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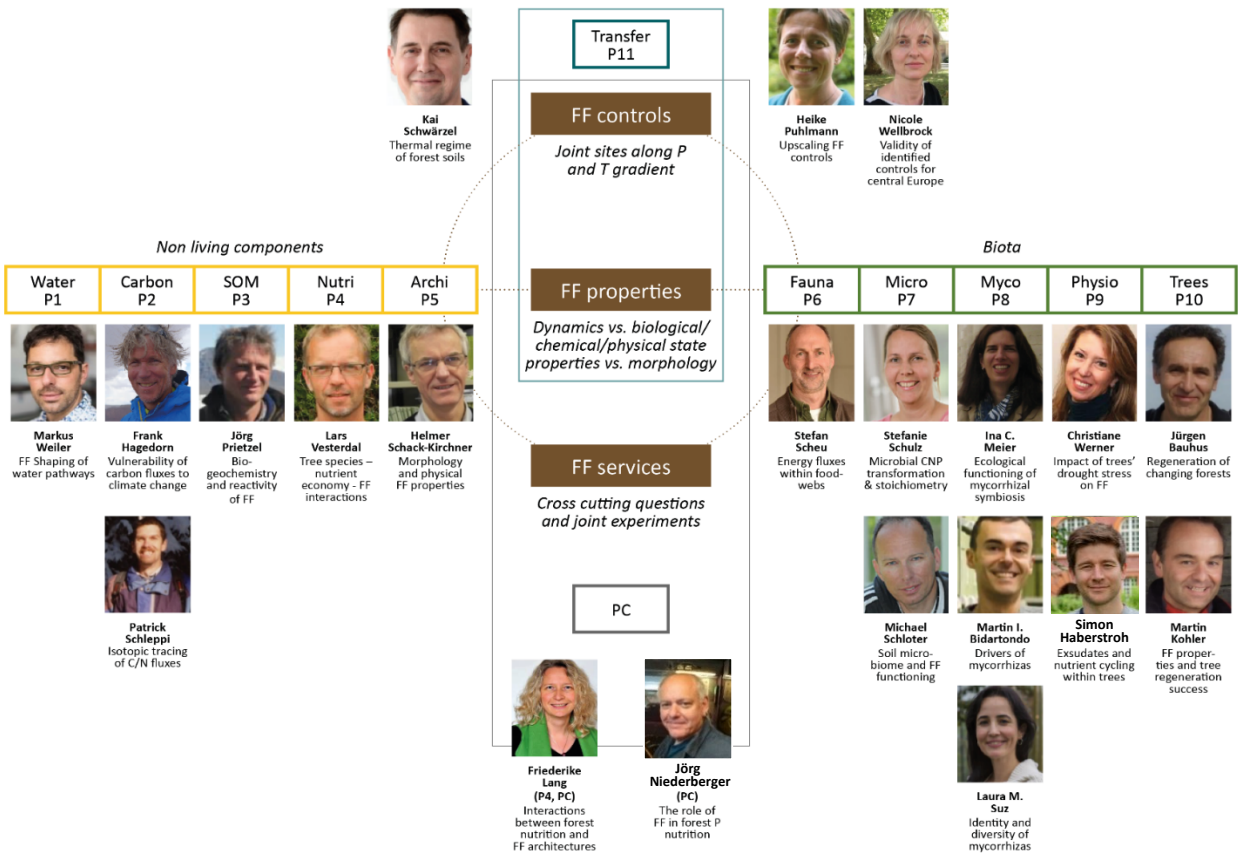

FOR 5315: FOREST FLOOR: Functioning, Dynamics, and Vulnerability in a Changing World

Project description:

The forest floor (FF) is the interface between above- and belowground parts of forest ecosystems. It provides habitat for a wide range of organisms, serves a seedbed and growth substrate for vegetation and acts as a central ecosystem hub where organic matter, nutrients, water and gases are stored, absorbed and transformed. As such, FF properties reflect complex interactions between biotic and abiotic ecosystem components, especially those related to microclimate and nutrient supply. An impact of climate warming on FF and associated services is likely especially in temperate regions where small changes in control variables may induce shifts from organic layer-dominated to mineral soil-dominated forests. Our RU focuses on analyzing the causal links between controls, properties, and ecosystem services of FFs. These links will enable (i) the determination of the service fulfillment through the FF in comparison to mineral topsoil, (ii) an assessment of FF vulnerability under climate warming and (iii) the use of FF properties as indicators for service fulfilment under given climatic conditions and properties of the mineral soil. These goals are directed by the overall hypothesis of the RU: Forest Floor properties of European beech forests are shaped by adaptations of organisms to the nutrient status of soils. The influence of climate warming on FF services depends on the interactions with these adaptations. This hypothetical framework will be implemented through specific hypotheses of 11 individual projects in close cooperation by focusing on combined phosphorus (P) and temperature impacts in European beech (Fagus sylvatica) forests admixed with Norway spruce (Picea abies) and sycamore maple (Acer pseudoplatanus). Twelve study sites allow the investigation of the interacting controls air temperature and P level of soils. At these sites, we will conduct 13C, 15N, 2H litter labelling experiments for process tracing and quantification and we will address nutrient, carbon and water dynamics. Our research will be complemented by studies addressing tree seeding experiments, microbial communities, soil fauna food webs, and root- and mycorrhiza-driven processes. Time-series analyses of existing data and ecological modelling will support process understanding, upscaling and scenario estimates.

This work was part of the Research Group FOR5315, funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) Project number: 457330647

Further information:
https://uni-freiburg.de/forestfloor

FOR 5315
Forest Floor

- The forest floor (FF) is the central hub in forests where organic matter, nutrients, and water are stored, transformed, and transferred. The FF is dominated by plant litter and its decomposition products, and thus differs fundamentally from the mineral soil.
- The role of FFs in nutrient, carbon and water cycles depends on the turnover rates and accumulated mass of the FF, which reflects strong interdependences with the abundance, activity and composition of soil microbial and faunal communities.
- The basic idea of our Research Group FOR 5315 is that the FF is an emerging ecosystem property resulting from interactive, climate sensitive responses of organisms to the nutrient supply by soils.

Forest Floor glossary *	
Organic Matter (OM):	Non-living material origin either plants or other soil biota.
Organic carbon (OC, C_{org}):	Carbon bound in organic compounds/matter.
Organic fine material (OFM):	Well decomposed organic material (OM), the origin of the organic material is not recognizable by naked eye .
Forest Floor:	The entity of all organic matter situated on top of the mineral soil or bedrock
Organic horizon:	A strata consisting of organic material (C_{org} ≥ 15% w/w) with a specific set of properties
Humus form:	A specific set or combination of organic horizons, including the topmost mineral soil layer, which form together a humus form with defined properties and distinct ecological relevance.

Organic horizon glossary *	
Ol horizon (WRB: Litter layer)	Not or hardly decomposed plant material. OFM < 10% v/v
Of (WRB: Oi, Oe)	Plant material showing considerably signs of decomposition, OFM clearly recognizable, 10% v/v ≤ OFM < 70% v/v
Oh (WRB: Oa)	Plant material in an advanced state of decomposition, OFM dominating, only few recognizable remains of plant material, OFM ≥ 70% v/v

Humus Form Glossary *	
Mull	High biological activity, anecic, endogeic earthworms, often base cation rich soils, fast litter decomposition (0,5 – 2a), transition to A horizon clear, Oh horizon absent.
Moder	Reduced biological activity, epigeic earthworms dominant, liter decomposition > 2a, transition to A horizon unclear. Oh horizon present, powdery or crumbly structure.
Mor	Limited soil fauna activity, fungi major decomposer, often acidic sites, slow litter decomposition several years (decades), transition to A or E horizon very sharp. Oh horizon present – compact, diffuse or sharp breakable.

* According to AG Boden (2024) Bodenkundliche Kartieranleitung, 6. Aufl., in 2 Bänden.

Detailed English description in Wachendorf et al. (2023): A Concept for a Consolidated Humus Form Description—An Updated Version of German Humus Form Systematics, Int. J. Plant Biol. 14, 658–686. https://doi.org/10.3390/ijpb14030050

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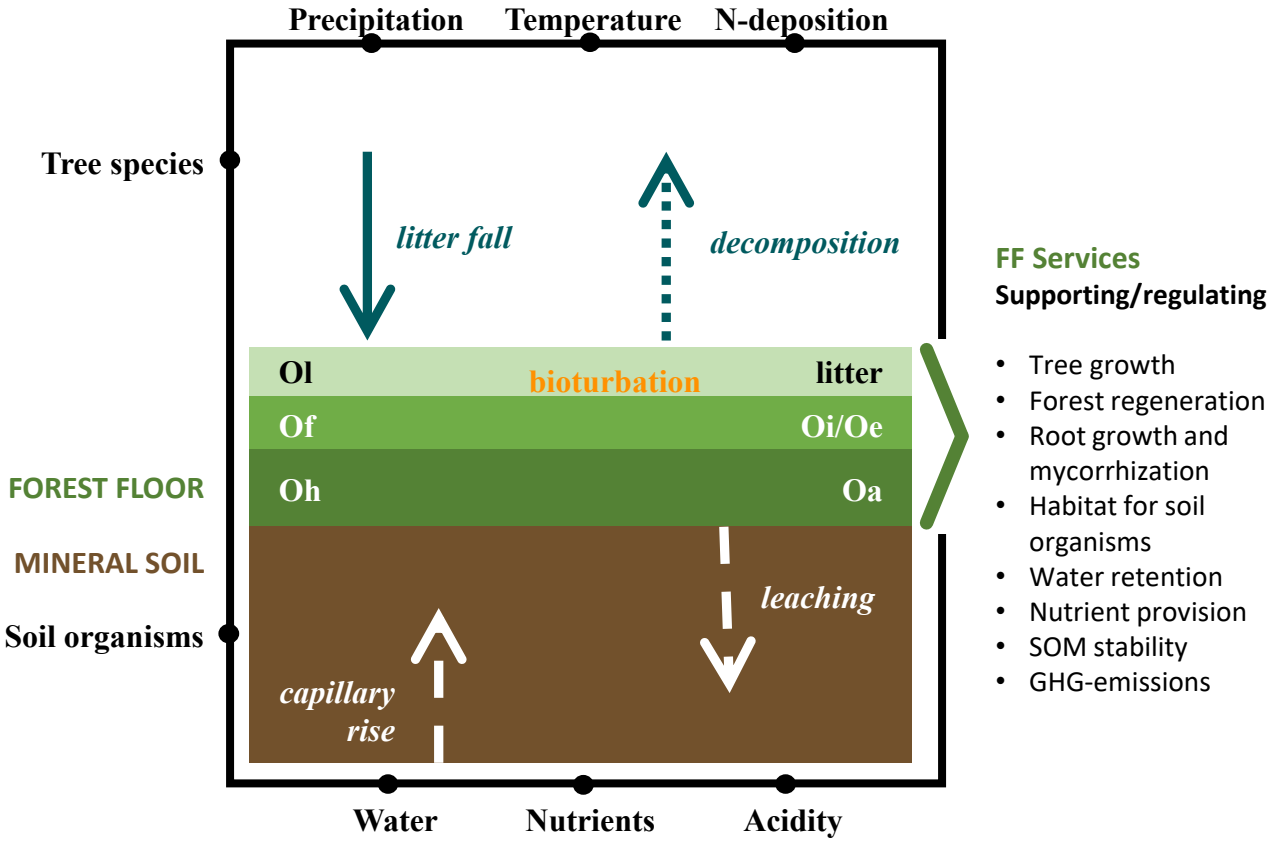

Schematic illustration of FF controls and services, horizon labeling: left German KA6, right WRB 4th ed.

- Mutually reinforcing interactions determine how much the FF or mineral soil dominates biogeochemical cycles and energy fluxes.
- With slow FF turnover, large proportions of nutrients are tightly cycled within the FF, organic matter accumulates due to limited decomposition and impaired bioturbation, and water is channelled through preferential flow-paths.
- With fast FF turnover, the mineral soil is the main place for plant nutrient uptake and organic matter transformation, and water percolates more homogeneously. The majority of forest change-related drivers will speed up FF turnover and ecosystem processes which depend on slow FF turnover will be impaired. Yet detailed information on these impacts is missing.
- Therefore, we provide knowledge on the vulnerability of FF processes against forest changes.

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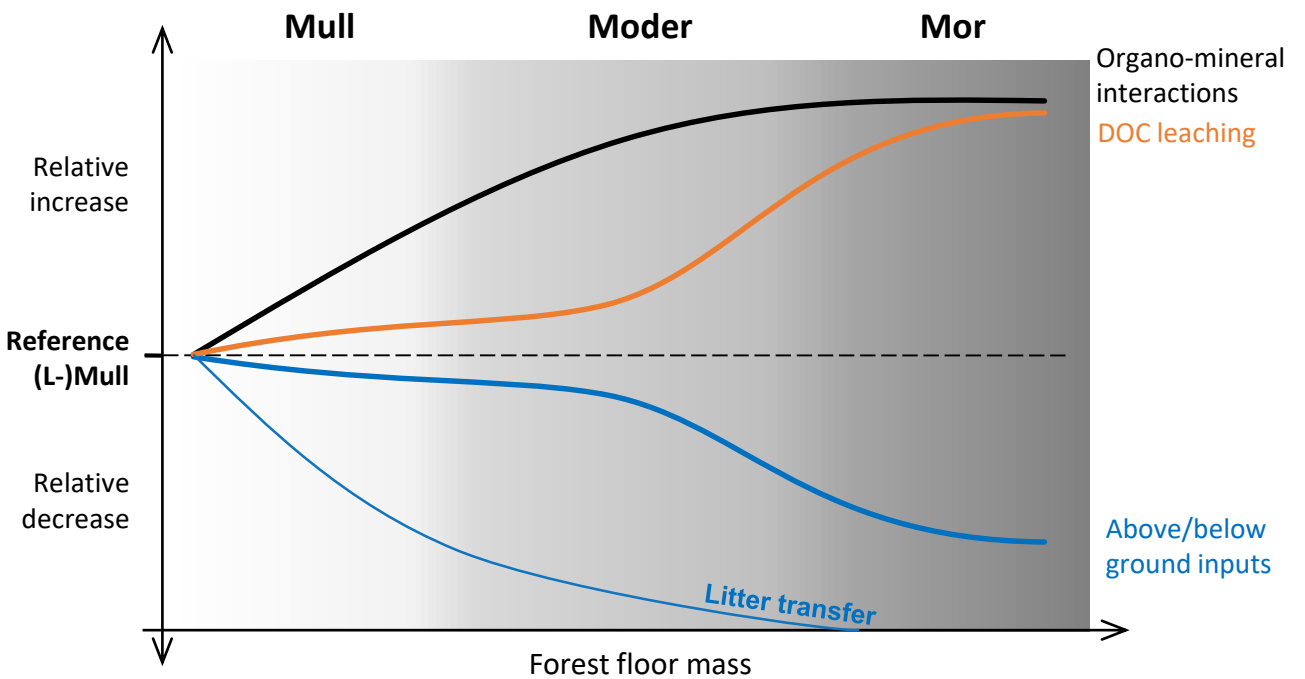
KA6/WRB

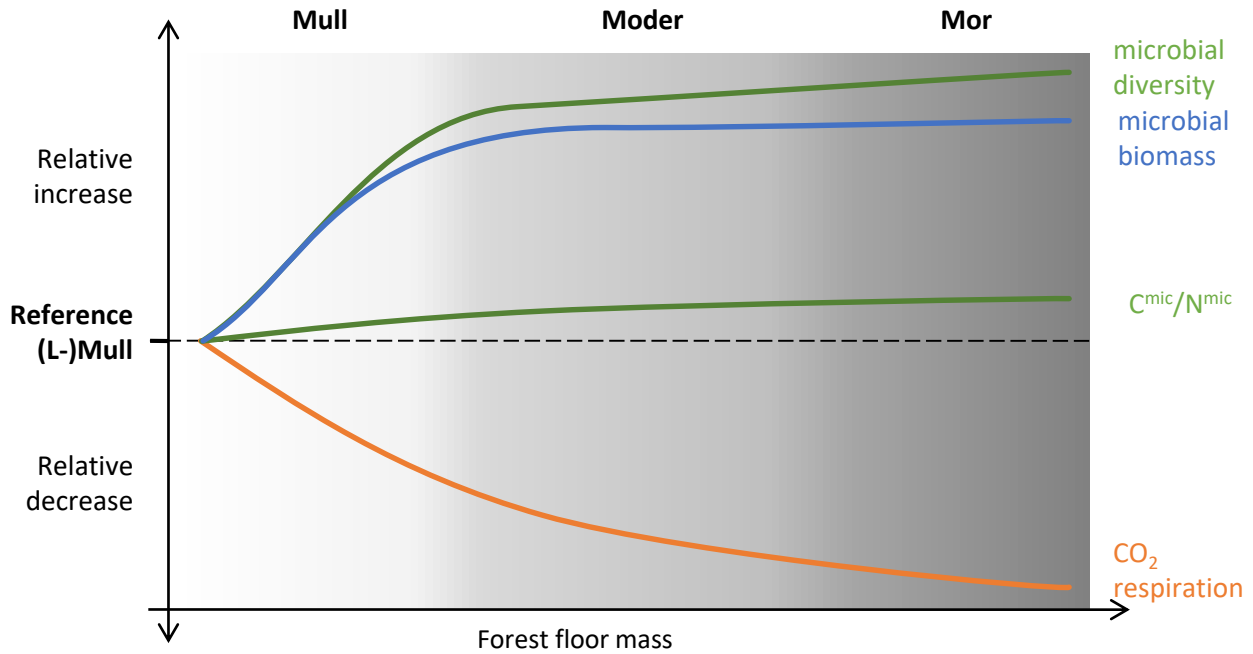
Ol/litter Ohf/Oe Obh/Oa1 Okh/Oa2 Ah/Ah

Photos: top, separated O horizons, with horizon definition KA6/WRB;
down left, example of a Mull humus form (L-Mull);
down right, example of a Moder humus form (typical Moder).

Def. **L-Mull**: Ol material (litter layer) of high decomposability, rapid decomposition (< 2a), Olf horizon (Oi, WRB) patchy, sparse and not present all year round, A horizon high base cation saturation, granular structure, rich in OC, clear signs of macro- and mesofauna activity (casts, middens, faecal pellets, channels)

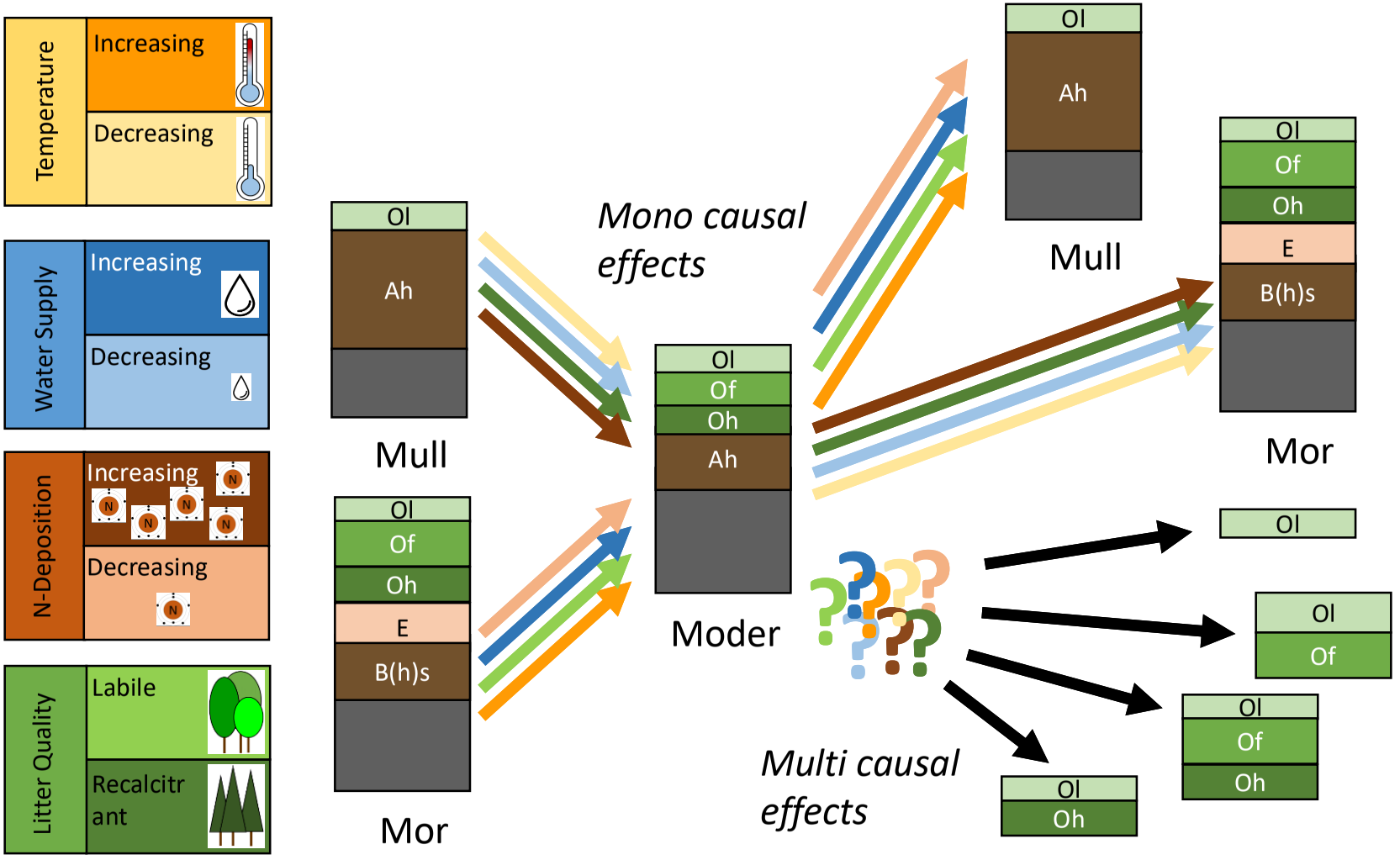


Share of organic matter present as organo-mineral interactions, ratio between above and below-ground input of organic matter into FFs and transfer of DOC and litter from FF into the mineral soil as depending on FF mass and humus form – all values are referenced by the L-Mull value.



The relevance of the FF for soil microorganisms as depending on FF mass and humus form – all values are referenced by the L-Mull value.

Changes in Forest Floor Controls



Uncertainties regarding the response of forest floors on changes in forest ecosystems

Take home messages

- FF is the result of complex interactions in forests.
- FF represents a kind of ecosystem-based adaptation to the given environmental conditions such as nutrient status, acidity, temperature or precipitation
- Its properties are driven by the organisms, which use the FF as a source for mineral nutrients, organic substrates, and water, and as habitat.
- The way of usage by the different organisms is adapted to environmental conditions and closely interconnected with its properties.
- Adaptation mechanisms to a particular factor seem to be often constrained in their effectiveness by the characteristics of other factors.
- The combination of different factors is decisive for FF development and functioning rather than the characteristics of single factors.