Connecting Biodiversity Monitoring with Soil Inventory Data – A Swiss Case Study

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Abstract

Thanks to a close cooperation between the field team of the biodiversity monitoring of Switzerland BDM and the staff of Swiss Soil Monitoring Network NABO an extensive soil sampling campaign could be carried out. Between 2011 and 2015 topsoil samples at levels down to 20 cm at approximately 1200 locations evenly spread over Switzerland were taken during the field campaign of the BDM indicator «species diversity in habitats» (Z9). For the first time, a nationwide harmonised soil data set that includes all main land use types is now available for a comprehensive evaluation. Preliminary results of the measured pH levels reveal the expected differences according to geology. The comparison of vascular plants, mosses and mollusks of the biodiversity monitoring with measured soil parameters allow the identification of soil properties which have a substantial impact on the species diversity in the various habitats of Switzerland. A first comparison between topsoil pH and the reaction value R of plants reveals its applicability as a proxy variable for soil acidity.

Zusammenfassung:

Dank der engen Zusammenarbeit des Feldteams des Biodiversitätsmonitoring Schweiz BDM und der Nationalen Bodenbeobachtung NABO konnte eine grossangelegte Bodenbeprobung durchgeführt werden. Zwischen 2011 und 2015 wurden an insgesamt rund 1200 gleichmässig über die gesamte Schweiz verteilten Standorten im Rahmen der Feldaufnahmen des BDM-Indikators «Artenvielfalt in Lebensräumen» (Z9) auch Bodenproben aus 0–20 cm Tiefe entnommen. Erstmals steht damit ein schweizweit konsistenter und alle wichtigen Landnutzungen umfassender Datensatz von Oberbodenproben für eine umfassende Auswertung zur Verfügung. Erste Auswertungen der pH-Werte zeigen die erwarteten Unterschiede aufgrund der geologischen Ausgangsgesteine. Ein Vergleich der Aufnahme von Gefässpflanzen, Moosen und Mollusken aus dem Biodiversitätsmonitoring mit gemessenen Bodenkennwerten ermöglicht es, Bodeneigenschaften zu definieren, die einen wichtigen Einfluss auf die Artenvielfalt in den verschiedenen Lebensräumen der Schweiz haben. Ein erster Vergleich des pH-Wertes mit ökologischen Zeigerwerten zeigt, dass die Reaktionszahl R der Pflanzen eine gute Schätzgrösse darstellt.

Keywords: biodiversity monitoring, soil inventory, pH, Switzerland, case study

1. Introduction

Switzerland is one of the first countries in the world to monitor its biological diversity. Following the world summit in Rio de Janeiro 1992, the Federal Office for the Environment initiated the Biodiversity Monitoring Switzerland BDM system in 1995. In accordance with the Convention on Biological Diversity to which Switzerland has committed itself, various biodiversity targets were defined and the action plan Strategy Biodiversity Switzerland strives to implement these strategic goals. Unfortunately, until very recently, the value of soil as part of the ecosystem was not appreciated within the Swiss Biodiversity Monitoring programme.

The main objectives of the BDM are to evaluate long-term trends and developments in biodiversity and to establish representative statements for the entire country by including normal landscape properties (www.biodiversitymonitoring.ch). Species richness and diversity are monitored at habitat and landscape level.

In the Swiss biodiversity monitoring framework the core indicator «species diversity in habitats», Z9, is designed to document changes in the species diversity of vascular plants, mosses and mollusks in Switzerland's major habitats (forest, grassland, arable land, settlements, alpine pasture and mountains) and in various altitudinal zones. Species richness analy-

ses of selected groups clearly indicate the ways its diversity is impacted by different land uses. Therefore, Z9 will provide information on the sustainability of different sectors of federal policy. In the past, soil properties were only monitored via indirect indicators such as «nutrient supply in the soil» by averaging nutrient indicator values according to LANDOLT et al. (2010) of all vascular plant species found in a sampling area (excluding unidentified species and collective species). Now the measured pH can be compared with the R-value (Reaktionszahl) to evaluate its applicability across diverse land use categories.

The main goals of this project are to establish a nationwide harmonised soil data set which includes all main land use types, hereby filling a fundamental gap in the national biodiversity monitoring, as well as to gain new insight in the distribution and diversity of vascular plants and mosses across Switzerland. Based on these analyses, soil properties and factor combinations important for high plant diversity can be deduced.

2. Material and Methods

The soil samples were collected on a regular grid of 6 by 4 km. The locations comprise a range in altitude from 199 m above sea level at Lake Maggiore to 2741 m altitude in the Central Alps. At each site 4 individual soil samples at 0–20 cm depth were taken outside the sampling area of the plant and mollusk sampling (Figure 1), so as not to disturb the plot. Due to shallow soils or rock fragments only 1, 2 or 3 soil samples could be taken at some sites. In total, a spatially well distributed data set consisting of some 1'200 sampling sites all over Switzerland was collected to constitute a comprehensive uniformly sampled and prepared soil data set which includes all land use types and regions.

Each soil sample was put into a plastic cartridge, labelled with a unique code specifying the coordinates and the position of the sample (TP A, B, C or D in Figure 1) and protected from heat and evaporation. The samples were sent by Swiss Post to Agroscope accompanied by a protocol specifying coordinates, date, current land use and the name of the person in charge of the sampling. All samples were weighed, dried at 40 °C and sieved at 2 mm in the laboratory of the Swiss Soil Monitoring Network (Desaules & Studer, 1993). The fine earth of some 4'500 individual soil samples are stored in the soil archive of NABO for subsequent analyses.

To make effective use of this unique data set various purpose and evaluation opportunities were established (MEULI et al. 2016). Connecting soil information with the vascular plant, mosses and mollusk recordings is a cornerstone of the BDM-NABO project (Figure 2).

For the first time in the biodiversity monitoring of Switzerland soil and plant information have been gathered at the same spot and set in correlation with each other. The specific indicator values (e. g. R-value) for vascular plants published in Flora indicativa

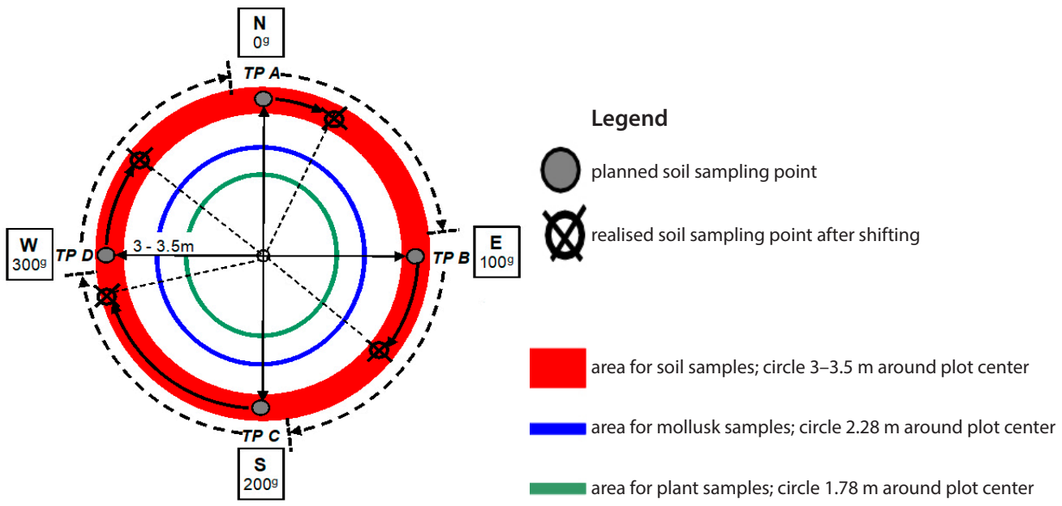

Figure 1: Sampling design of the BDM-NABO project

(LANDOLT et al. 2010) can now be tested in other land use areas, similarly to the way it is already possible for forest vegetation (WSL 2017). The R-values and their expectation ranges are summarized in Table 1.

3. Results

The explorative data analysis of pH reveals a fairly distinct pattern; approximately 20 % of the sampling locations are extremely or strongly acidic and about 25 % show alkaline topsoil conditions (Table 2a). Mean value and median are close to each other indicating a fairly even distribution (Table 2b).

Neutral to alkaline conditions are common in the Swiss Plateau, largely dominated by a mixture of lime and crystalline moraine, material spread over the area by glaciers during ice ages and covering the underlying molasses. Furthermore, regional analyses show large differences between the northern and southern side of the Alps. Acidic topsoil conditions occur frequently in the southern valleys of the Valais and the Grisons as well as in the Canton Ticino, areas in which crystalline rocks and sediments prevail (Figure 3).

As a preliminary result of connecting vascular plant recordings with soil parameters the correlation of the mean pH and the mean R-value per site, consisting of at least 3 plant types, are illustrated in Figure 4. Overall the linear correlation fits fairly well (R2 = 0.56); however, in strongly acid soils (< 3.3) the R-values are mostly to low, whereas between pH 4.5 and 7 R-values tend to fluctuate around 3 and 3.5.

Table 1: Definition of the R-value and expectation range according to LANDOLT et al. (2010)

R-value	Description	pH expectation range
1	Strongly acid	2.5–5.5
2	Acid	3.5–6.5
3	Weakly acid to neutral	4.5–7.5
4	Neutral to weakly alkaline	5.5–8.5
5	Alkaline	6.5– > 8.5

The strength of the correlation varies considerably among the different land use types. Strong linear relation was found in alpine pasture (Figure 5) in the absence of strongly acid soils.

4. Discussion and Outlook

The BDM-NABO soil data set is the first soil data set based on a regular grid which covers all regions of Switzerland and fills a large gap in the framework of Swiss soil information and connects the biodiver-

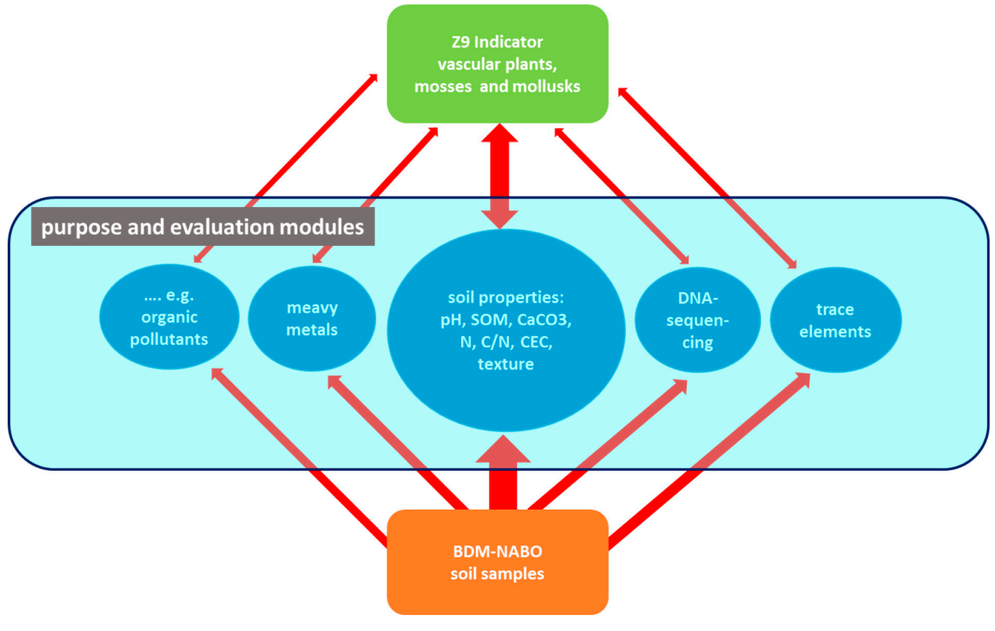

Figure 2: Linking soil properties and vascular plant, mosses and mollusk recordings: an overview

Table 2a: Classification of pH-values according to the Swiss soil classification (BGS 2010)

pH-class ($CaCl_2$)	value ranges	number
strongly alkaline	> 8.2	0
alkaline	7.7–8.2	7
weakly alkaline	6.8–7.6	289
neutral	6.2–6.7	145
weakly acidic	5.1–6.1	288
acidic	4.4–5.0	144
strongly acidic	3.3–4.3	212
extremely acidic	< 3.3	21

Table 2b: Statistical parameters of the pH-values

number	1106
minimum	2.70
10 % percentile	3.77
25 % percentile	4.53
median	5.66
mean	5.61
75 % percentile	6.79
90 % percentile	7.30
maximum	7.97

sity monitoring of Switzerland with measured soil parameters. Topsoil pH levels reflect the underlying geology. For the first time, measured soil parameters can be linked with species richness of vascular plants, mosses and mollusks on national scale. Connecting soil information with the outcome of the vascular plants, mosses and mollusks survey enables the determination of the impact of soil properties on their species richness and diversity. The comparison of measured pH and R-value as an indicator for soil acidity reveals its applicability as a proxy variable across diverse land use types.

In a next step soil organic carbon, nitrogen, cation exchange capacity and texture will be analysed and C/N-ratio determined. Furthermore, DNA-sequencing will be performed on a subset. When relating to the findings of the BDM, these informations may help to improve our understanding of the impact of soil conditions on species diversity. Therefore, soil information clearly provides a great added value to Biodiversity Monitoring in Switzerland.

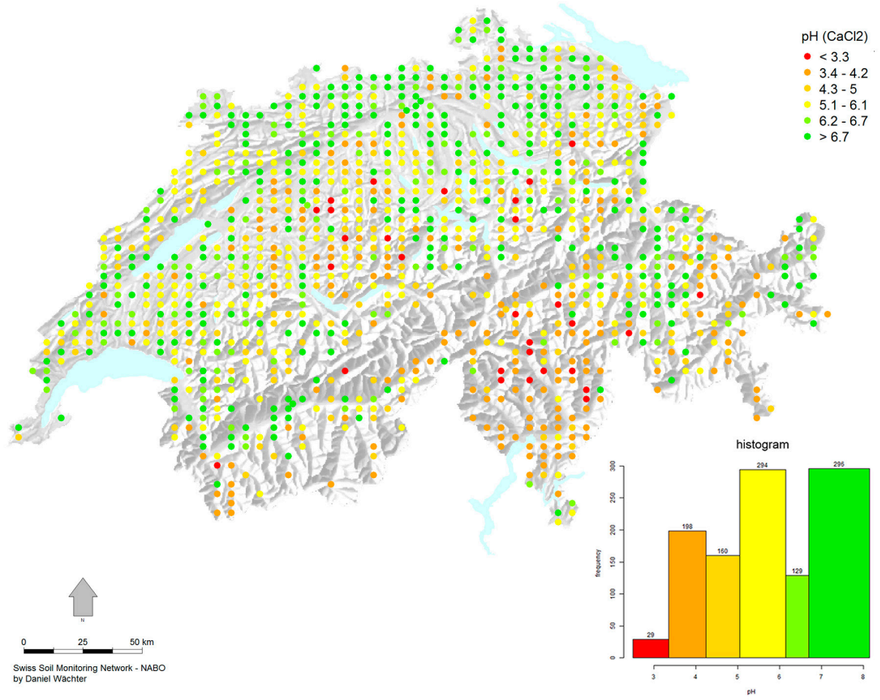

Figure 3: Map of Switzerland with topsoil pH. Sampling locations are evenly spread over the expanse of Switzerland

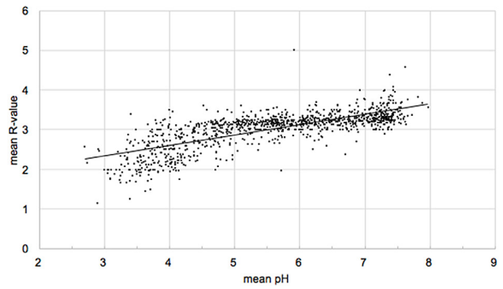

Figure 4: Scatter plot of R-values according Landolt et al. (2010) against pH for all sites with more than 3 vascular plant species (n = 1099). The line indicates the correlation (y = 0.26x + 1.56; R^2 = 0.56).

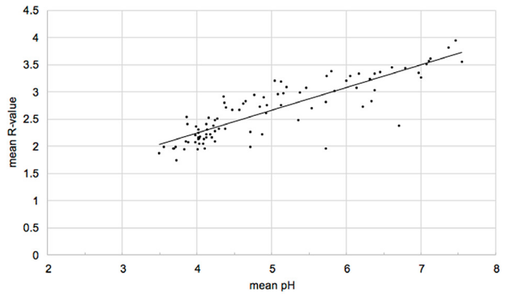

Figure 5: Scatter plot of R-values according Landolt et al. (2010) against pH for the 92 alpine pasture sites (y = 0.42x + 0.57; R^2 = 0.74).

Acknowledgements

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