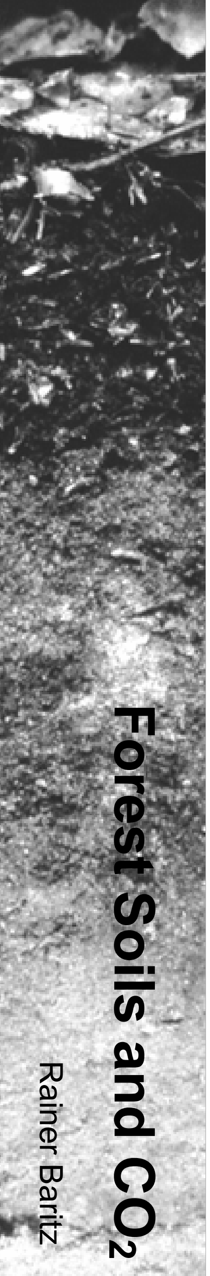
Management change

Change of deposition regime

Almost all drivers of the C and N cycle are expected to change!



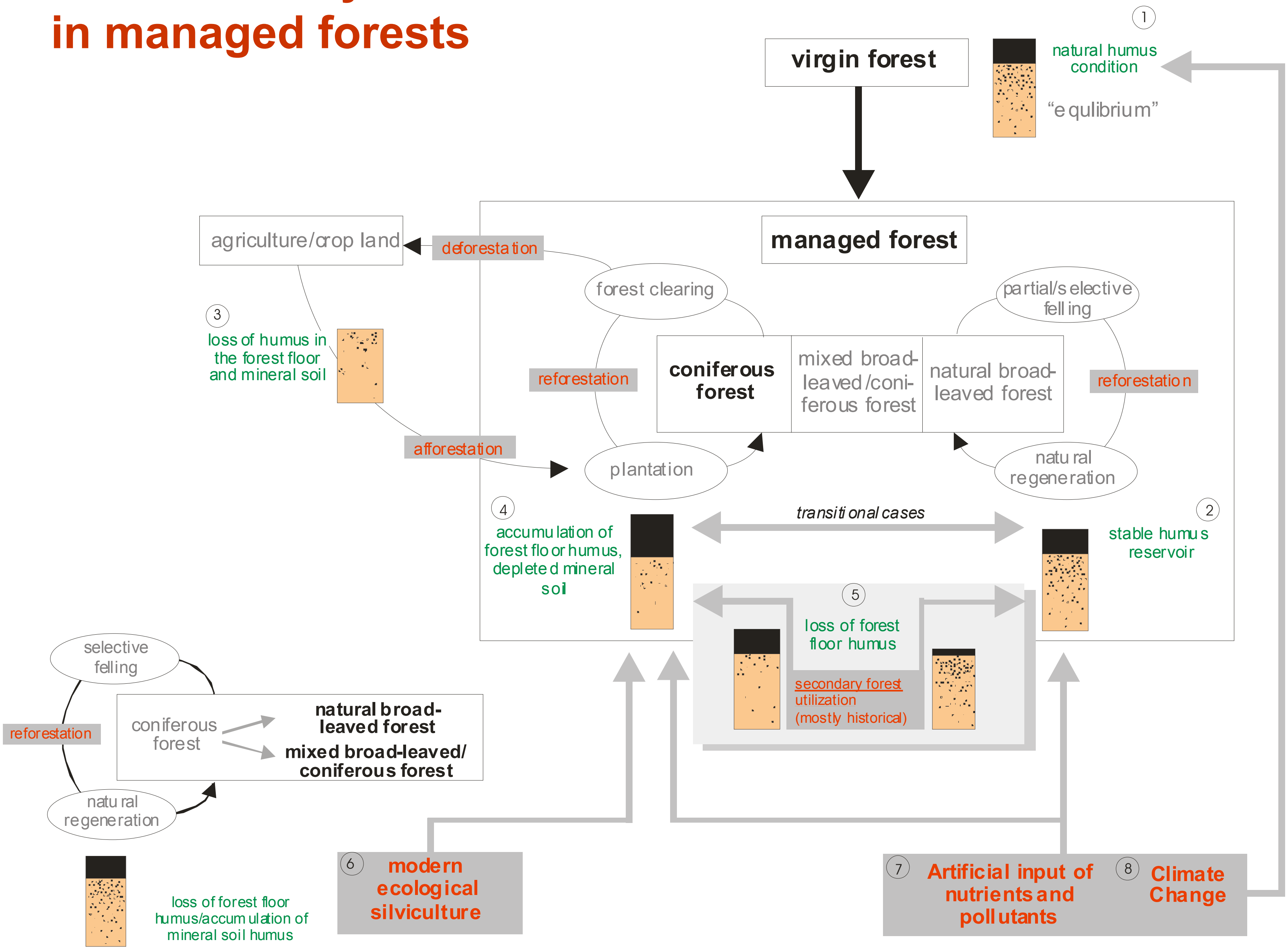
Forest Management



Forest Soils and CO_2

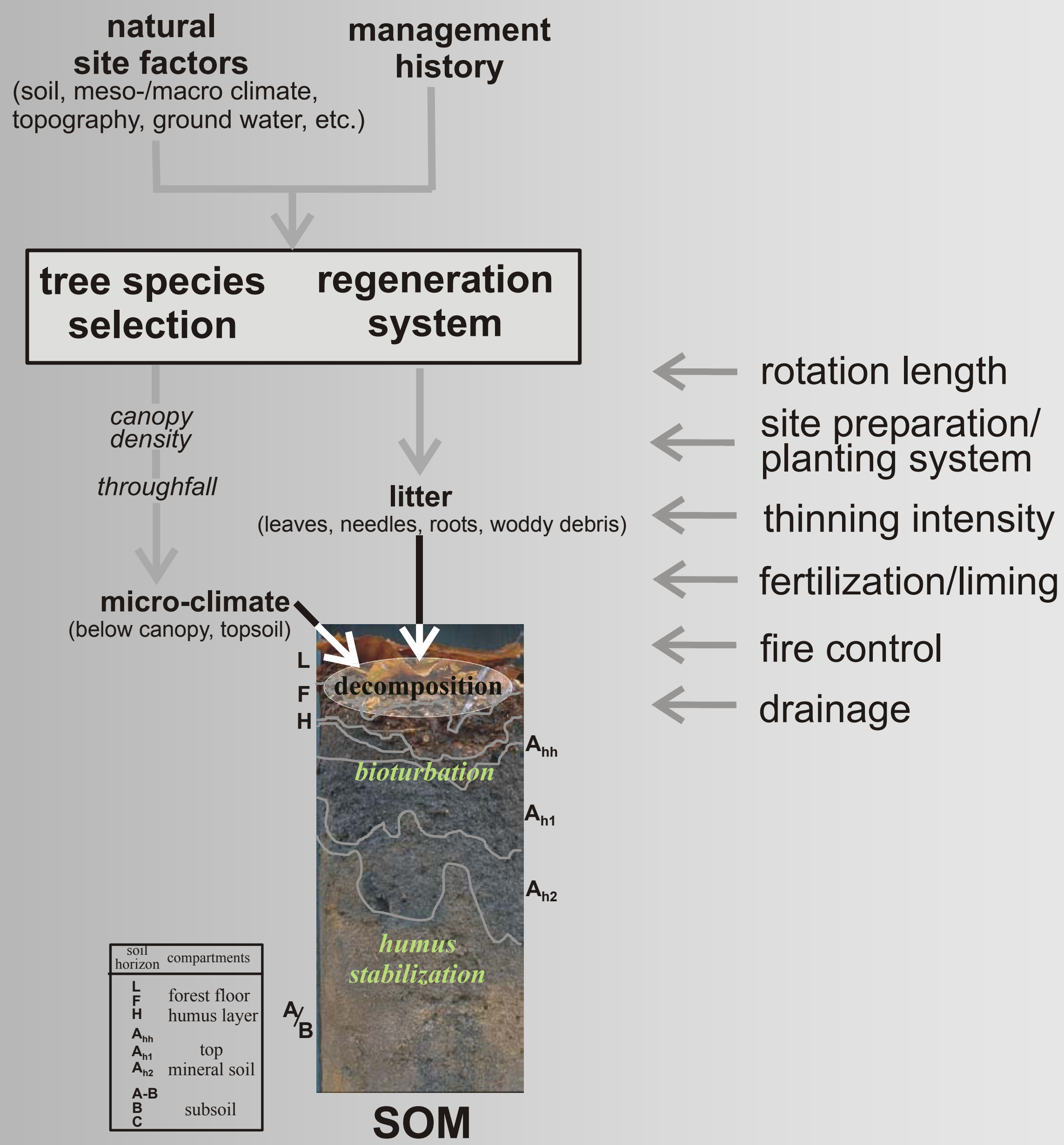
Rainer Baritz

➢ Soil carbon dynamics in managed forests



BGR

➢ Management Types: TWG SOM



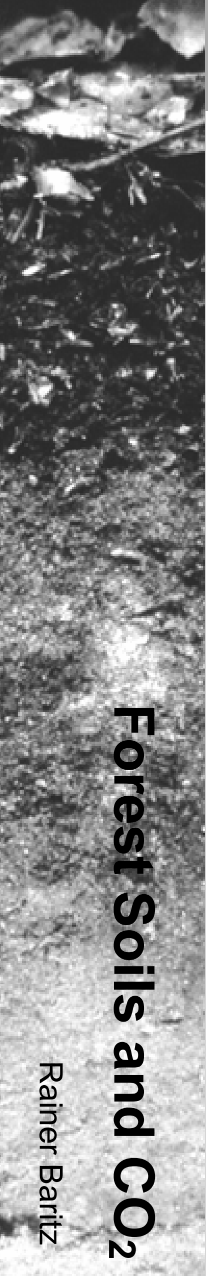
Forest Soils and CO_2

Rainer Baritz

BGR

Bordeaux, 2004

➢ Management Types: TWG SOM



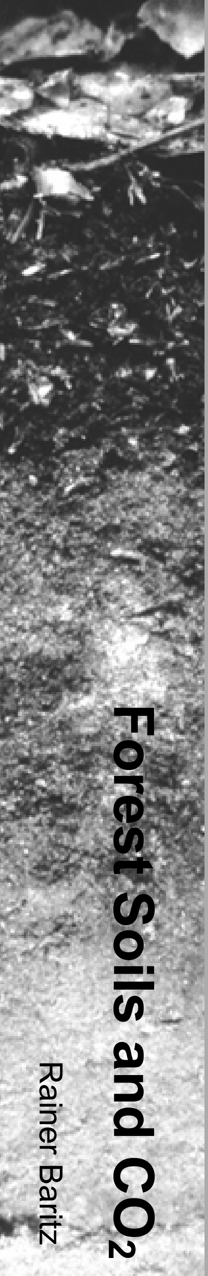
	SOM content	Bio-diversity	Farm economy	N_2O emission
Land use change				
arable – permanent pasture	+	+ (1)	–	+
permanent pasture – arable	–	– (1)	+	–
arable – forest *incl. bioenergy crops*	+	+	–	–
forest – arable	–	–	+	+
set aside (*natural revegetation*)	+	+	*subsidized*	–
Agricultural land use practices				
pasture: grazing intensity ↑	+/–	–	+	+
pasture: grazing – mowing	–	?	+ ?	-
mineral fertilization	+?	–	+	+
organic fertilization	+	+	+	+
conservation tillage	+	+	??	+
maximise soil cover (*green manure*)	+	+	+	?
maximise use of crop residues	+	+	+	+
irrigation	*effects are highly variable: soil type, crop, degree of salinisation, sensitivity to erosion and compaction*			
organic farming	+	+	(2)	
decrease drainage	+	+	–	– (–?) (3)
buffer strips	+	+	–	–
peatland management	*effects mostly relate to the regulation of drainage*			
Forestry				
forest preservation	+	+ +	–	0
natural regeneration	+	+	+	0
plantation forestry	(–)	(+)	+ +	(–)

(1) Depending on intensity of pasture management

(2) Depending on degree of internalization of all costs for all farming systems

(3) Effects on CH_4 also need to be considered

BGR



Conclusions

Data basis

- not representative
- soil inventory do not meet model (and C and N cycle) requirements
- Long term measurements and higher amount of trace gas measurements needed
- high systematic error
- models do not sufficiently account vertical C „re-“distribution

Research

- soil inventory and flux research insufficiently coupled (→ cooperate with CarboData platform)
- enourmous amount of domestic and international research
- policy demand clearly formulated
- careful site description/management type/historical land use required for every research plot!
- Improved descrition of humus type and soil water regime needed as well

BGR