

## Monitoring carbon budgets

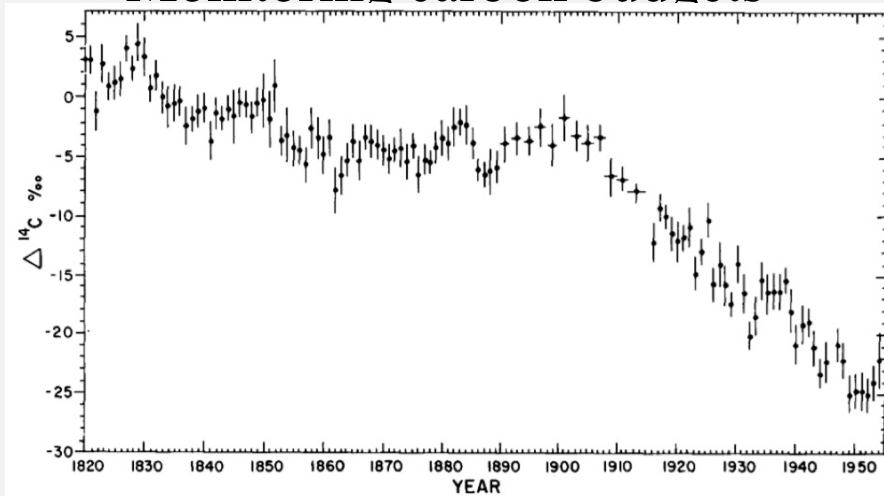
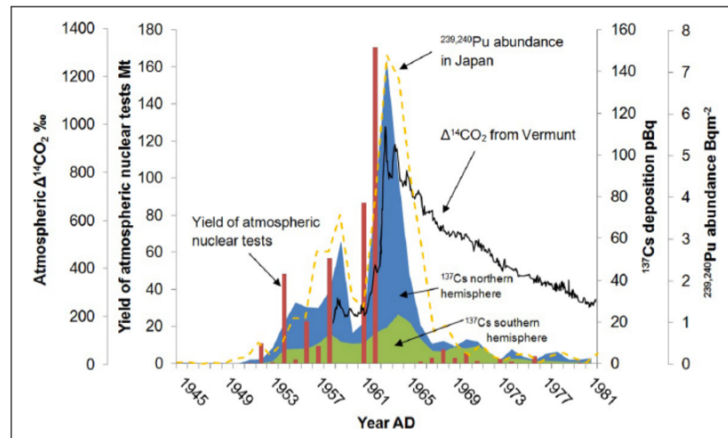
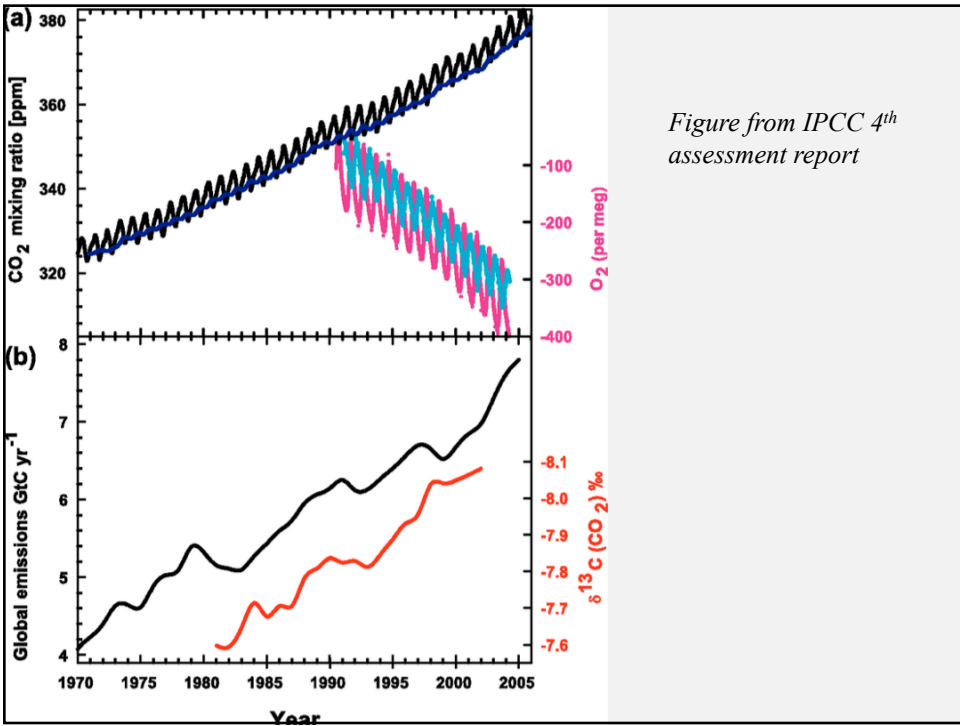
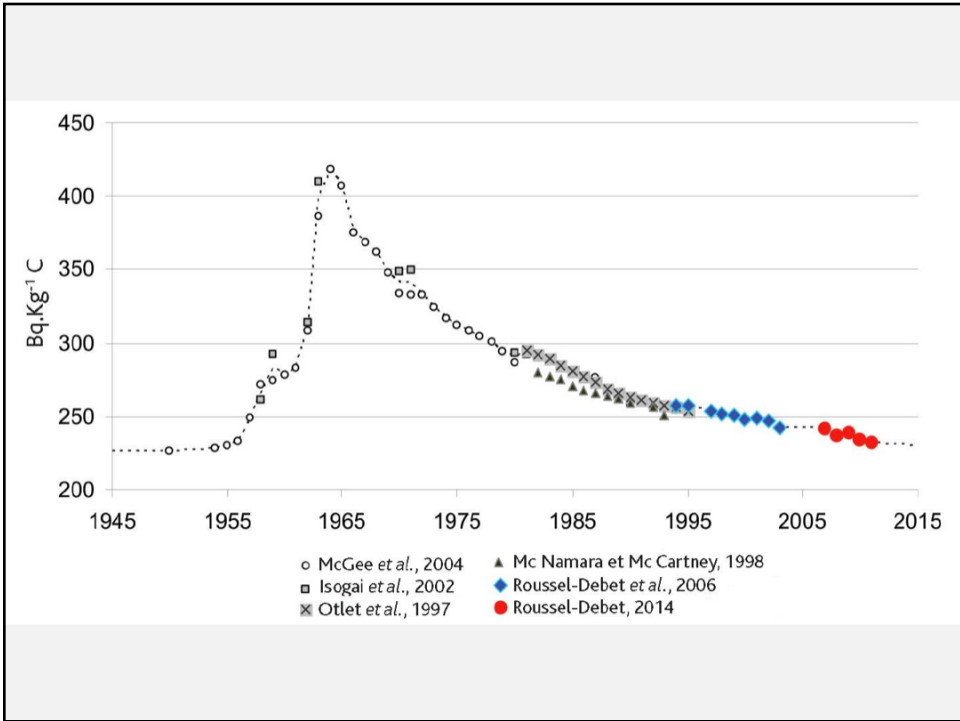


Fig. 2. Atmospheric  $\Delta^{14}\text{C}$  levels, derived from tree rings, between 1820 and 1954. Single-year determinations are given, except for the 1890–1915 interval (Table 1). The vertical bar denotes one standard deviation.  $\Delta^{14}\text{C}$  levels of the 1895–1915 interval probably give an upper limit only (see text).

Suess effect on  $^{14}\text{C}/^{12}\text{C}$  in  $\text{CO}_2$ ,  
*from Stuiver and Quay, 1981, EPSL 53:349-362*



**Figure 6.** Yield of atmospheric nuclear tests per year shown by bars (UNSCEAR, 2000),  $^{137}\text{Cs}$  deposition in Northern and Southern Hemispheres represented by areas (UNSCEAR, 2000),  $^{239,240}\text{Pu}$  deposition in Japan shown by the dashed line (Hirose et al., 2000) and  $\Delta^{14}\text{CO}_2$  measured at Vermont, Austria shown by the solid line (Levin et al., 1985). The yield of atmospheric nuclear tests in the atmosphere peaked in 1962.  $\Delta^{14}\text{CO}_2$  at Vermont,  $^{239,240}\text{Pu}$  in Japan and  $^{137}\text{Cs}$  deposition in the Northern Hemisphere peaked in 1963 and  $^{137}\text{Cs}$  in the Southern Hemisphere in 1964.



## Biogeochemical cycling (on land)

- Living tissue – C H O  
obtained from water and CO<sub>2</sub>
- P – ATP – energy transformations  
N – proteins  
K – cell activity & regulation  
N &/or P, K usually limit terrestrial productivity
- More than 20 other elements

## Nutrient Uptake

- Plants obtain essential elements from soil incorporate them into biochemical molecules (e.g., N from NO<sub>3</sub><sup>-</sup> incorporated into amino acids)
- plant roots get ions through several pathways
  - passive uptake - with water can be adequate
  - actively excluded - occurs w/abundant ions
  - active transport - uptake is enhanced by enzymes
  - apparent response - to increase the root/shoot ratio

## Nutrient Balance

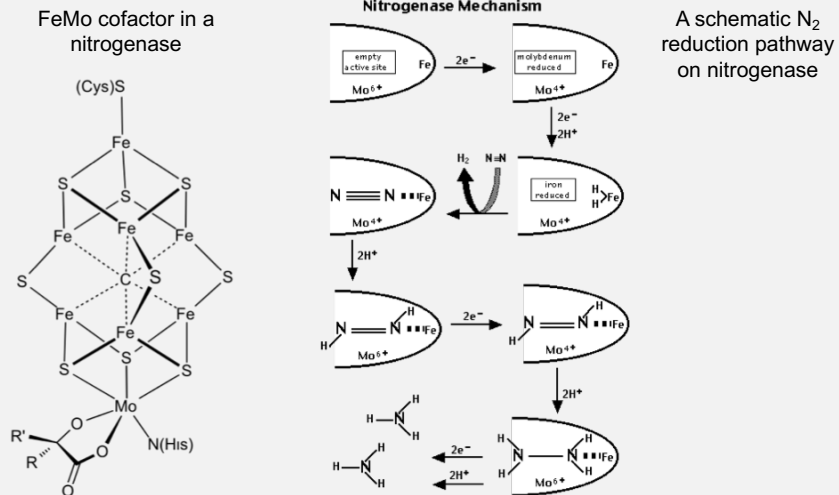
- adequate supply and balance of nutrients is necessary
- if nutrient levels ↓, plants grow slower
- plants have varying reactions to fertilizers -  
↑ N then concentrations of other nutrients may be inhibited or ↑ N enhances uptake of several other elements

## Nutrient Assimilation

- Earth atmosphere is almost 80% N<sub>2</sub>
- plants cannot assimilate N<sub>2</sub> into organic material
- terrestrial N fixers - soil bacteria and symbiotic root nodule bacteria; aquatic ecosystems – cyanobacteria

## Nitrogen fixation

Nitrogen fixation is a microbial (bacterial) process that converts  $N_2$  to a biologically useful form. The process is the subject of intense research interest, but is still not well understood at either the molecular or organismal level.



Bacteria convert  $NH_3$  (ammonia) to  $NO_2^-$  (nitrite) and  $NO_3^-$  (nitrate) = Nitrification

Ammonia is returned to the system by decomposition, plant refuse, leaf litter, corpses and feces

Roots absorb ammonia or nitrate which plants convert into organic forms such as amino acids and proteins (animals must obtain N in organic form by consuming plants or other animals)

Denitrifying bacteria convert nitrogenous minerals in soil to  $N_2$

## Nutrient Allocation and Cycling in Land Vegetation

- nutrients allocated to growth of new plant tissue – leaves and fine roots receive the largest proportion of the annual nutrient uptake
- nutrient concentrations in mature foliage are related to PS rates and plant growth – analysis of foliage is often used as an index of site fertility
- rainfall leaches nutrients from leaf surface and puts them back in soil– throughfall (cycles K) and stemflow
  - rate of nutrient loss affected by shape, surface texture, leaf age, surface area to volume ratio

- plant litterfall is the dominant pathway for nutrient return to the soil, especially N and P
- nutrients are accumulated most rapidly during the early development of forests and more slowly as the above ground biomass reaches a steady state
- Global pattern of C/N C/P N/P in vegetation is similar to biomass  
Tropical>Temperate>Boreal forests

## Biogeochemical Cycling in the Soil

- most of the annual nutrient requirement of land plants is supplied from the decomposition of dead materials in the soil
- main biogeochemical transformations in the soil are performed by fungi and bacteria whose biomass typically compose <3% of the organic carbon found in soils

1. nitrogen cycling – the mineralization of N from decomposing materials begins with the release of  $\text{NH}_4^+$  by heterotrophic microbes = ammonification
2. biogeochemical cycles of N and S (Sulfur) are linked in terrestrial ecosystems
3. biogeochemically available S is held in organic forms; S is derived from atmospheric deposition and weathering of rocks; the cycle of S and P in the soil is affected by chemical and biological reactions
4. P is held in organic forms, and transformations of organic P in soil are difficult to measure because of the rapid reaction with inorganic P
5. during fires, nutrients are lost in gasses and in particles of smoke; soil nutrient availability increases with the addition of ash to soil

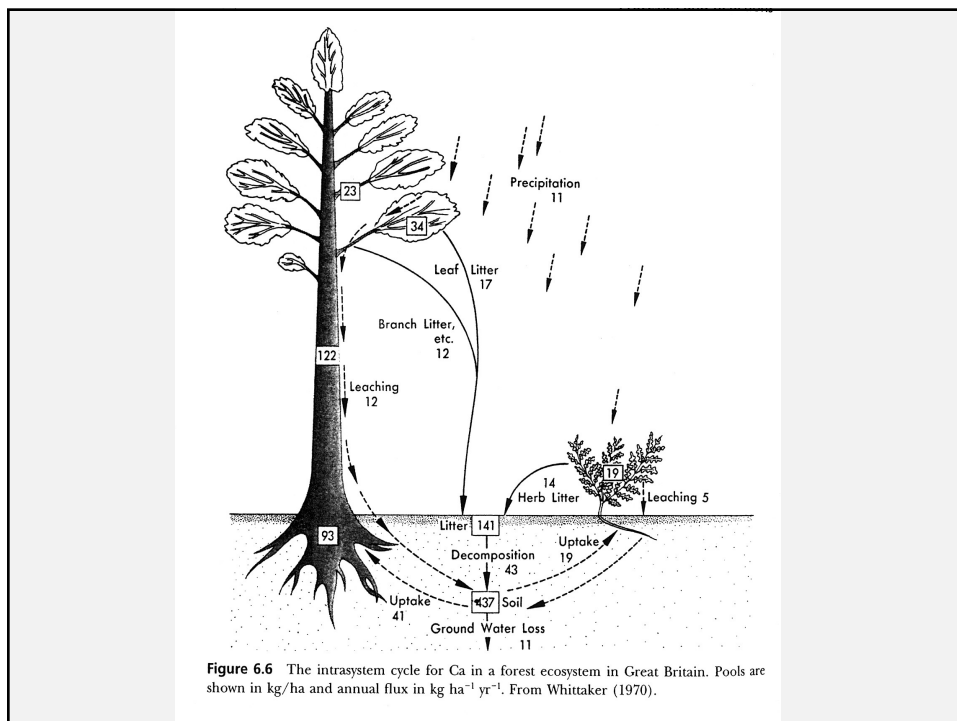
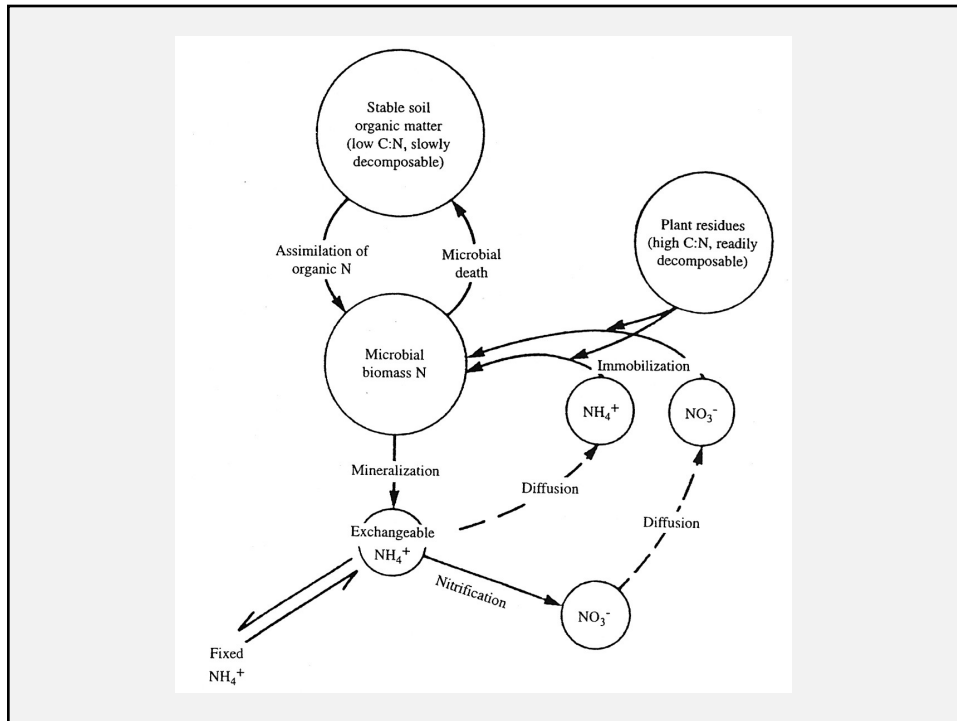


Figure 6.6 The intrasystem cycle for Ca in a forest ecosystem in Great Britain. Pools are shown in kg/ha and annual flux in kg ha<sup>-1</sup> yr<sup>-1</sup>. From Whittaker (1970).