European forestry research and the challenge of the global change

proposed new forest function and practise

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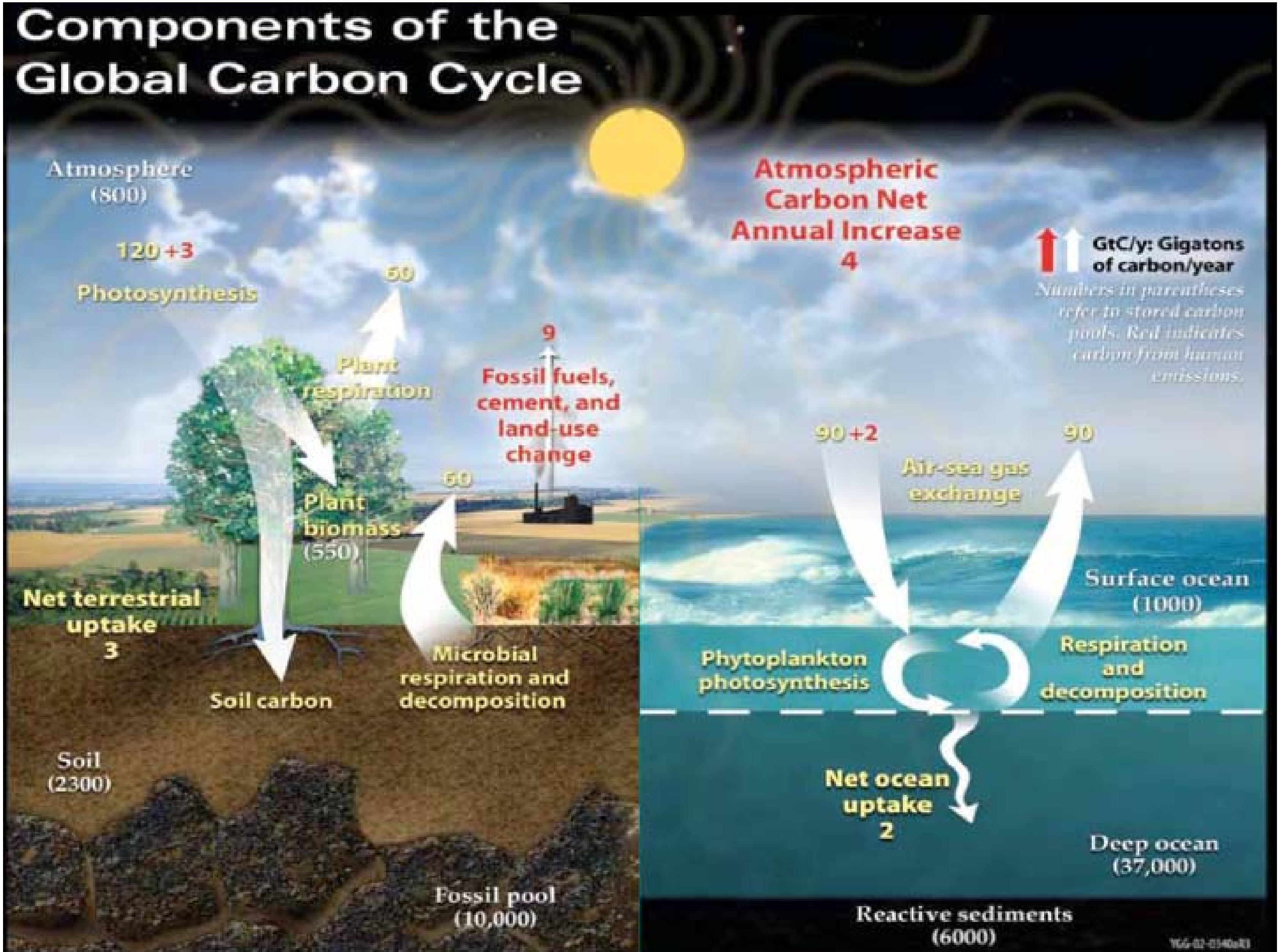
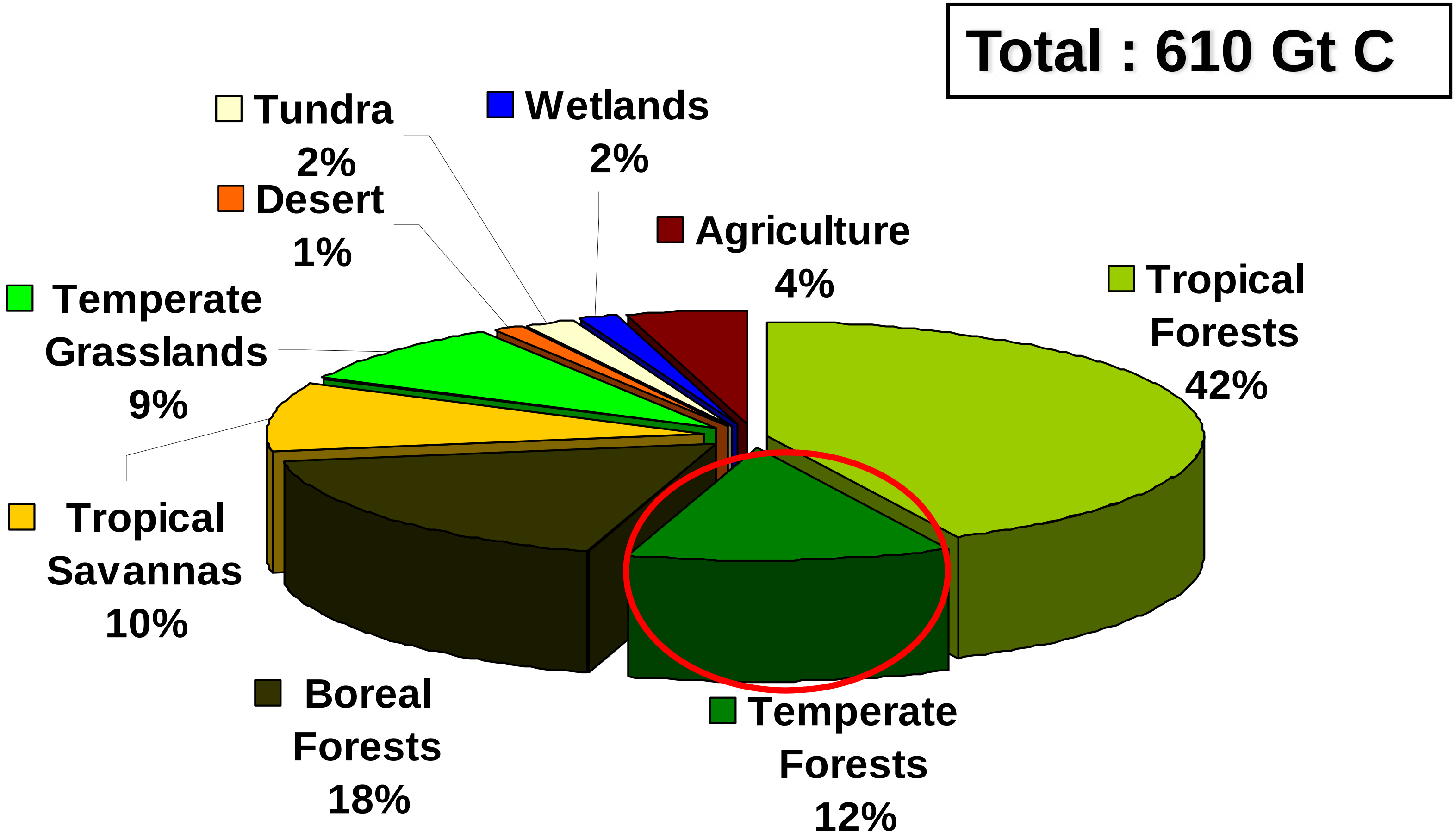
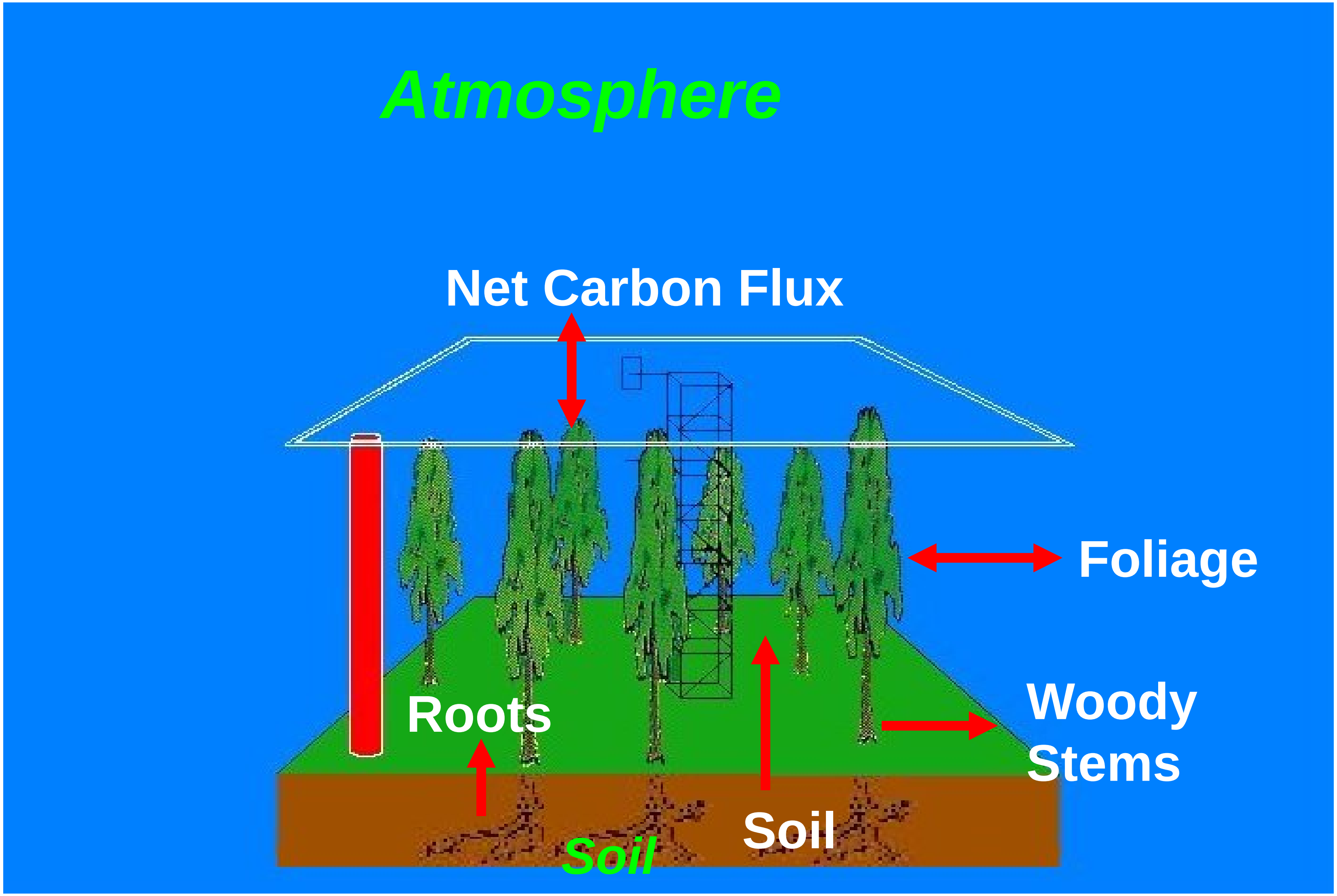

Components of the Global Carbon Cycle
Atmosphere
(800)
120 +3
Photosynthesis
60
Plant respiration
9
Fossil fuels, cement, and land-use change
Atmospheric Carbon Net Annual Increase
4
GtC/y: Gigatons of carbon/year
Numbers in parentheses refer to stored carbon pools. Red indicates carbon from human emissions.
90 +2
90
Air-sea gas exchange
60
Plant biomass
(550)
Net terrestrial uptake
3
Surface ocean
(1000)
Phytoplankton photosynthesis
Respiration and decomposition
Microbial respiration and decomposition
Soil carbon
Soil
(2300)
Net ocean uptake
2
Deep ocean
(37,000)
Fossil pool
(10,000)
Reactive sediments
(6000)

Carbon Stocks : Terrestrial Vegetation

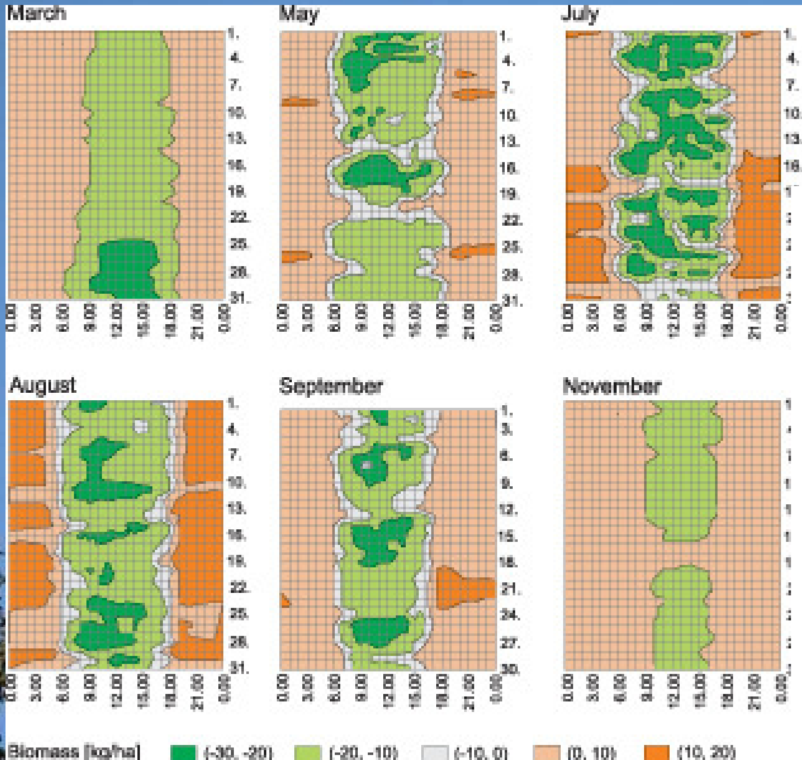


Source: Dixon et al. 1994, Schlesinger 1998

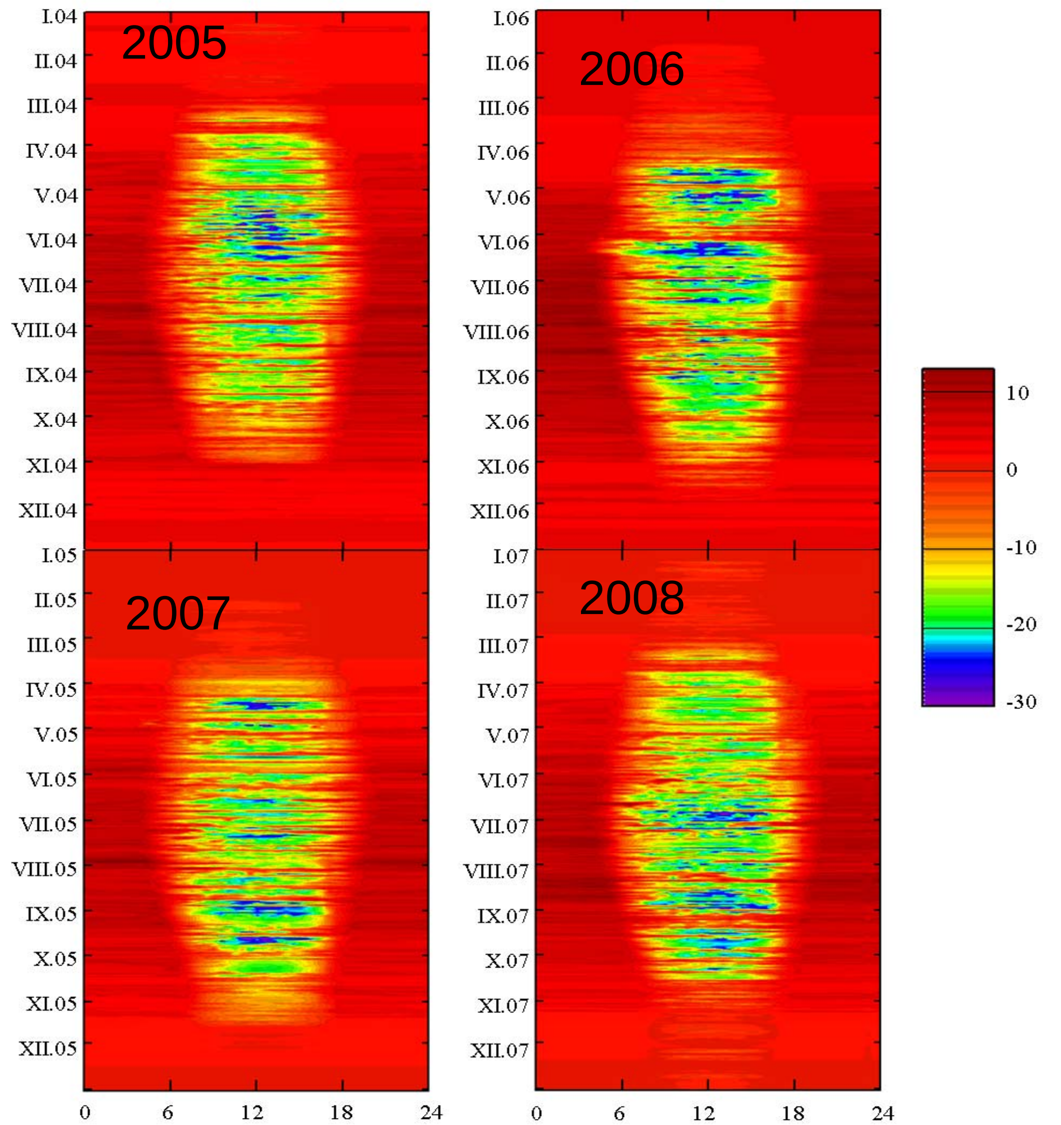
Forests at the interface

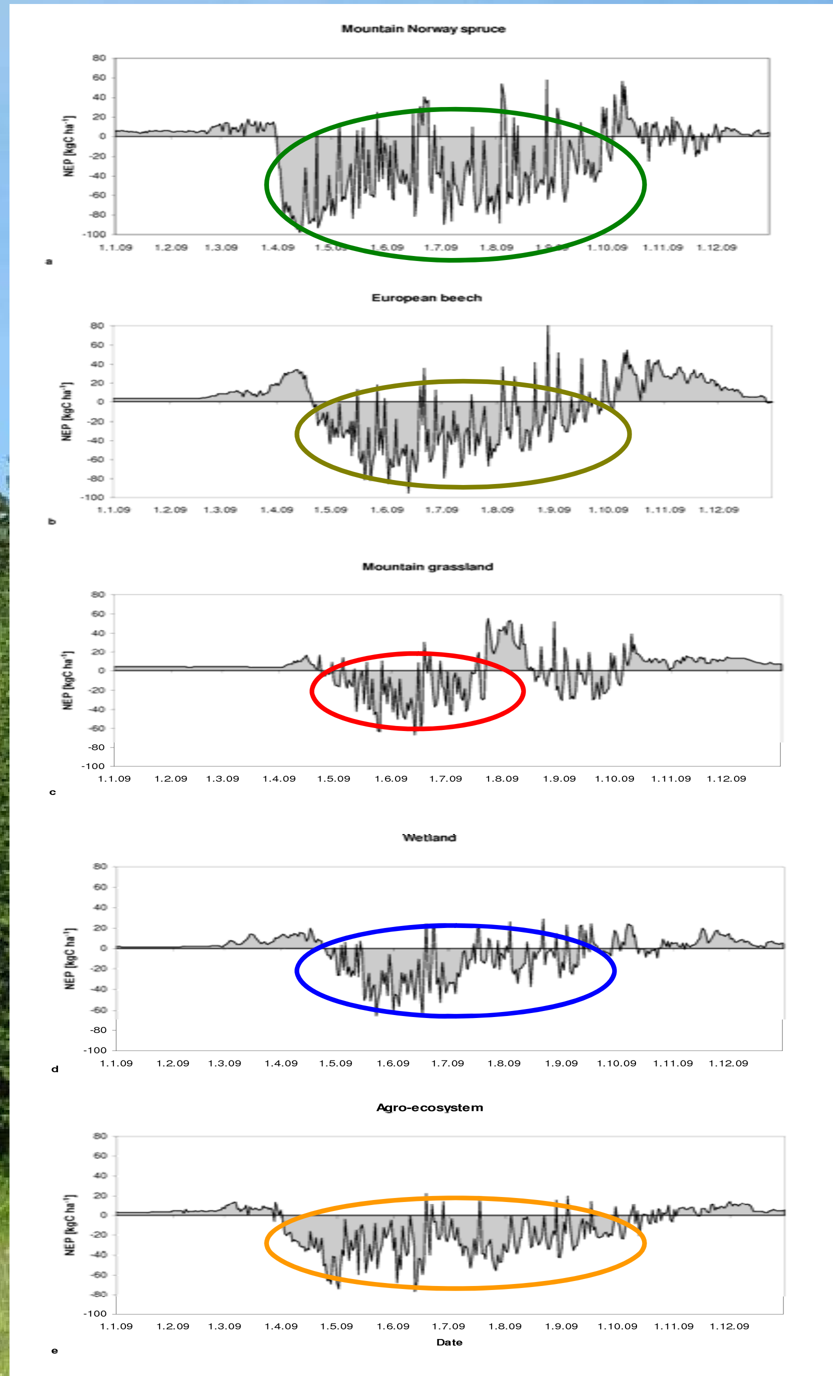


Seasonal course 2006



Inter-seasonal course





Mountain Norway spruce
NEP [kgC ha⁻¹]
a
European beech
NEP [kgC ha⁻¹]
b
Mountain grassland
NEP [kgC ha⁻¹]
c
Wetland
NEP [kgC ha⁻¹]
d
Agro-ecosystem
NEP [kgC ha⁻¹]
1.1.09 1.2.09 1.3.09 1.4.09 1.5.09 1.6.09 1.7.09 1.8.09 1.9.09 1.10.09 1.11.09 1.12.09
Date
e

Carbon Forestry

Manage our forests to conserve and enhance their carbon content

-- consistent with the provision of other goods and services, *e.g*., timber production, biodiversity conservation…

How to do this?

Minimize carbon losses

Maximize carbon gain

Substitute for fossil fuels

--- through the management cycle!

The basic duty of the Carbon forestry

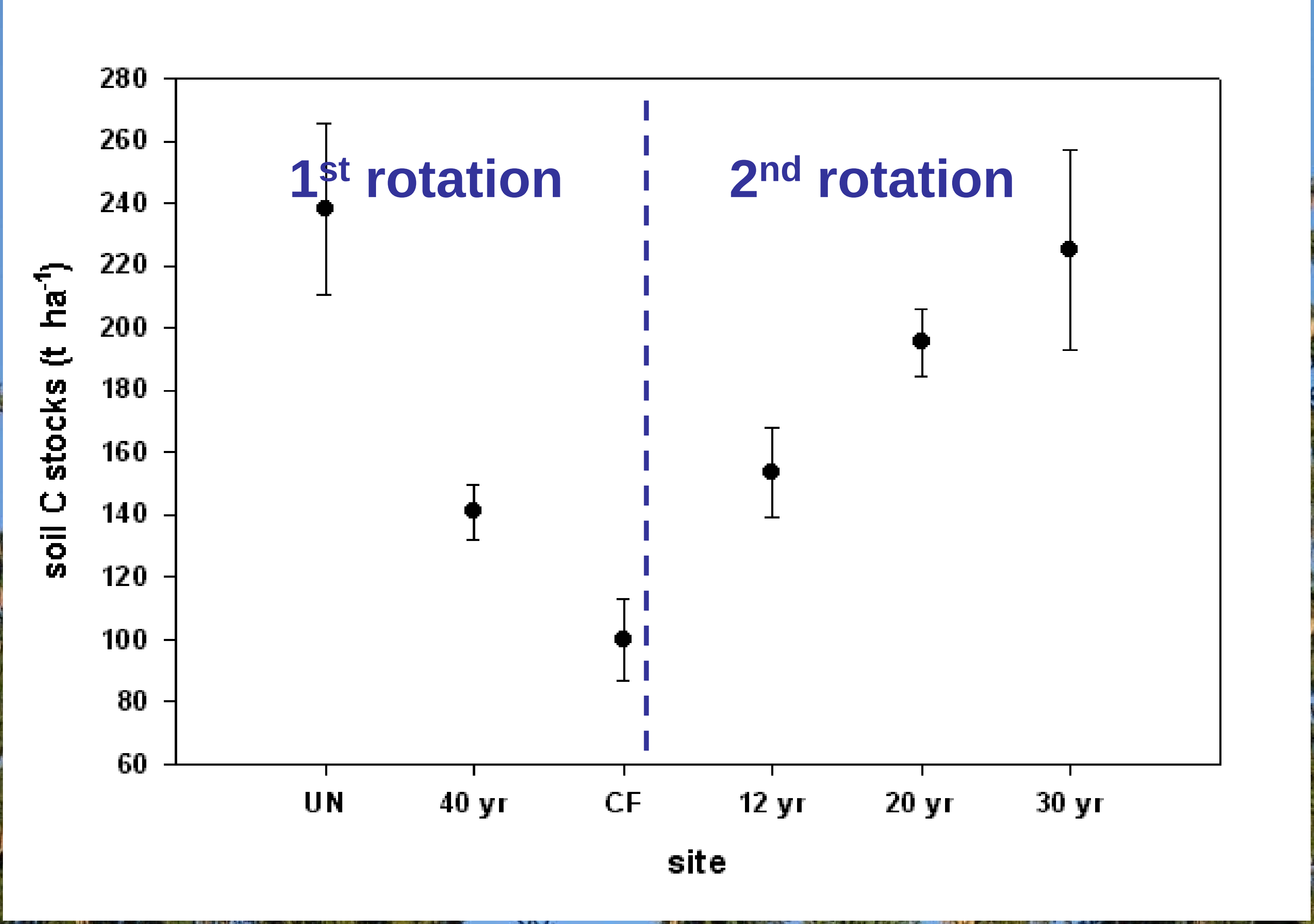
To minimise carbon losses

To maximise carbon gain

Impacts of forest management on carbon fluxes and stocks

- Site preparation and planting
- Thinning
- Harvest

Change in soil carbon stocks – *Sitka spruce*



Conclusions:

- intuitively important soil C losses, that depend on the land use history of the site, e.g., first, second rotation …, and planting methodology;

- quantitative information on soil CO_2 emissions and removals during rotations only just becoming available -- much more needed!!

Impacts of forest management on carbon fluxes and stocks

- Site preparation and planting
- Thinning
- Harvest

Effects of Different Thinning Scenarios on Production Processes

SCEN	APAR	GPR	NPR	RFR	**LAI** reduction /pattern
2	0.83	0.81	0.88	0.66	1/3 regular in rows
3	0.89	0.87	0.96	0.67	1/3 selective
4	0.77	0.75	0.86	0.51	1/2 regular in rows
5	0.53	0.48	0.59	0.25	3/4 regular respacing
6	0.01	0.01	0.01	0.00	solitary tree
7	0.79	0.77	0.86	0.57	11/25, 1/5 in rows + random
8	0.78	0.76	0.86	0.55	11/25, 1/5 in rows + regular

Fractional reduction in fluxes ***relative*** to scenario 1 (unthinned)

APAR absorbed PAR **GPR** gross photosynthetic rate

NPR net photosynthetic rate **RFR** foliage respiration rate

Conclusions from the model experiment

• Thinning intensity and design affects carbon uptake of the remaining trees in a *non-linear* manner.

• The main determinant is stand density (i.e., *LAI*); the second is spatial heterogeneity of the leaf area density (*LAD*) (i.e., grouping of leaves into shoots, shoots into branches and branches into crowns).

• A very substantial reduction of CO_2 uptake can be expected with LAI reductions larger than 50 %.

• Recovery to maximum CO_2 uptake may take from 3 to 15 years, depending on age at the time of thinning and reduction in the number of trees.

• BUT as yet - We have little basis for *forecasting* the effects of thinning itself, or the machines used on the subsequent rates of soil respiration and CO_2 efflux *(now being measured)*.

Stand carbon stocks in (tonne (C)/ha):

- Before thinning
  - above ground 21
  - below ground 7.5
  - Total 28.5

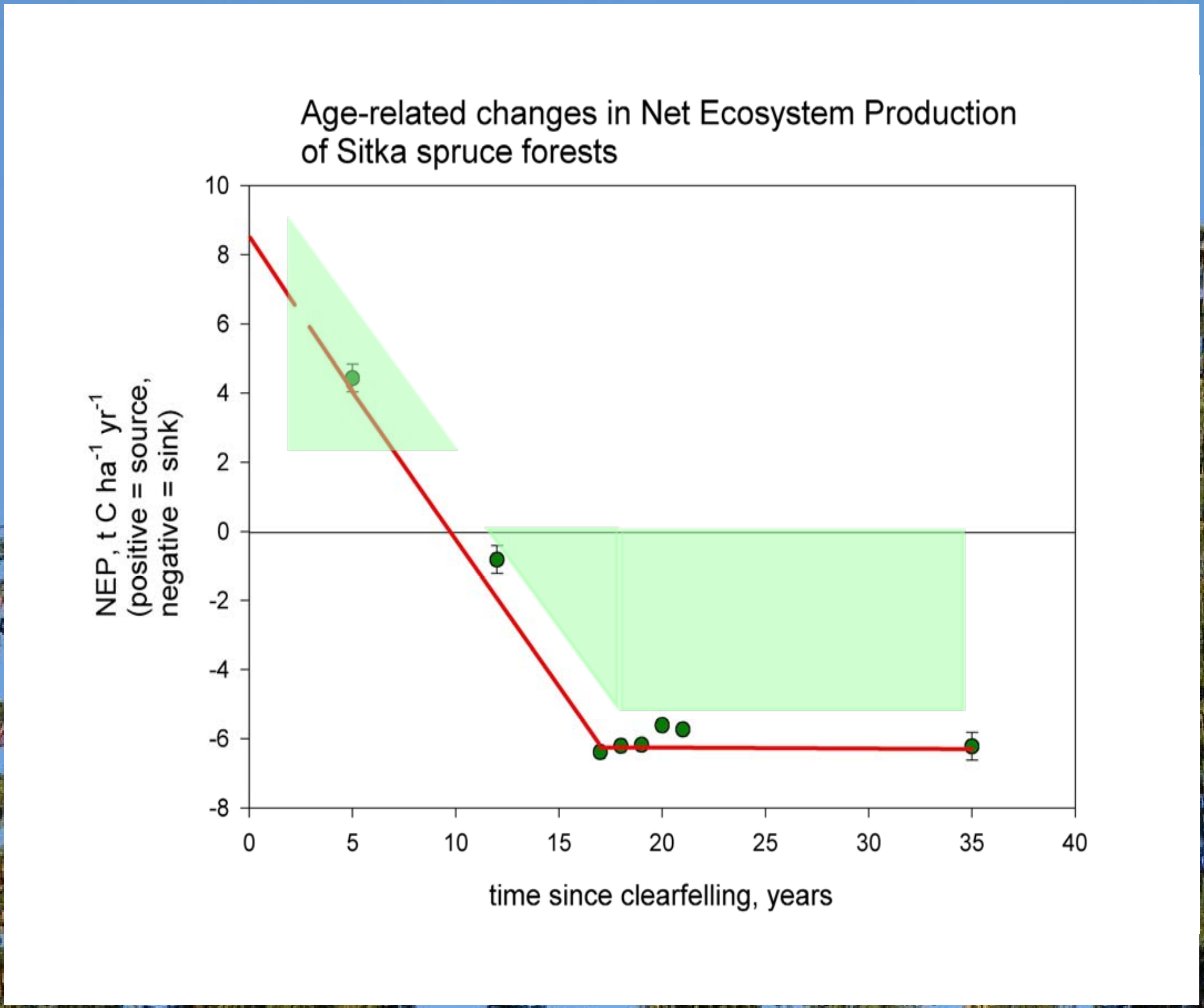
- After thinning
  - above ground 12
  - below ground 4
  - Total 16

- Amounts of C transferred instantly:
  - logs to saw and pulp mills 8
  - leaves, branches and top to the forest floor 2
  - roots and stumps to the soil compartment 2.5
  - Total 12.5

Impacts of forest management on carbon fluxes and stocks

- Site preparation and planting
- Thinning
- Harvest

NEE: net C fluxes over one rotation; spruce on a peaty gley (1st rotation)



To maximize carbon gain

- develop a carbon-based silvicultural system
- fertilize (but be wary for N_2O emissions)
- irrigate in Mediterranean and savannah climates
- drain in North temperate climates (but be wary for enhanced CO_2 emissions)
- retain CWD and windthrow on the forest floor and assist its transfer to the soil compartment
- encourage natural regeneration

To minimize carbon losses

- modify site preparation – ploughing, mounding, burning etc.,
- reduce disturbance of soil carbon by heavy machines by use of *brashmats*,
- conserve thinnings, lop & top and harvest residues by distributing them on site so that they are reincorporated,
- or use them as biofuel for energy substitution.

Brash mats have been shown to be very important for retention of soil structure, but their effects on CO_2 emissions have still to be demonstrated.

Carbon Forestry

Manage to conserve carbon, as well as to provide other services

Minimize carbon losses

- modify site preparation - ploughing, mounding, burning etc.
- protect soil carbon from heavy machines with brashmats
- preserve thinnings, lop & top and harvest residues, or use for energy substitution

Maximize carbon gain

- develop a carbon based silvicultural system
- fertilze (but be wary for N_2O emissions)
- preserve windthrow (CWD), encourage natural regeneration

General Conclusions

1. Forest sinks account for close to 40% of fossil fuel emissions at present and this should be increased by new management strategies for forest and agricultural lands
2. As emissions continue to rise this proportion will inevitably decline and sinks will become less important
3. Soils and soil processes are very important components of forest sinks
4. The magnitude of sinks needs to be established across entire management cycles, including natural and managerial disturbance
5. Better knowledge of integrated C and N cycles in relation to sinks is urgently needed
6. Trace gas inventories (esp. N_2O) are needed if N-fertilizers are used to increase carbon sinks
7. Fully coupled GCM, C-cycle and N-cycle models with up to date representation of processes are needed for projections
8. Protection and enhancement of carbon sinks is a service that forests and agricultural lands can provide; we need a new-style ‘carbon forestry’ for this purpose

Thank You…