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НОВЫЕ МЕТОДЫ И РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЙ ЛАНДШАФТОВ В ЕВРОПЕ, ЦЕНТРАЛЬНОЙ АЗИИ И СИБИРИ

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This monograph shall inform you about up to date methodologies and recent results in landscape research. It is intended as a guide for researchers, teachers, students, decision makers, stakeholders interested in the topic of landscape science and related disciplines. It provides information basis for decision makers at various levels, from local up to international decision bodies, representing the top level of landscape science in a very short form.

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Photos 1,2. Field research plots of the Lithuanian Research Centre for Agriculture and Forestry, and two typical soil profiles within the soil mosaic of the agricultural landscape. Soils are a Haplic Luvisol and an Albic Gleyic Luvisol. Soils are typical for landscapes having a leaching regime. In case of redoximorphic properties in the deeper part of the soil profile temporary stagnant water or, like in the right photo, a sometimes relictic shallow water table may occur. In both cases, this is often associated with a slow lateral movement of water and leachates.

Основная глава 8.3 Мониторинг лесов
Main Chapter 8.3 Forest Monitoring

Chapter III/11: MONITORING PROCESSES IN FOREST SOILS OF THE NORTHEAST GERMAN LOWLANDS
Глава III/11: Мониторинг процессов в почвах под лесом в Северо-Восточной Низменности Германии

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ABSTRACT. The goal of the National Forest Soil Inventory is to provide a periodic overview on the spatial and temporal variation of forest soil condition. With regard to the anthropogenic and natural influencing factors the intensive monitoring sites of the Level II-program serve to gain a better understanding of the relevant cause-effect relationships. By the example of the Northeast German lowlands, the data obtained can be used to record changes in forest soil condition and to interpret them properly in the context of the effective pedogenic processes. An important factor that has shaped the soil condition in the past decades is the atmospheric deposition of nutrients and pollutants. Due to the generally improved air quality, an increasing dependence of the slightly changing soil properties on the natural conditions (e.g. parent material) as well as on the influence of the stand structure can currently be observed.
INTRODUCTION

For landscape research, reliable and representative environmental data are needed. A tried and tested measuring system which meets this demand is the National Forest Soil Inventory (NFSI), which is presented in this paper using the example of the Northeast German Lowland region. In the German federal state of Brandenburg, the NFSI includes 322 systematically distributed survey plots (1). Brandenburg is covered with 1.1 million hectares of forest area which corresponds to about one third of the state area. Both for ecosystems and on the scale of the landscape, forest soils fulfill crucial functions with regard to the water, nutrient and heat balance. The forest soil inventory was designed above all to investigate the current condition of forest soils in connection with atmospheric inputs. By repeating the NFSI every 15 years, changes over time can be detected with regard to deposition of air pollutants and climate change and their influence on soil chemical properties and site characteristics. Moreover the NFSI forms a suitable basis for the regionalization of inventory data and their coherent representation in the overall context of the landscape (2).

In addition to the extensive inventory plots of the NFSI as part of the European Level I monitoring program (3), there are eight intensive monitoring sites in Brandenburg which are representative of typical natural areas of the state (4). These sites are at the same time part of the European Level II monitoring program. All these intensive monitoring sites are equipped according to the standards of the ICP-forests (3) to model ecosystem water and element fluxes with high temporal resolution. This allows a detailed analyzes of the key ecosystem processes (5, 6).

SURVEY DESIGN

The NFSI is conducted as a co-operation between the Federal Government and the German states. The states are responsible for the assessment, analysis and evaluation of their own data. The survey is coordinated by a task force of the Federal Government and the German states. The Thünen-Institut of Forest Ecosystems keeps this data in a central database and is in charge of analyzing it nationwide.

For historical reasons there are two different inventory grids in the state of Brandenburg, each covering the whole forest area with a plot distance of 8x8 km. In total 322 plots were examined in the years 2007 and 2009 (NFSI II). 147 plots of this sample had already been examined in 1992 (NFSI I). The next inventory will take place as planned in the year 2022. The position of all examination plots is shown in Fig. 1.

At each inventory site a comprehensive soil profile and site description were made. Both the vegetation and stand characteristics were recorded and needle / leaf samples were taken to analyze the current tree nutrition status. On each plot, soil material from eight circularly arranged satellite points was combined to one composite sample. The distance between sampling center and satellite points was 10 m. Soil sampling plots of the NFSI II were shifted 10 Gon from NFSI I satellites. Samples were taken from the organic layer (OF/OH-horizons) excluding the litter horizon (OL), as well as from the mineral soil in 0-5 cm, 5-10 cm, 10-30 cm, 30-60 cm, 60-90 cm, 90-140 cm and 140-200 cm. To measure the bulk density in the laboratory, additional undisturbed core samples were taken of the mineral soil at the same depth intervals as the composite samples. The sampling procedure is described in detail in (7). Laboratory analyzes included pH, carbonates, organic carbon, total nitrogen, effective cation exchange capacity, plant available nu-

KEYWORDS: forest, soil, monitoring, forest inventory, soil survey, soil condition, soil acidification, carbon storage, forest nutrition, air pollution

ключевые слова: лес, почва, мониторинг, инвентаризация леса, обследование почвы, состояние почвы, подкисление почвы, запасы углерода, питание леса, загрязнение воздуха

Резюме. Целью Национальной инвентаризации лесных почв является периодический обзор пространственных и временных изменений их состояния. Что касается антропогенных и естественных факторов воздействия, то интенсивные участки мониторинга программы II уровня служат для лучшего понимания соответствующих причинно-следственных связей. По примеру Северо-Восточной Низменности Германии полученные данные могут быть использованы для регистрации изменений состояния лесных почв и их правильного понимания эффективных педагогических процессов в них. Важным фактором, который сформировал состояние почвы в последние десятилетия, является осаждение питательных и загрязняющих веществ из атмосферы. В связи с общим улучшением качества воздуха в настоящее время наблюдается возрастание зависимость незначительно изменяющихся свойств почвы от природных условий (например, материнской породы), а также от влияния структуры древостоя.

56
trient stocks, total elements including heavy metals, particle size distribution, coarse fragments and bulk
density of about 2.500 soil samples per inventory.
On the intensive monitoring sites meteorological parameters as well as soil moisture, element concentra-
tions in soil solution and current tree growth are continuously recorded by data logger. Via radio modem
the data are transferred to a PC at the Eberswalde Forestry Competence Centre in a daily to weekly cycle.

**CASE STUDY: STATUS AND DYNAMIC OF SOIL ACIDIFICATION**
The area of Brandenburg is situated in the transitional zone of oceanic and continental climate. The annu-
al average temperature varies regionally between 8.6– 9.3°C (1). The annual climatic water balance rang-
es from minimum values of about –82 mm to maximum values of about +36 mm. The parent materials
are Quaternary sediments. In the topsoil mainly glacial cover sands, glacial fluvial sands, aeolian dune
sand and glacial loam occur. The most common soil type is the podzolic brown-earth (WRB: Spodic
Arenosol). The brown-earths differ in various degrees of the development of the spodic horizon. In addi-
tion, Podzols occur on the nutrient-poor dune sands and Luvisols on glacial loam. The inventory sample
consists of about 70% pine, 7% oak and 3% beech stands. 16% are other deciduous stands and 4% other
coniferous stands.

![Figure 1 – Forest area in the state of Brandenburg with plots of the National Forest Soil Inventory and
Intensive Monitoring Sites of the Level II programm.](image1)

Indicators of the soil condition show on the one hand a dependence on the natural site properties. For
example, the total calcium content in 0-90 cm depth shows a spatial distribution pattern that reflects a
dependence on geology, particularly on the stratigraphy. Thus in the northeastern part of Brandenburg
there are the younger Pleistocene deposits with accordingly higher total Ca contents (Fig.2).

![Figure 2 – Total Calcium stock [kg/ha] in 0-90 cm soil depth at the NFSI-plots of the state of Brandenburg with growing districts](image2)
However, anthropogenic factors characterize in particular the dynamic of slightly changing soil parameters such as pH-value and base saturation. Between NFSI I and NFSI II a decrease in the pH-values was recorded in the humus layer and the mineral top soil to 30 cm depth. In the subsoil it is not significant. The base-saturation as a sensitive indicator of soil acidification has decreased significantly in all depths of the examined soil body (Fig. 3) and the calcium and magnesium stocks have changed from predominantly low-medium to low (Ca) and from low to very low (Mg) values, respectively (valuation levels by (8)). The leaching of calcium and magnesium ions, which had formerly been deposited by flying ash from brown coal power plants, is seen as one of the reasons for this obviously strong soil acidification in a relatively short period. A pronounced loss of base-cations is recorded especially in those soils that had unusually high base saturations for these normally nutrient-poor sandy soils at the time of NFSI I (9).

In the 1970s and 1980s the chemical topsoil condition was strongly affected by the atmospheric deposition situation. Until the first NFSI, particularly southern Brandenburg was one of the regions of central Europe most influenced by immissions. Different deposition intensities of acid sulphur compounds and ashes from brown coal-fired power stations with buffering capacities overlapped in a regionally varying pattern.

After the reunification, the atmospheric deposition strongly decreased due to decommissioning of industrial plants, introduction of flue gas cleaning systems and the use of low-emission energy sources. Of particular note is the elimination of the basic dust input, with the result that the importance of the acid deposition for the acid-base-status of the top-soils increased. With the end of this specific atmospheric input after the reunification, the accumulated mobile anions of sulfuric acid were leached out, taking corresponding amounts of calcium and magnesium cations with them. These results clearly differ from regions with formerly high depositions of sulphur, where sulphur was accumulated as aluminium hydroxyl sulphate under acid conditions. Based on element balances of intensive monitoring sites (Level II program) it was shown that the base stocks of the sites previously affected by flying ashes are now nearly exhausted (5, 10). Using the data of the NFSI II it can be confirmed that these individual findings from case studies are representative for a large part of the forest area in Brandenburg. Thus, in the regions formerly affected by dust deposition, it is assumed that the reduced base-saturation recorded in the NFSI II represents a more natural state than the artificially elevated values at the time of the NFSI I.

![Figure 3 – Base saturation of the NFSI plots of Brandenburg (below: NFSI I in the years 1992/93; above: NFSI II in the years 2007 and 2009)](image)
CONCLUSIONS
1. The National Forest Soil Inventory in combination with the intensive monitoring sites of the Level II-program is suitable for the representation of changes in the soil condition both descriptively and causally analytically.
2. Current data show very high dynamics of fundamental soil chemical properties.
3. The changed element input rates by atmospheric deposition induced the decrease of base stocks of forest soils in the Northeast German lowlands. As a result, currently many sites are returning to their naturally nutrient-poor status, which corresponds to the silicate-poor parent material.

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