Forest floor, soil and decomposition processes

- ✓ The soil in forest ecosystems usually consists of a number of layers, or horizons, that collectively comprise the complete soil profile.
- ✓ Recognition of the processes that occur in these horizons is an essential part of understanding nutrient cycling in forest ecosystems.
- ✓ A characteristic property of forest soils is a nearly permanent cover of leaf litter and woody debris.
- ✓ Beneath this surface organic layer, distinct soil horizons usually develop with different chemical, physical, and biological properties.
- ✓ Humans have altered the development of soil horizons by changing the natural sequence of disturbance, the kinds of plants, animals, and microbes present, and the nutrient capital in forest soils.
- ✓ The basic processes, however, remain the same by which nutrients are made available in the soil, taken up by plants, and eventually returned in organic residues.

Forest floor, soil and decomposition processes

- ✓ The forest floor is often easy to separate from the underlying layers of mineral soil, but these two major categories may be further subdivided.
- ✓ The forest floor often consists of L, F, and H layers.
- ✓ The L layer consists of fresh, undecomposed litter.
- ✓ The F layer lies immediately below the L layer and consists of fragmented organic materials in a stage of partial decomposition.
- ✓ This layer is dominated by organic materials in cellular form, and fungi and bacteria are common.
- ✓ Beneath the F layer lies the H or humus layer, primarily consisting of amorphous, resistant products of decomposition and with lower proportions of organic matter in cellular form.
- ✓ The lower portion of the H layer often shows an increasing proportion of inorganic mineral soil constituents, but organic components still dominate .
- ✓ The humus form is the part of the topsoil that is strongly influenced by organic matter and coincides with the sequence of organic (Ol, Of, Oh, H) and underlying organo-mineral horizons (A, Ae, Aa).
- ✓ Plant remains like leaves, needles, wood, root exudates, etc., form a prominent part of the primary production of forest ecosystems .

Fig. 4.2 An image of a forest floor. (Courtesy of John Wittenberg)

Fig. 4.3 Three zones of the forest floor

Soil Organic Matter a source of plant nutrients

- ✓ Soil organic matter and humus are terms which refer to the partially decomposed residue of plants, animals, and other organisms.

- ✓ Organic matter refers to all organic material including fresh crop residues.

- ✓ Humus is the more stable decomposed organic residue.

- ✓ Organic matter has long been recognized as having many beneficial effects on physical and chemical properties of the soil.

- ✓ Some of the more important effects of organic matter are: Improves Soil Structure. Organic matter acts as a bonding agent which holds soil particles together in aggregates. Without organic matter, aggregates are less stable and are easily broken apart.
- ✓ Good soil structure promotes water movement and root penetration while reducing soil crusting, clod formation, and erosion.
- ✓ Contributes to Cation Exchange Capacity (CEC). Soil organic matter has great ability to attract and hold cations .

- ✓ Provides Plant Nutrients. One of the most important attributes of organic matter is its contribution to soil fertility. Approximately 90% to 98% of the total N and S and 30% to 50% of the P exist in the soil in organic forms.

- ✓ Soil organic matter is approximately 5% N and 0.5% P or S.

- ✓ Organic matter is also the primary reservoir for available forms of most of the micronutrients.

- ✓ Even though plants are not able to utilize nutrients in organic matter directly, decomposition of humus releases ionic forms of nutrients which are available to plants.

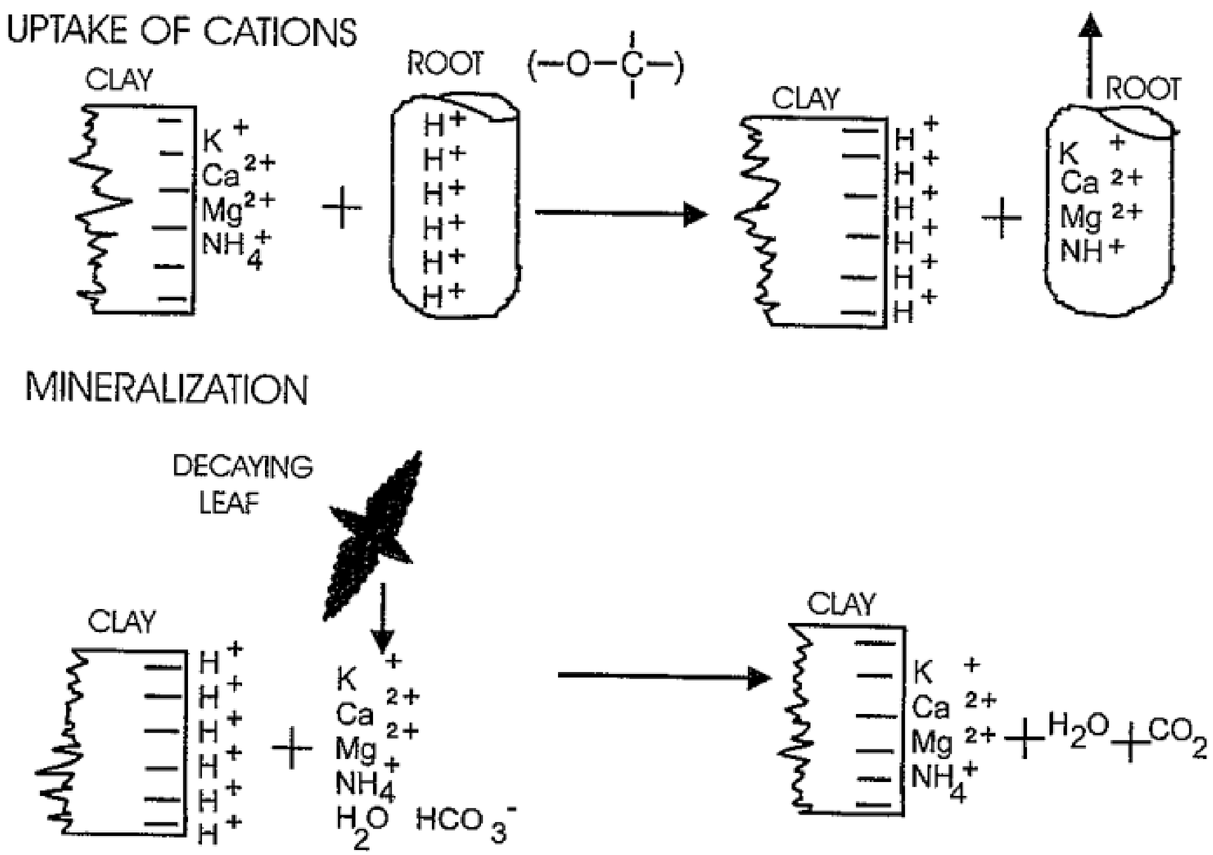

Figure 6.5. The cation cycle begins with positively nutrient ions held on negatively charged clay particles. The cations are excharged for hydrogen ions released as organic acids by plants. Roots take up the nutrients and leaf litter returns them annually to the soil. Through decomposition, nutrient cations are released to return again to the soil exchange sites. (From Glatzel 1991, Warring, Running 1998).

Forest composition and nutrient availability

- ✓ Forest composition and nutrient availability are often closely interlinked.
- ✓ In the case of nitrogen, tree species with extremely low requirements are adapted to soils where DON is the major form present.
- ✓ most conifers are adapted to intermediate conditions where NH_4^+ is the dominant form.
- ✓ Ecosystem retention of N, is also progressively reduced with increasing availability, so that high losses of NO_3^- usually indicate an excess availability while a dominance of DON in leachate reflects extreme scarcity of N.

The following summarizes some key points and implications from the last three sections

- ✓ Fragmentation and mixing are essential steps that a host of small soil animals perform on litter before it is subjected to microbial decomposition.
- ✓ Decomposition of woody debris, leaf litter, and belowground components of detritus proceeds at significantly different rates. For this reason, it is generally recommended that these organic pools be separately recognized.
- ✓ Moisture and temperature conditions strongly affect decomposition and mineralization rates.
- ✓ The chemical quality of the organic substrate, which can be quantified by C:N ratios, strongly affects the mineralization and immobilization processes.

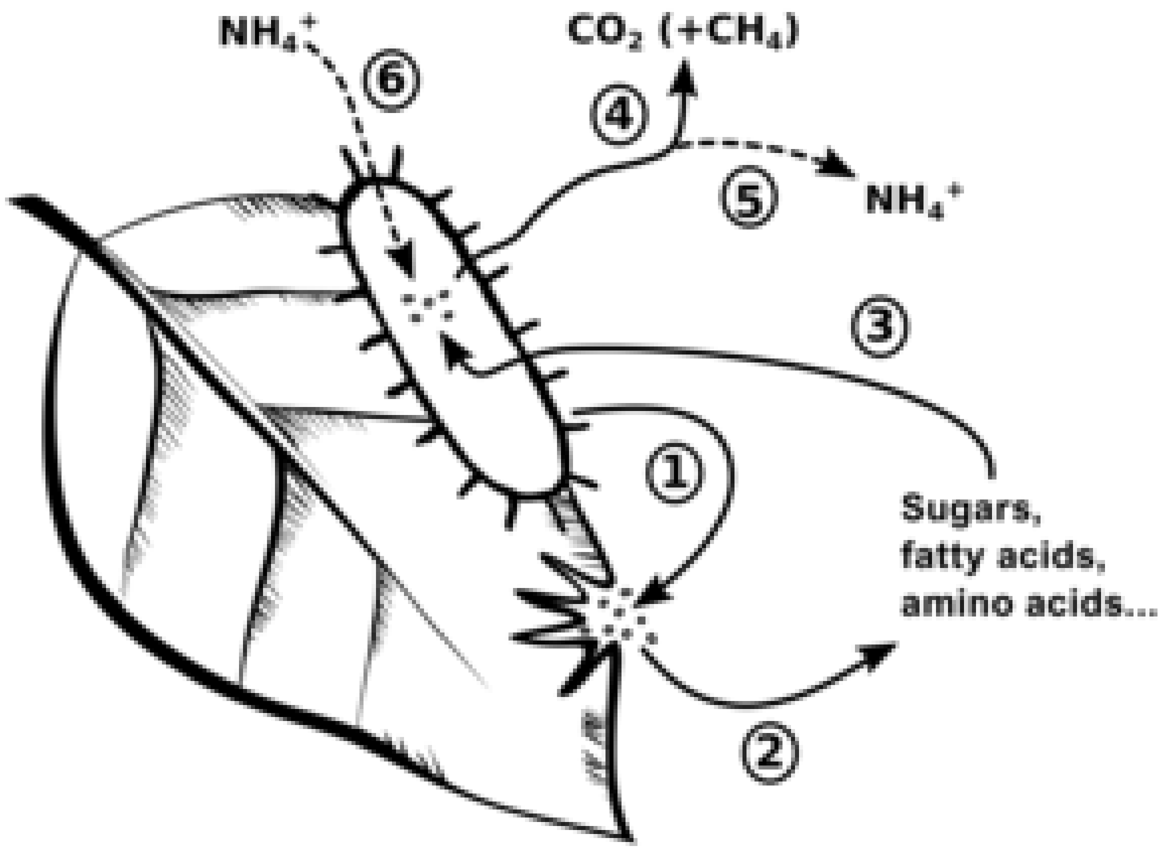

Fig. microbial decomposition

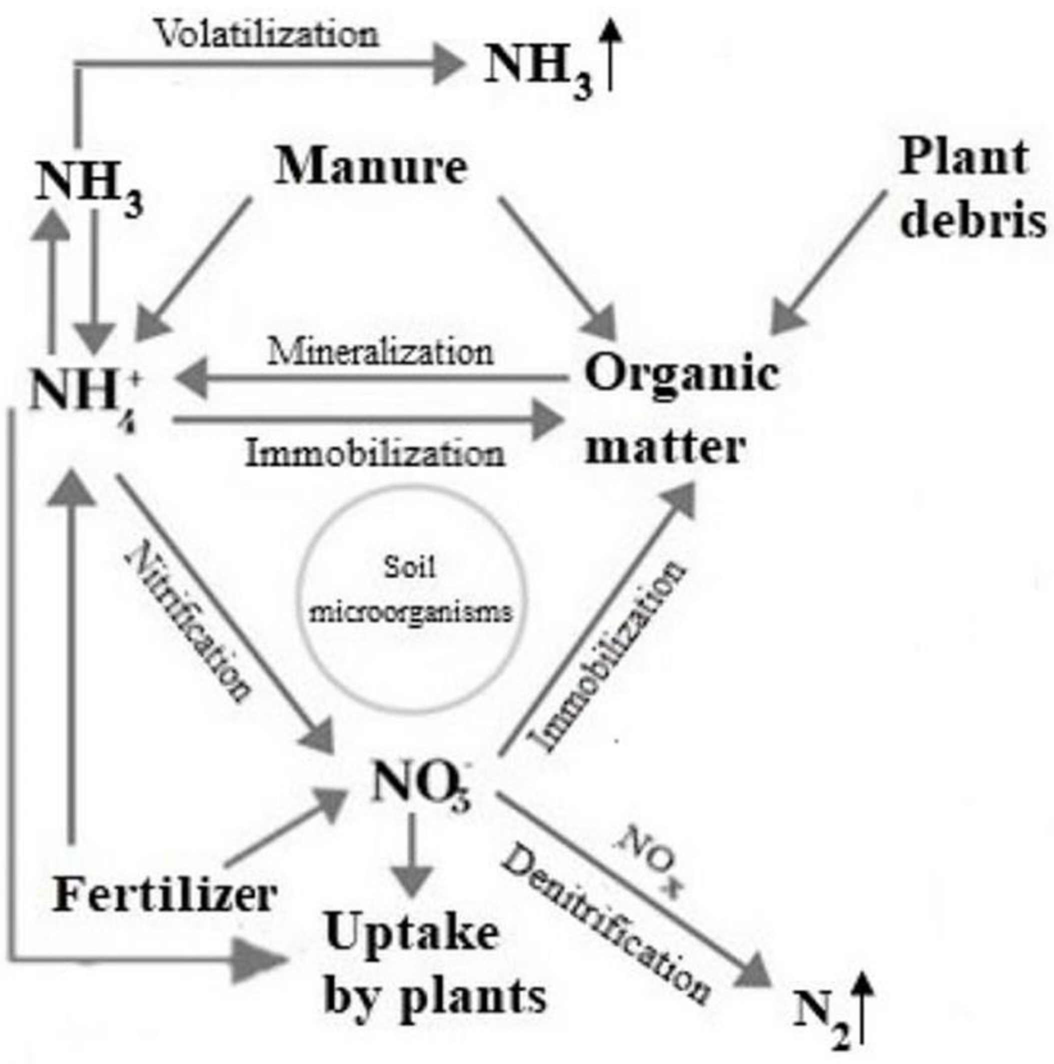

Fig. microbial decomposition

Nitrification is a process of nitrogen compound oxidation (effectively, loss of electrons from the nitrogen atom to the oxygen atoms), and is catalyzed step-wise by a series of enzymes.

$$2\,NH_4^+ + 3\,O_2 \longrightarrow 2\,NO_2^- + 4\,H^+ + 2\,H_2O$$ (*Nitrosomonas*, *Comammox*)

$$2\,NO_2^- + O_2 \longrightarrow 2\,NO_3^-$$ (*Nitrobacter*, *Nitrospira*, *Comammox*)

OR

$$NH_3 + O_2 \longrightarrow NO_2^- + 3\,H^+ + 2\,e^-$$

$$NO_2^- + H_2O \longrightarrow NO_3^- + 2\,H^+ + 2\,e^-$$