

Forest Floor Nutrient Dynamics in Chestnut Plantation Ecosystems

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Abstract

Nutrient content and detrital biomass in the forest floor of a mature chestnut plantation at Karies (Agio Oros mountain, Athos peninsula, northern Greece) was measured in autumn of the year 2010. These measurements were compared to their expected values (bibliography based values). All nutrients storage and organic matter were fairly similar, even though measurements in this study were slightly higher than expected.

Keywords: Chestnut plantations, Forest floor

1. Introduction

In temperate forest ecosystems the forest floor, or aboveground detritus, is one of the major reservoirs of the elements required for ecosystem metabolism and structural maintenance. Remezov and Pogrebnyak (1969) note that, in the course of the biological cycle, forest vegetation extracts the required nutrient elements from the soil and returns them to the soil, in proportions which are most favourable for its development; as a result of the succession of forest generations, the uppermost soil horizons become enriched in nutrient elements in the proportions required by the vegetation. That is, over a period of years the nutrients are concentrated where they are needed. This enrichment process depends directly on the release of nutrients from the litter.

As part of an integrated research program on the ecological structure, productivity, and biogeochemical cycling pathways of a chestnut plantation at Karies (Agio Oros mountain, Athos peninsula, northern Greece), we sought to quantify the standing crops, or pools, of nutrient elements and detrital biomass in the forest floor and to estimate the rate at which nutrient elements are lost from the forest floor.

2. Materials and Methods

2.1 Organic Layers

Soil sampling was conducted in October 2010. At each site, three circular sample plots (314 m² each) were established. In each sample plot, three sampling points were randomly selected. At each sampling point, we measured the depth of the organic layer and manually extracted a litter sample. Sampling at woody, rocky, or disturbed locations was avoided. If sampling at a randomly selected location was not suitable, sampling was conducted 0.5 m in each of the cardinal directions (in the order north, south, east, west) until a suitable sampling location was encountered. Samples of forest floor were obtained by pressing a 625 cm² steel sheet sampling frame (10cm deep) into the forest floor and collecting all organic material above the mineral soil. In each of these samples the horizons L and F, H were separated and carefully placed in plastic bags. The L horizon is composed of fresh or slightly discoloured, with no or weak breaking up, material. The F horizon is composed of medium to strongly fragmented material with many mycelia and thin roots and the H horizon is a humified amorphous material (Papamichos, 2006). Mineral soil was removed after successive sieving. All forest floor and samples were oven-dried to constant weight at 70°C and weighed. Litter subsamples were then ground in a Willey mill to pass a 40 mesh stainless steel sieve before being analyzed.

2.2 Chemical Analyses

Litter subsamples were combusted in a muffle furnace at 520°C for 4 h and diluted with HCl in a 1:1 ratio v/v (Allen et al., 1974). The solutions were analyzed for total P colorimetrically using the phosphomolybdenum blue method, and for total Ca, Mg, Na, K, Fe, Mn, Cu, and Zn by atomic absorption spectroscopy. Total N was determined by Kjeldahl analysis. The organic matter was determined by loss on ignition at 540°C for 5 h.

3. Results and Discussion

The total carbon storage (as represented by dry total litter weight) is significantly higher in our study than the bibliography-based expected values (Ganiatsas, 1963; 1975) (Fig. 1). Total litter weight in the forest floor was fairly stable throughout cutting ages. This fact suggests that the forest floor should soon be approaching a steady state.

An estimate of the composition of the leaf litter is given in Table 1. Over much of the cuttings' age, the amounts of nutrients, in general, were either approximately the same or greater than the bibliography-based expected values (Ganiatsas, 1963; 1975) (Fig. 2). A likely explanation for this is that there was more leaching due to higher rainfall in autumn 2010 than in the previous periods (Ganiatsas, 1963; 1975).

Litter profile gives some idea of the dynamics of litter decomposition and of elemental mobility (Table 1). Particularly noteworthy here are the decreasing concentration of magnesium through the litter profile and the increasing concentrations of ash-free organic matter, calcium, potassium, sodium, nitrogen, and phosphorus. This may have been due to the increased precipitation during the sampling period.

The increasing concentration of ash-free organic matter through the litter profile is attributable to metabolic losses of carbon dioxide and water, which decrease the carbon, hydrogen, and oxygen content of the decomposing material (Witkamp, 1971). Potassium increase is probably due to the high solubility of potassium compounds and the lower stability of monovalent vs. divalent cations in cation-exchange complexes. In general, however, in complex systems such as forest litter and soil, with many different exchange materials present and many biochemical processes taking place, it is difficult if not impossible to generalize on the exchange behaviour of cations on the basis of simple chemical arguments because the relative exchangeability varies considerably with the nature of the exchanger and the concentration of the solution (Wiklander, 1964).

It is reasonable to expect that the biologically critical elements nitrogen and phosphorus would tend to be retained and to increase in concentration during decomposition. Furthermore, nonsymbiotic nitrogen fixation probably adds to the original nitrogen content of the litter.

4. Conclusion

In brief, the forest-floor nutrient pools reported on here represent the result of a number of competing processes; principally litterfall, precipitation, leaching, microbial decomposition, and microbial immobilization, or uptake. For nitrogen, the additional processes of fixation, nitrification, and denitrification must be added. These processes result in a situation in which magnesium tend to be selectively concentrated in the Aoo layer of the forest floor, while ash-free organic matter, calcium, potassium, sodium, nitrogen, and phosphorus tend to be concentrated in the Ao layer of the forest floor.

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Table 1. Change in concentration of litter components through the litter profile

Layer	Ash-free organic matter %	Ca mg/gr	Mg mg/gr	K mg/gr	Na mg/gr	N mg/gr	P mg/gr
Aoo	68.42	12.77	5.23	2.81	0.50	1.22	0.923
Ao	89.25	17.73	3.86	3.32	0.59	1.23	0.995

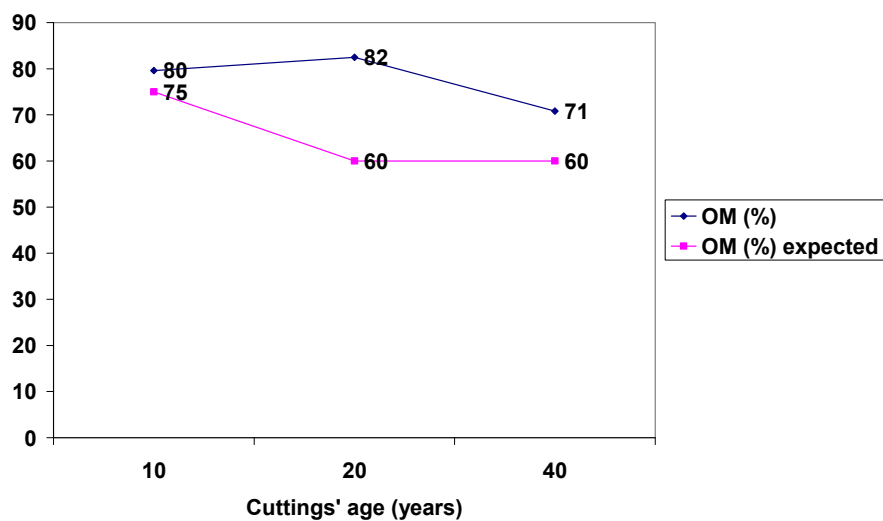
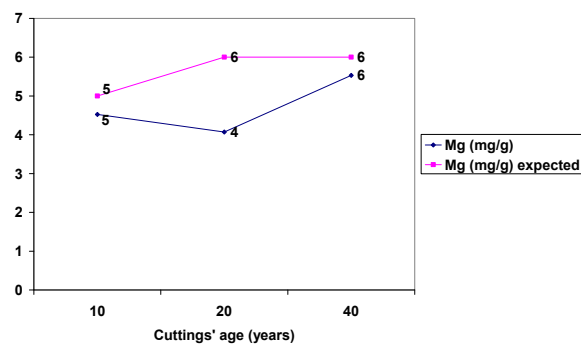
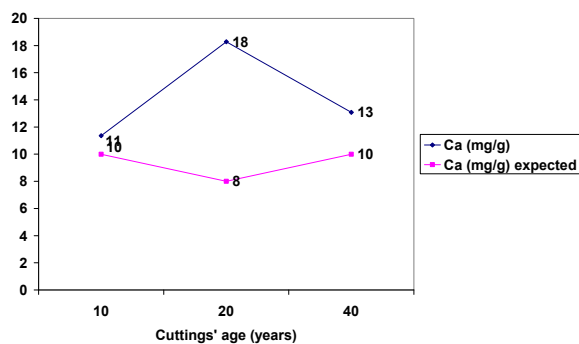
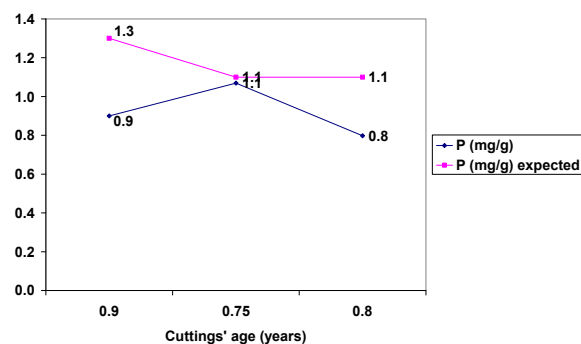
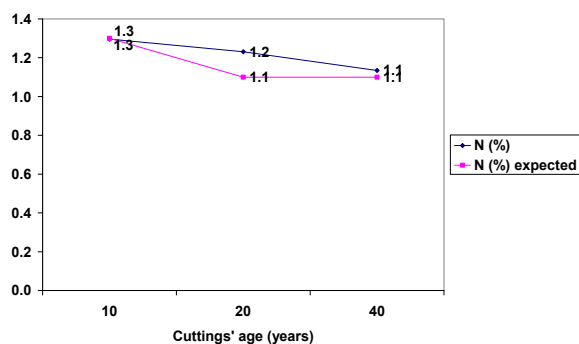


Figure 1. Total oven-dry weight of forest-floor litter (%)



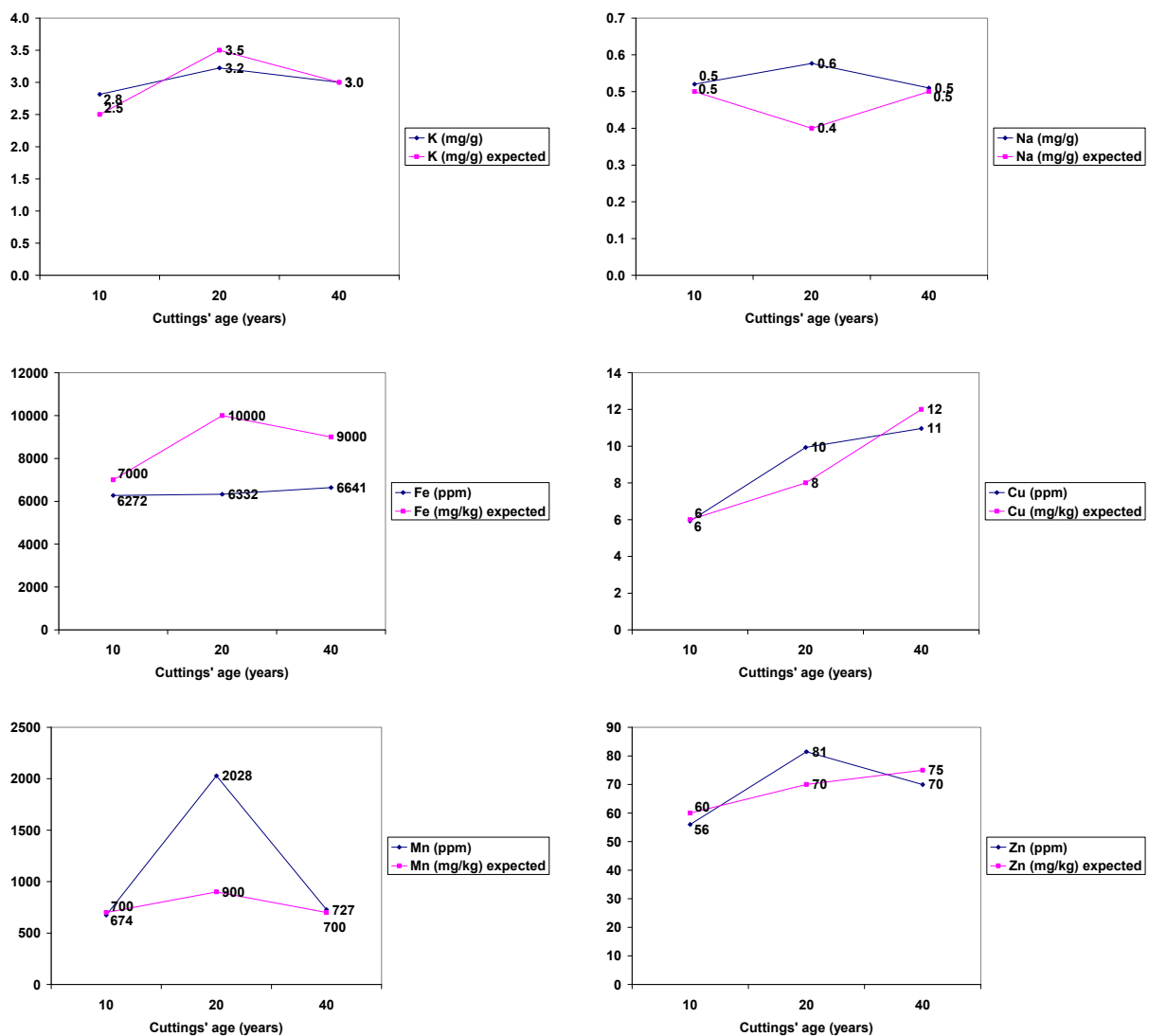


Figure 2. Total forest floor content of selected nutrients