Soil food web structure and mineralisation rates during secondary succession after land abandonment

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Introduction

Taking arable land out of production is a widespread method to restore species rich vegetation[1]. However, the development towards species rich vegetation is slow, depending on above and belowground interactions and processes[2]. After land abandonment the soil organic matter (SOM) quantity is expected to increase resulting in an increased C mineralisation rate (C_{min}), while the SOM quality is expected to decrease resulting in a shift from a bacterial to fungal energy dominated food web and a decrease in N mineralisation rates (N_{min})[2,3]. The stability of the web is expected to increase, possibly explaining the slow succession.

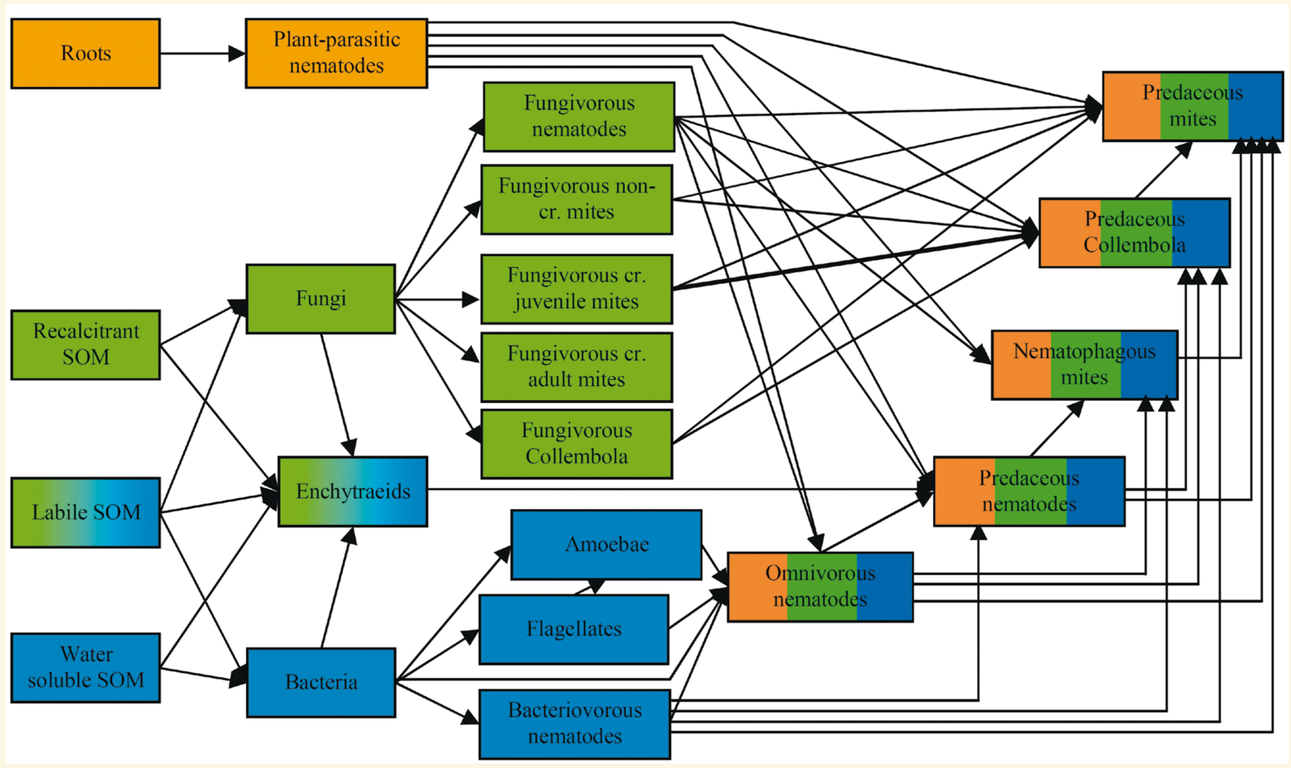

Figure 1. Soil food web diagram (orange groups represent the root energy channel (EC), green groups represent the fungal EC and blue groups represent the bacterial EC. The biomass of each group and total C_{min} and N_{min} was measured on each field (fig. 2). For each EC the C_{min} and N_{min} was calculated using a food web model[4]. Stability was calculated for the web conform De Ruiter et al[5]. cr = cryptostigmatic.

Figure 2. The study sites: three ex-arable fields and a heathland[6]. Field age represents time since abandonment.

Abundance

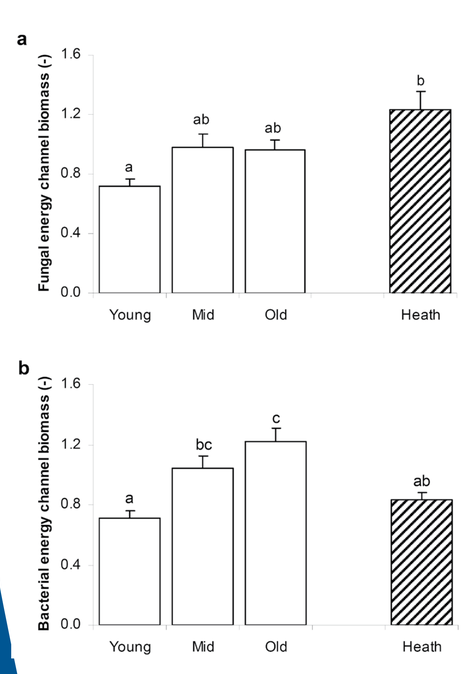

Figure 3. Fungal EC biomass (a) and bacterial EC biomass (b) increased[6].

Mineralisation

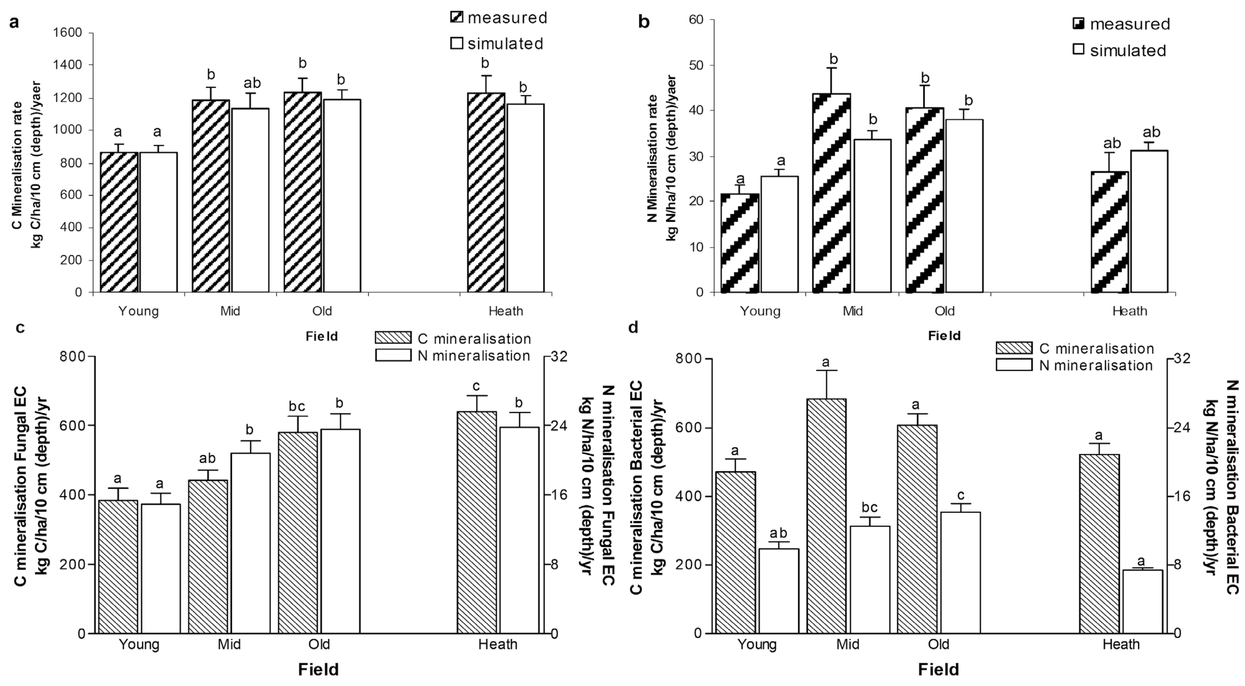

Figure 4. Total C_{min} increased initially with field age and then levelled off (a), total N_{min} also increased, but was lower in the heathland than in the old field (b), fungal EC C_{min} and Nmin increased (c) and bacterial EC C_{min} did not significantly change with field age, while bacterial EC N_{min} increased with field age, but was lowest in the heathland (d).

Stability

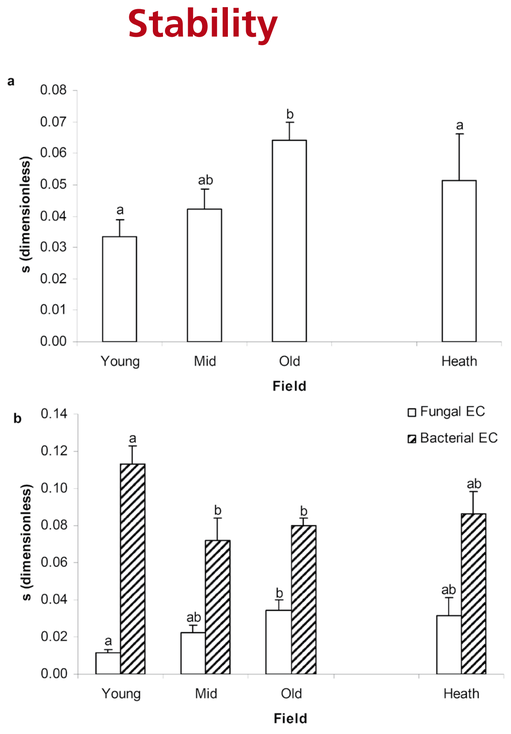

Figure 5. Soil food web stability decreased (an increased minimum degree of intraspecific interaction needed for matrix stability (s)[5]; a). Stability of the fungal EC was higher than the bacterial EC ($p<0.001$; b).

Discussion

Fungal channel biomass increased, but unexpectedly also bacterial channel biomass increased (fig. 3) probably due to the absence of a decrease in SOM quality. Because SOM quality did not decrease N_{min} could increase during secondary succession parallel to C_{min} (fig.4a-b). However, N_{min} was lower in the heathland than in the old field because quality was lower in the heathland as well. Fungal channel contributions to C_{min} were similar as those of the bacterial channel, while fungal channel contributions to N_{min} were higher than the bacterial channel (compare fig. 4c and d). Moreover, fungal channel contributions to mineralisation rates increased in contrast to those of the bacterial channel. Stability unexpectedly decreased (fig. 5). Results suggest an initial increase in biomass and mineralisation rates followed by a phase in which no significant changes occur. This was caused by the unexpected absence of a change in SOM quality and the high stability of the webs, which probably explains the slow development towards heathland as observed in restoration projects.

References: [1]Walker et al., Biological Conservation, 2004. [2]Wardle et al., Science, 2004. [3]Baer et al., Ecological Applications, 2002. [4]Hunt et al., Biology and Fertility of soils, 1987. [5]De Ruiter et al., Science, 1995. [6]Holtkamp et al. submitted to Applied Soil Ecology

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