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The effects of thinning on soil chemical properties, microbial community composition and lignocellulolytic activities – results of a five year monitoring program at a pine forest stand

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Introduction:

Forest management practices (e.g. canopy removal) can have crucial effects on soil organic matter turnover and nutrient budgets. As a result of canopy removal, such as thinning or clear-cutting, microclimatic properties are altered, as well as the quantity and quality of substrate inputs into the soil. In colder climates, the most significant changes with potentially high impact on soil microorganisms are increased soil moisture caused by higher through fall and higher soil temperatures caused by increased direct sunlight. Additionally, changes in soil pH value, as well as accumulated forest floor carbon and nitrogen levels were also reported. As a consequence of these changes, the composition of the soil microbial community may be altered or microbial activities may increase. It can be hypothesized that soil organic matter decomposition and humus dynamics might be accelerated with a loss of stabilized organic matter or with nutrient leaching (humus activation). Such effects are a matter of considerable concern in forest management and therefore need detailed study. The aim of our study was to test the hypothesis that thinning would change soil microbial community structure and increase microbial activities in the short term, i.e. five years after thinning.

Material and Methods:

A 62 year old pine stand located in northeastern Germany (Brandenburg, Ost-Prignitz, Revier Beerenbusch) was studied with respect to a thinned *vs*. an unthinned treat-

ment (year of thinning: 1999, degree of canopy opening: 0.4). During a period of five years (2000-2005), samples of the organic (O) and the mineral layer (A) of an acid brown earth have been collected at 5 mini plots (50 cm * 50 cm) in November and April, and along a transect (total distance 50 m, lag distance: 5 m), respectively. Contents of soil organic carbon (C_{org}), total nitrogen (N_t) and pH were determined according to DIN-ISO protocols, molecular composition of carbon compounds was analyzed by solid state 13C NMR. Soil microbial biomass (C_{mic}) and basal CO_2 respiration were assayed. A suite of soil enzymes involved in the degradation of lignocellulose (endo-cellulase, exo-cellulase, β-glucosidase, endo-xylanase, exo-xylanase, phenoloxidase, peroxidase) was determined photometrically. Microbial community structure and biomass of bacteria, actinomycetes and fungi, were assayed by PLFA analysis.

Results and Discussion:

Five years after thinning, contents of C_{org} and N_t as well as pH in the humus layer and in the mineral soil horizon were unchanged in both treatments. Furthermore, NMR analyses revealed no evidence of any significant differences in the molecular distributions between the thinned and unthinned treatments. Total microbial biomass as derived from substrate-induced respiration as well as biomasses of bacteria, fungi and actinomycetes as derived from PLFA analysis showed no significant differences between the treatments, while the biomass of the organic layer was significantly higher than the biomass of the mineral layer. Correspondingly, soil basal CO_2 respiration as a measure of general microbial activity displayed no significant differences between the thinned and unthinned treatment, but significant differences between the organic and mineral horizon. Moreover, the enzyme activities showed no significant differences between treatments but significantly higher activities in the organic layer as compared to the mineral layer. From these data, the hypothesis that thinning would rapidly stimulate microbial activities and thus lignocellulose decomposition, could not be verified. Concerning community composition, PCA with the PLFA data provided first evidence of significant differences between the thinned and unthinned treatments (in April 2004).

Conclusion:

The results of this study lead to the conclusion that during five years after thinning, no significant differences in soil chemical and microbiological properties could be found at the study site, in comparing a thinned and an unthinned treatment. Our results confirm reports of other authors who found only minor evidence of increase in microbial activities and litter decomposition, as an immediate consequence of thinning, or who found highly variable responses of decomposition rates to more vigorous management

practices, such as clear-cutting. These results should be confirmed for any particular site, so that early warning to forest management, in regard to increased humus dynamics or nutrient leaching can be provided. Therefore, continued monitoring of soil organic matter composition, microbial activities and community patterns is required.