2 The Nitrogen Cycle in Terrestrial Ecosystems
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2.1 Introduction

The terrestrial nitrogen (N) cycle comprises soil, plant and animal pools that contain relatively small quantities of biologically active N, in comparison to the large pools of relatively inert N in the lithosphere and atmosphere, but that nevertheless exert a substantial influence on the dynamics of the global biogeochemical N cycle. After carbon (ca. 400 g kg\(^{-1}\)) and oxygen (ca. 450 g kg\(^{-1}\)), N is the next most abundant element in plant dry matter, typically 10–30 g kg\(^{-1}\). It is a key component of plant amino and nucleic acids, and chlorophyll, and is usually acquired by plants in greater quantity from the soil than any other element. Plant N provides the basis for the dietary N (protein) of all animals, including humans.

In this chapter we will describe how N cycles through the soil-plant-animal continuum within terrestrial ecosystems, and how N may be added (inputs) or removed (losses) from these ecosystems. The cycling occurs via decomposition of organic matter in soil, which then provides available N for plant and microbial uptake. Nitrogen subsequently returns to the soil organic N pool following plant or microbial death or via dung or urine from grazing animals. Decomposition of organic matter is mediated by the microbial biomass (Fig. 2.1), which, despite being a very small N pool within soil organic matter, has long been recognised as a critical nutrient pool, with the living microbial biomass providing the enzymes for decomposition and the dead microbial biomass representing a labile pool of soil N. Human activities exert enormous influences on the turnover and cycling of N within terrestrial agroecosystems.

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Soil Biology, Volume 10
Nutrient Cycling in Terrestrial Ecosystems
P. Marschner, Z. Rengel (Eds.)
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Major inputs to the terrestrial N cycle occur naturally via biological fixation and by wet and dry deposition (Fig. 2.1), with comparatively minor amounts fixed by lightning (Galloway et al. 1995). Humans have a direct impact on N inputs to terrestrial systems in several ways: (1) by the industrial fixation of N, mainly into manufactured N fertilisers, (2) by increasing the productivity and area sown with N$_2$-fixing legume crops and pastures, and (3) by use of the internal-combustion engine (Jenkinson 2001). It is estimated that human activity has resulted in a doubling of the fixation of “unreactive” N$_2$ from the atmosphere to biologically “reactive” forms on land (Vitousek et al. 1997). This has fuelled an increase in biomass productivity and provided the protein needed to feed a global population of 6 billion people consuming around 25 million tonnes N per year (Jenkinson 2001).

Losses of inorganic and organic N from terrestrial systems to the atmosphere or hydrosphere can occur in liquid, solid or gaseous phases. Nitrate (NO$_3$), dissolved organic N and soluble organic N can be lost by leaching (Fig. 2.1). Off-site transport of organic and mineral N occurs due to wind and water erosion, and formation of aerosols. Whilst most deliberate inputs of N are localised, the mobility of reactive N means that the influence can spread regionally and even globally (Vitousek et al. 1997). Thus, increased N availability in the biosphere contributes to many contemporary environmental problems (Galloway et al. 2003).