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Vegetation ecology of springs - from catchments to bioindicators

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background → acidification

Deposition of acids has been one of the biggest environmental problems in Central and Northern Europe and beyond in the last decades. Even though acid deposition in central Europe has sharply declined, catchments are only slowly recovering and acidification remains an important environmental issue. It has lead to damage of forest trees as well as to alteration of soils, groundwater, springs and streams.

catchments → springs

As groundwater flow is unidirectional and continual in springs, species' occurrence in their seepage zone is expected to be controlled mainly by hydrochemical properties. To test which environmental compartments the vegetation of springs is reflecting in fact, we investigated the influence of 21 springwater hydrochemical properties, 52 catchment traits, and spatial configuration on plant species composition of 73 springs in forested catchments, using NMDS, Mantel tests, and path analyses.

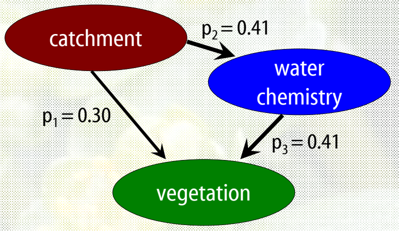

Fig. 1: Presumed causal relationships between the compartments of the functional chain between catchment and spring. Path coefficients between the distance matrices of the three parameter sets are included.

Results show that vegetation is significantly related to springwater hydrochemical parameters as well as to catchment properties. Most of the catchment's influence on vegetation is expressed indirectly via springwater chemistry and not directly.

A large proportion of the catchment's influence on springwater chemistry can be explained by the elevational position of the spring, which represents the intensity of acidification that has taken place.

ecological patterns → bioindicators

Hydrochemical conditions are found to be more important for species composition than physical or spatial factors. Low pH-values accompanied by high concentrations of Al, Cd, Zn and Mn are the main factor that is related to species composition. Using multivariate ordination and modelling techniques *Chrysosplenium oppositifolium* and *Cardamine amara* are identified as indicator species for non-acidic water chemistry, whereas the mosses *Sphagnum fallax* and *Polytrichum commune* are found to be dominant under acidic conditions.

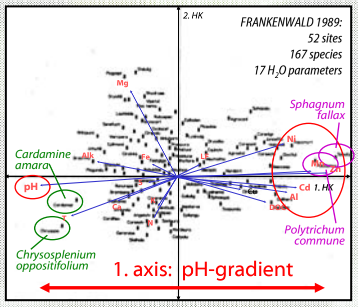

Fig. 2: Multivariate ordination (RDA) of hydrochemical parameters of springwater and corresponding plant species.

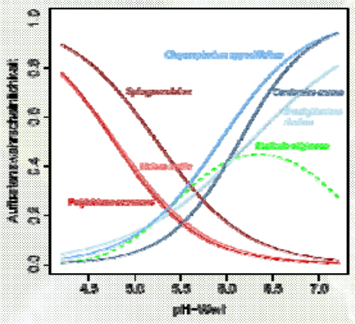

Fig. 3: Species-response curves with respect to pH, derived by a generalized linear model from presence/absence data.

spatio-temporal patterns → monitoring

Spatial patterns of load situations can be shown both with water analyses and vegetation records. They appear clearly on all spatial scales: within springs (sub-plot scale), within catchments, within landscapes (e.g. Frankenwald, see Figures) and between landscapes (comparison of 5 regions).

Surprisingly, changes in dominance of the selected indicator *species* can not be directly linked to trends of acidification and recovery. This could be caused by a delayed reaction due to persistent dominance patterns (inertia). In contrast the response of the whole plant *community* shows first signs of recovery, which suggests the dynamic applicability of the monitoring system in the long run.

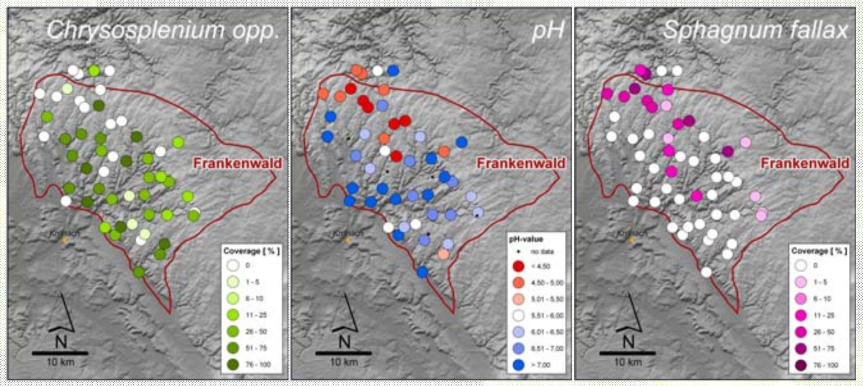

Fig. 4: Spatial patterns of load situations can be detected with water analyses as well as with vegetation records. Springwater pH-value (centre) shows the same pattern as reflected by the indicator species Chrysosplenium oppositifolium (left) and Sphagnum fallax (right).

outlook → cooperation

Springs are characterised by a relative constancy of hydrophysical and hydrochemical parameters. We expect that environmental changes (temperature, acidity) will influence water quality and particularly affect the stenoecious crenophilic species. Spring vegetation proves to be a good indicator system to represent groundwater chemistry, which in turn reflects the geochemical and hydrological conditions of forested catchments. Patterns of spring water chemistry and vegetation emerge at various spatial scales and can provide valuable ecological information for several other disciplines.

references

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Zang, Audorff & Beierkuhnlein (in prep.): Species response to pH thresholds: a matter of scale?

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