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**Effect of fire on the invertebrate communities  
in chestnut forests in Southern Switzerland**

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## SUMMARY

In many forest ecosystems, forest fires represent the most important factor of natural disturbance. In Switzerland, the region most affected by this phenomenon is the southern slope of the Alps, where about 90% of the surface area burned on a national level has occurred.

In the last 30 years, most forests south of the Alps have no longer been managed, and forest fires have become an important factor in regulating forest biomass. The ecological consequences of this fact are still poorly known. Under similar circumstances, in other parts of the world, fire is known to be an important selective force, initiating successional changes in plant and animal communities, and in some cases enhancing biodiversity. However, current knowledge on the consequences of forest fires for faunistic biodiversity is fragmented and mostly limited to fire prone regions of the world where fire occurs mainly during the summer time. There appear to be no quantitative data about the influence of fire frequency and the time elapsed since the fire in temperate deciduous forests, where fast spreading surface-fires of low to medium intensity occur mainly in winter time. Such data are indispensable to understand the ecological role of fire and to define the ecological value of forest areas with high fire frequency on the basis of their invertebrate fauna. With this knowledge we are better able to develop preventive measures and conservation strategies in chestnut forests of southern Switzerland.

In the region of Locarno (Canton Ticino, Switzerland) I selected 25 sites within a mosaic of burnt areas of different age and frequency embedded in a matrix of unburnt former coppices of chestnut forest. This chronosequence of burn times and frequency facilitated the space-for-time substitution approach. I compared 6 unburnt sites, 2 freshly burnt sites, 8 sites which had burned once at different times in the last 30 years, and 9 sites where fires occurred repeatedly in the last 30 years. Three sets of three traps (1 pitfall trap, 1 window trap, 1 eclector) were installed at 23 study sites, while only 3 pitfall traps were installed in 3 other sites, making a total of 72 trap sites.

In order to obtain reproducible data, we collected insects of different taxonomic groups using standard methods from March to September 1997. Litter dwelling species were sampled using pitfall traps and surface eclectors (emergence traps). Flying and flower visiting species were sampled using window traps in combination with a yellow water pan.

Based on these data, I explored the influence of fire frequency and time elapsed since the last fire on species richness and species composition at different levels: overall data, taxonomic level based on 12 different taxonomic groups of 7 different orders (Isopoda, Aranea, Coleoptera, Neuroptera, Hemiptera, Hymenoptera, Diptera) and functional level based on 6 different groups (ground-litter saprophagous, epigaeic zoophagous, pollinophagous, phytophagous, flying zoophagous, saproxylophagous).

The effect of fire on the fauna is discussed from the points of view of biodiversity, conservation, specific ecological requirements, and ecological functionality, trying to bridge the gap between the underlying theoretical concepts and the practical requirements.

In the **first chapter** I investigate the effect of fire on the floor habitat, dwelling spiders as a well-known bioindicator group and therefore useful for comparative purposes. I demonstrate that fire affected both species richness and species composition. Post-fire development of the spider community is chiefly due to individuals which survive *in situ*. No characteristic pioneer species were found in any of the burnt sites. Indirect effects of fire on the spider community were revealed through interactions between species arising from the changing environmental conditions following a fire. After a single fire, changes in community composition were only observable during the first two years. At sites that experienced repeated fires, there was a more persistent influence on community composition, until 6-14 after the last fire. These sites were characterised by an increase in species richness and species diversity, conforming to the intermediate disturbance hypothesis. The presence of a wide ecological range of species in 'repeated fire' sites is probably due to the wide range of environmental structures and of microclimate conditions at the soil surface, with a predominance of xeric conditions.

In the **second chapter**, I focus on the effect of fires on invertebrate groups related to dead wood as an important element of unmanaged and burnt forests. I selected three well known xylobiont beetle families (Cerambycidae, Buprestidae and Lucanidae) that I investigated on two different spatial scales: a small scale (0.25 ha) and a large scale (6.25 ha). The results showed that fire did not have a direct effect on the species richness of these groups. However, on the small spatial scale fire had an indirect effect on species composition by maintaining highly structured and relatively open stands with large amounts of dead wood and big oak trees, which are favoured by fires. On a large spatial scale, the mosaic of different habitats and successional stages following burning, as well as fire residuals as important dispersal pools, probably played an important role for the saproxylic species composition and in maintaining a high species richness.

In the **third chapter** I focus on the effect of fire on overall arthropods biodiversity, on 12 taxonomic groups specific to certain habitat types, and on scarce and endangered species. I demonstrated that fire enhances overall biodiversity. The overall species richness and/or abundance, as well as those of most taxonomic groups, were significantly higher in plots with repeated fires than in the unburnt control sites. Plots with only one fire in the last 30 years harboured intermediate number of species. Negative effects of fire were found only for isopods and weevils. Moreover, fire frequency had a significantly positive effect on species richness of the guilds of open forest species and forest edge specialists, without affecting interior forest species. Furthermore, open forest species and forest edge species were already predominant in intact forests, which indicates that these forests are highly resilient to disturbance. Endangered species were favoured by fire, and the presence of few pyrophilous species suggest an adaptation of the ecosystem to disturbance by fire, even so the knowledge about Southern European pyrophilous insects is still very scarce.

The **fourth and last chapter** gives an overview of the resistance and resilience of the ecosystem to fire from a functional point of view, grouping the species into 6 different functional groups: ground-litter saprophagous, flying and epigeic zoophagous, phytophagous, pollinophagous, and saproxylophagous. The response to fire of the various functional groups depends on the direct mortality during the fire and on the grade of adaptation of the species to disturbance, and therefore to the new post-fire environmental

conditions. Most functional groups in the chestnut forests were more resilient to single fires than to repeated events. I demonstrated that fire induces changes among the dominant and subdominant species setting back the process of competitive exclusion. The changes and fluctuations in environmental post-fire conditions switch the competitive balance between species, allowing a redistribution of dominance among the species in all functional groups. Formerly inferior competitors become dominant, responding to the dominance reduction and dynamic equilibrium hypotheses.

The investigation presented here suggests that both the formerly intensive management of these forests (until the 1950s), and a history of frequent fires which goes back to the Neolithic period, have played an important role in the development of the species assemblage of invertebrates in the chestnut forests of the Southern Swiss Alps, as well as in the high resilience of the functional groups.

In order to ensure continuity in these evolutionary endogenous processes and to avoid species loss, a financially sustainable forest management is required which mimics the natural disturbance caused by forest fires. Such a management must also minimize the risk of erosion and landslides in densely inhabited hilly areas.