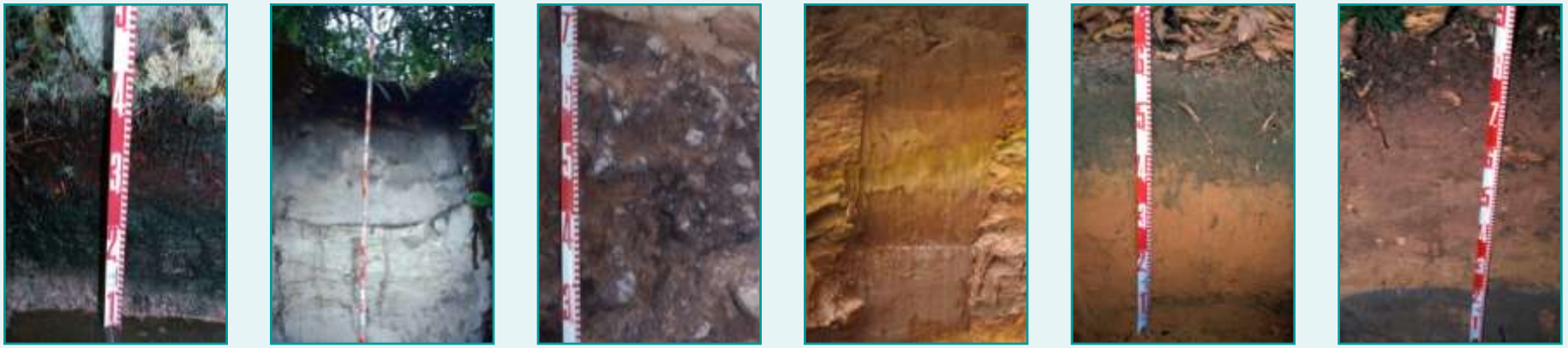
# Accounting for Soil Organic Carbon (SOC) under the IPCC Guidelines

## - Practical Sampling Approaches -



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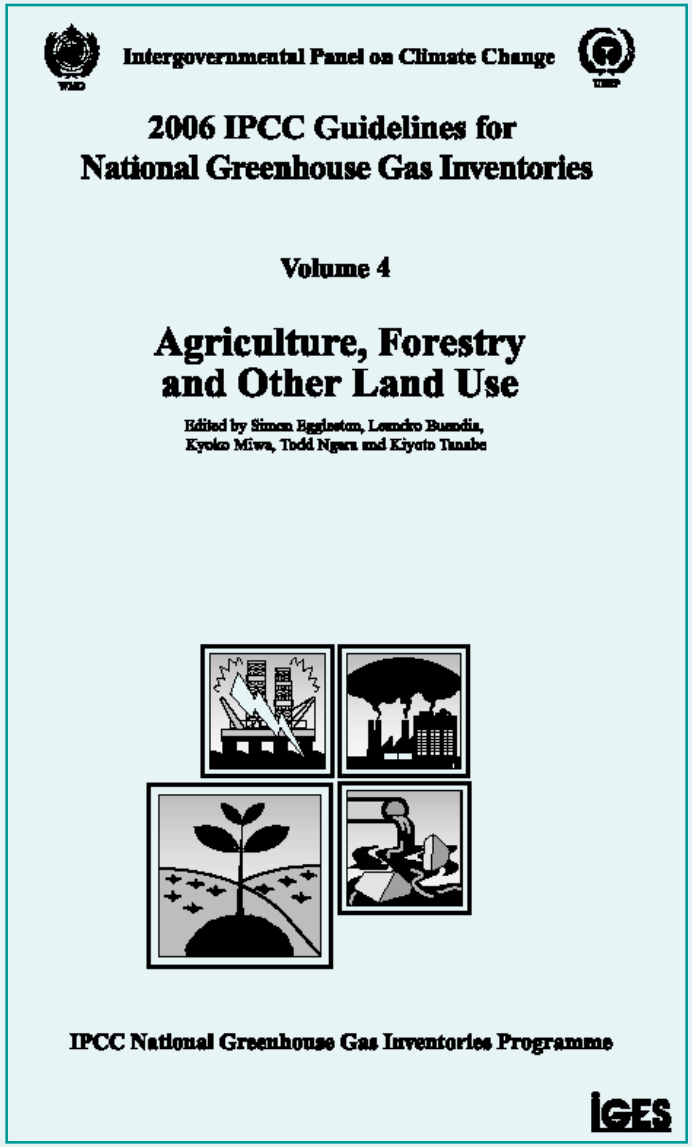
# Background

- Globally, mineral forest soils contain approx. 700 billion tons of carbon.
- SOC of mineral forest soils (0-1 m) varies between 20 and 300 t $ha^{-1}$, depending on forest type and climatic condition.
- Roughly 50% of that is contained in the upper 30 cm of the soil profiles.
  - Because in forest soils the highest input is from above-ground litter, soil organic matter tends to concentrate in the upper soil horizons.
  - Carbon held in the upper profile is often the most chemically decomposable, and the most directly exposed to natural and anthropogenic disturbances.

# Background

*'2006 IPCC Guidelines for National Greenhouse Gas Inventories'*

- Allow for accounting changes in soil carbon pools from land use conversion (e.g. forest → grassland);
- Or also within the same land use type (e.g. forest → managed forest).
- If no national soil inventory data exist, the simplest approach will be taken based on widely accessible, yet coarsely resolved input data (e.g. soil type, climate regions, LU classification) and default values...



# Requirements

- Tabled values for SOC pools in the default depth of 0-30 cm include under forest of tropical wet climate:
  - 44 t $ha^{-1}$ for HAC soils (e.g. cambisol)
  - 60 t $ha^{-1}$ for LAC soils (e.g. ultisol)
  - 66 t $ha^{-1}$ for sandy soils

  → very roughly and conservatively calculated

**TABLE 2.2**
**TIER 1 DEFAULT VALUES FOR LITTER AND DEAD WOOD CARBON STOCKS**

| Climate | Forest type | | | |
|---|---|---|---|---|
| | Broadleaf deciduous | Needleleaf evergreen | Broadleaf deciduous | Needleleaf evergreen |
| | Litter carbon stocks of mature forests | | Dead wood carbon stocks of mature forests | |
| | (tonnes C $ha^{-1}$) | | (tonnes C $ha^{-1}$) | |
| Boreal, dry | 25 (10 - 58) | 31 (6 - 86) | n.a.[b] | n.a |
| Boreal, moist | 39 (11 - 117) | 55 (7 - 123) | n.a | n.a |
| Cold Temperate, dry | 28 (23 - 33)[a] | 27 (17 - 42)[a] | n.a | n.a |
| Cold temperate, moist | 16 (5 - 31)[a] | 26 (10 - 48)[a] | n.a | n.a |
| Warm Temperate, dry | 28.2 (23.4 - 33.0)[a] | 20.3 (17.3 - 21.1)[a] | n.a | n.a |
| Warm temperate, moist | 13 (2 - 31)[a] | 22 (6 - 42)[a] | n.a | n.a |
| Subtropical | 2.8 (2 - 3) | 4.1 | n.a | n.a |
| Tropical | 2.1 (1 - 3) | 5.2 | n.a | n.a |

Source:

Litter: Note that these values do not include fine woody debris. Siltanen *et al.*, 1997; and Smith and Heath, 2001; Tremblay *et al.*, 2002; and Vogt *et al.*,1996, converted from mass to carbon by multiplying by conversion factor of 0.37 (Smith and Heath, 2001).

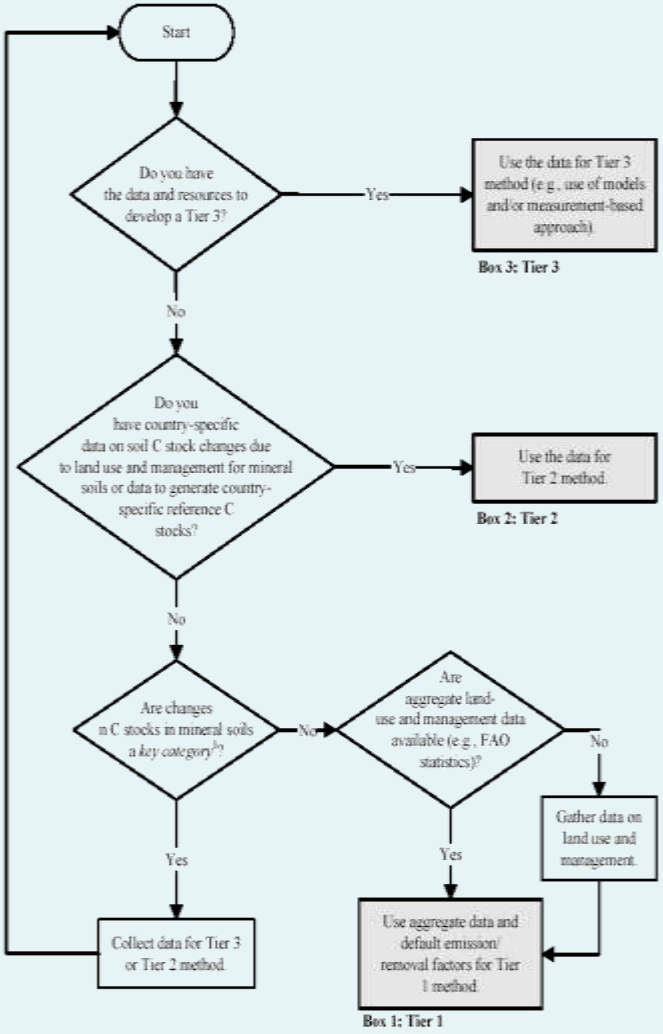
Dead Wood: No regional estimates of dead wood pools are currently available – see text for further comments

[a] Values in parentheses marked by superscript "a" are the 5th and 95th percentiles from simulations of inventory plots, while those without superscript "a" indicate the entire range.

[b] n.a. denotes 'not available'

# Requirements

- More detailed and more country-specific accounting is possible with tier 2 and 3 approaches.
- Consistent inventories are required representing all land use (forest) types, climatic zones and edaphic regions depending on the tier chosen.
- Relevant *IPCC Guidelines* chapters:
  - 1.3.3 Identification of key categories
  - 2.3.3 Change in carbon stocks in soils
  - 4.2.3 Soil carbon (Forest land remaining forest land)



# First Steps

*Gathering already available reference data on:*

- Forest types and forest structure (inventories)
- Land use history
- Establish comparisons between managed and unmanaged sites of the same forest type, ideally under comparable edaphic conditions.

  → should be already available.

- Amend these data with appropriate (repeated) soil inventories on the respective monitoring sites.

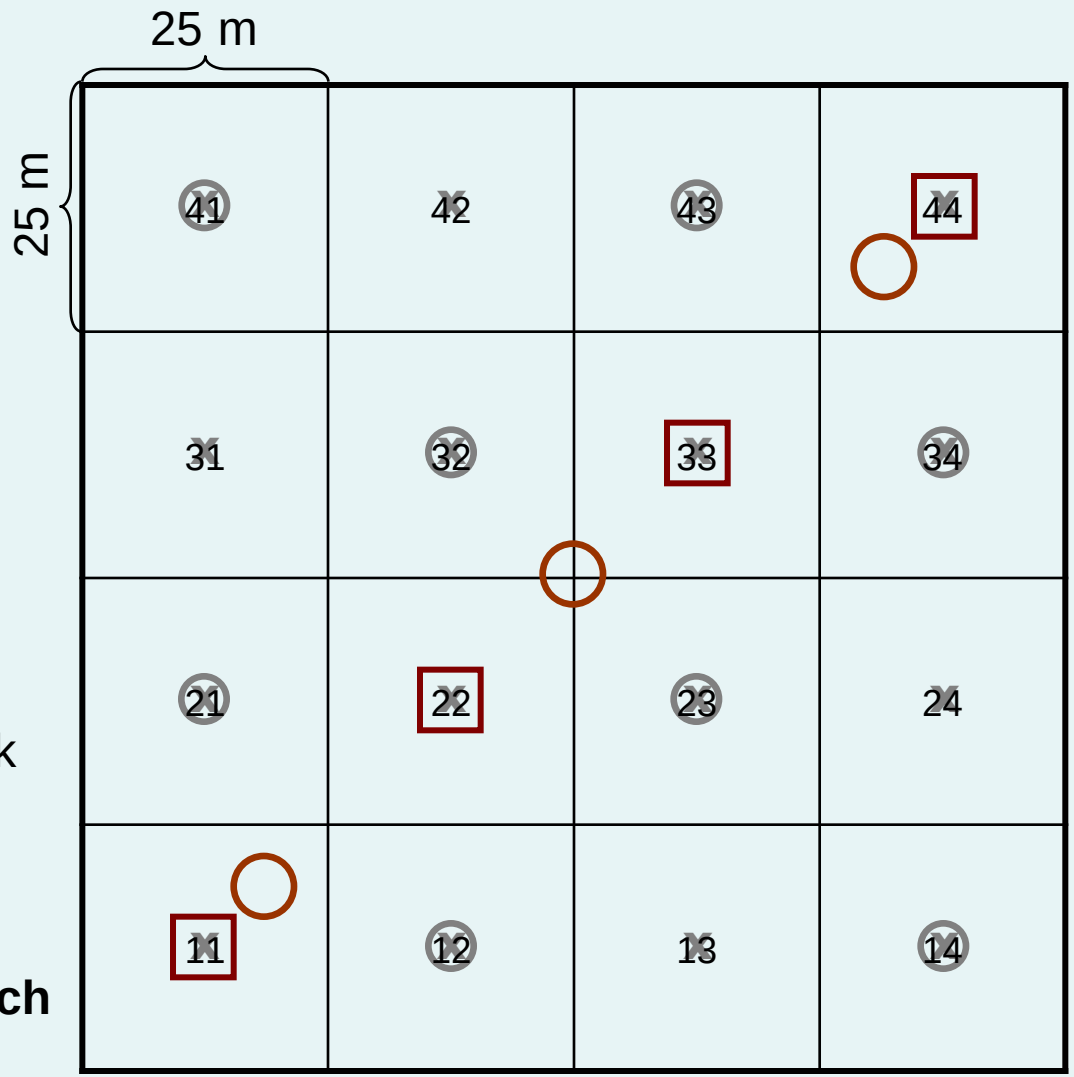
# Sampling Scheme

x **Maximum approach**
(Easy-to-sample soils)
→ 16 samples

⊗ **Reduced approach**
(Badly coreable soils)
→ 8 samples

□ **Soil pit approach**
(Soils with substantial rock content)
→ 4 samples

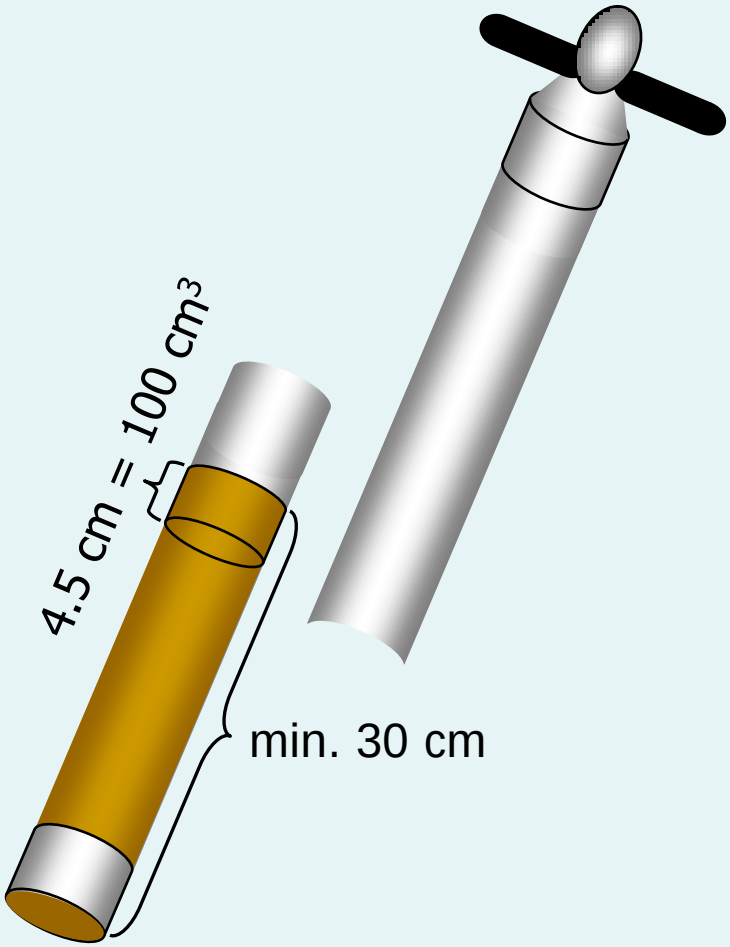
○ **Reduced soil pit approach**
→ 3 samples



# Soil Sampling

**Soil Coring (Split-tube sampler)**

- Where soil is soft and void of large rocks.
- Desired soil depth increments:
  0-5, 5-10, 10-20, 20-30 cm
- Thick fine root layers could be challenging
- Representative proportions of 100 $cm^3$ can be obtained and used for bulk density measurements prior to analysis.
  - Kindly cross check core lengths with hole depth to account for compression!
  - Collect samples from the bottom up!

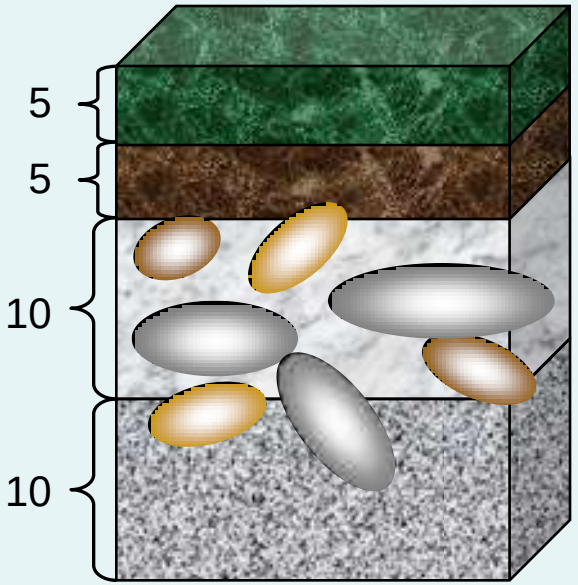


# Soil Sampling

## Soil Pit Sampling

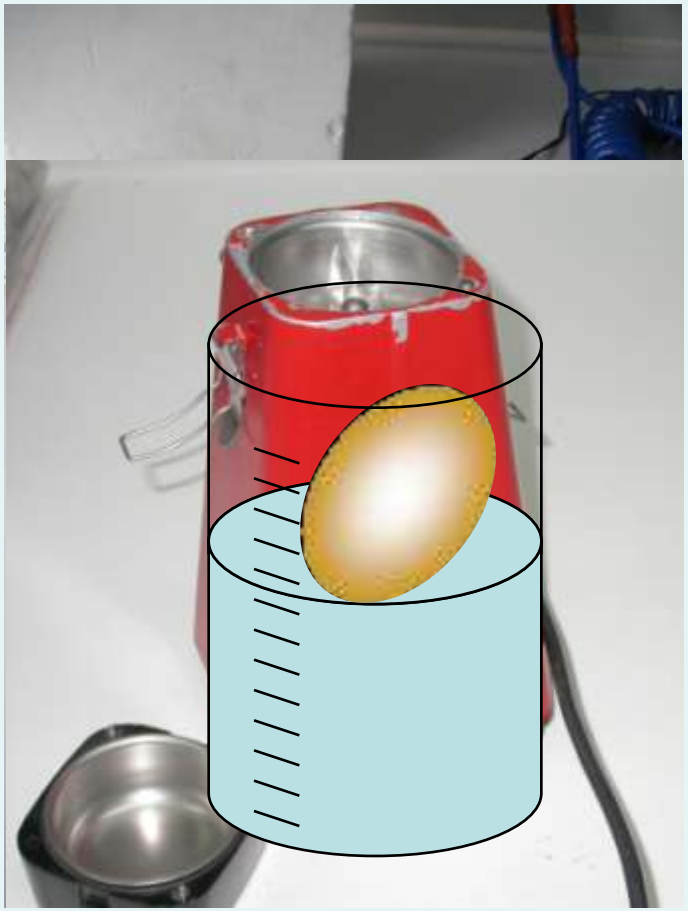
- Where large rock volumes prohibit coring or do not account sufficiently for stone volume.
- Desired soil depth increments:

  0-5, 5-10, 10-20, 20-30 cm
- Carefully collect all rocks (> 2 mm) and coarse roots from each depth increment of 30 x 30 cm area into a plastic bag.
- Perform sampling of fine soil and bulk density separately alongside the profile.



# Soil Processing - PNG

- Oven drying of all mineral and organic material at 40 °C
- Weighing of samples for bulk density determination
- Sieving for fine earth fraction (< 2 mm) to obtain 50 g dry mineral fine earth
- Grinding of dried litter material (Obtained from 30 x 30 cm area per sample site)
- Determination of rock volume per depth increment after wet sieving of material using the displacement technique.



# Lab Analysis - Germany

- Grinding of mineral soil
- $H_2O$-content determination at 105 °C
- Weighing of subsamples for analysis
- Analysis of C and N content in the CN-Analyzer



# Conclusions

- Soil inventory is necessary for SOC accounting under the IPCC Guidelines and will be worth it for considering true values rather than very conservative default values.
- Sampling schemes should be standardized nationwide to safeguard consistency of the results.
- Taking into account the high variation of natural conditions at least a stratified approach (cf. 'tier' approach under the IPCC) should be adopted.
- A responsible and careful sampling and the diligent pre-processing of the samples as well as a through documentation will guarantee reliable results.

# Outlook

**Litter and coarse woody debris**

- Litter is defined in the IPCC guidelines as wooden material > 2 mm.
- Coarse woody debris is commonly considered dead wood > 7 cm in diameter.
- Both carbon stocks may be accounted for under the IPCC guidelines but only very little scientific data hampered the development of robust tabled values.
- There is a great potential in investigating also those carbon pools and accounting for them nation-specific on the basis solid data.

# Let's get started...

# Thank You for Your Attention

