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Insects, infestations and nutrient fluxes

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Forest ecosystems are characterized by a high temporal and spatial variability in the vertical transfer of energy and matter within the canopy and the soil compartment. The mechanisms and controlling factors behind canopy processes and system-internal transfer dynamics are imperfectly understood at the moment. Seasonal flux diversities and inhomogeneities in throughfall composition have been reported from coniferous and deciduous forests, and in most cases leaf leaching has been considered as principle driver for differences in the amount and quality of nutrients and organic compounds (Tukey and Morgan 1963).
Since herbivorous insects and the processes they initiate received less attention in past times, ecologists now emphasize the need for linking biological processes occurring in different ecosystem strata to explain rates and variability of nutrient cycling (Bardgett et al. 1998, Wardle et al. 2004). Consequently, herbivore insects in the canopies of forests are increasingly identified to play an important role for the (re)cycling and availability of nutrients, or, more generally, for the functioning of ecosystems not only in outbreak situations but also at endemic (non-outbreak) density levels (Stadler et al. 2001, Hunter et al. 2003).
Before, little attention was paid to insect herbivores when quantifying element and energy fluxes through ecosystems, although the numerous and different functions insects fulfill in ecosystems (e.g. as pollinators, herbivores or detritivores) were unanimously recognized (Schowalter 2000). Amongst the reasons for this restraint was the argument that the total biomass of insects tends to be relatively low compared to the biomass of trees or the pool of soil organic matter (Ohmart et al. 1983). A second argument which was put forward to justify the inferior role of insects in nutrient cycling were the supposed low defoliation losses between 5-10% of the annual leaf biomass, or net primary production, due to insect herbivory under endemic situations (Larrson and Tenow 1980).
However, at times of insect mass outbreaks with leaf area losses up to 100%, nutrient fluxes are strongly affected at the ecosystem level and consequently attract greater attention (Grace 1986). In this context, mass outbreaks of herbivore insects constitute a class of ecosystem disturbance (Pickett and White 1985). More specific, insect pests meet the criteria of biogeochemical “hot spots” and “hot moments” (McClain et al. 2003) as they induce temporal-spatial process heterogeneity or changes in biogeochemical reaction rates, but not necessarily changes in the structure of ecosystems or landscapes.
This contribution presents a compilation of literature and own research data on insect herbivory effects on nutrient cycling and ecosystem functioning from the plot to the catchment scale. It focuses on temperate forest ecosystems and on short-term impacts as exerted by two focal functional groups of herbivore canopy insects (leaf and sap feeders). In detail, research results on effects operating on short temporal scales are presented including a) alterations in throughfall fluxes encompassing dissolved and particulate organic matter fractions, b) alterations in the amount, timing and quality of frass and honeydew deposition and c) soil microbial activity and decomposition processes.