1. Introduction

Eutrophication of freshwater, resulting from excessive N and P loads, is a global phenomenon leading to a wide range of water-related problems, including unpalatability of drinking-water, release of several toxins which are known to pose serious health hazards to livestock and humans, and a general deterioration of water quality. Phosphorus (P) is often the limiting nutrient for algae blooming, hence its control is of prime importance in reducing the accelerated eutrophication of freshwater (SHARPLEY & REKOLAINEN, 1997). The European Community has addressed this problem by starting the COST (Co-operation in Science and Technology) Action 832 „Quantifying the Agricultural Contribution to Eutrophication". Key subject areas of work included the establishment of common terminology, sampling and analytical procedures, principles of fertiliser and feed recommendations, soil organic and inorganic P release, soil erosion and leaching, incidental loss, P loss risk assessment, hydrological pathways, scaling issues, approaches to modelling and future research needs (WITHERS & CHARDON, 1998). By contrast to agricultural mineral soils, the effect of setting-aside, re-wetting and restoration measures of the P mobilization and pollution of freshwater in hydrologically sensitive areas has yet no been a important field of research on the European level, despite of its great importance.

The soils of **hydrologic sensitive regions** are often Histosols (named according to incomplete decomposition of primary organic matter). Global experience showed that intensive agricultural use of Histosols resulted in decreasing soil fertility, oxidation of peat and corresponding CO_2-emissions to the atmosphere, nutrient transfer to aquatic ecosystems and losses in the total area of these native wetlands. To prevent these negative environmental effects and restore some of the wetlands ecosystems, set-aside programs and re-wetting measures were promoted in several countries. There were indications in the literature that the restoration of Histosols and wetlands as a mean of environmental protection may result in an enormous P mobilization and accelerated eutrophication risk. MARTIN et al. (1997) observed relationships between ground water table and P release into soil solution and between the history of drying/re-wetting and the proportions of soluble P fractions in Histosols from the "Everglades Nutrient Removal Project" (Florida/USA). In the "Marsh Conservation Project" (Florida/USA), ROBINSON et al. (1998) measured P-concentrations up to 10 mg l^{-1} soluble reactive P after re-wetting. Their modeling results suggest that the re-wetted Histosols will be a source of continuous P-release for the next 30 years. In the "Drömling", a shallow lowland peat area in Saxony-Anhalt (Germany), KALBITZ et al. (1999) observed gradual increases in the proportions of soluble P in soil (≈ 200 kg ha^{-1}) and the P-concentrations in near-surface groundwater (≈ 0,04 mg l^{-1}) after re-wetting of the formerly intensive agriculturally used Histosols. In the Hula Valley (Israel) HAMBRIGHT & BAR ILAN (1995) observed elevated P concentrations following the re-wetting of peat soils, up to 0.35 mg l^{-1} of total P in a newly formed lake, much higher than data reported earlier in the outlet of the Jordan River from the basin. The following **hypotheses** were formulated to explain these observations: (1) Mineralization of organically bound P during drying, aeration and oxidation of peat plus input of mineral and organic P fertilizer in periods of intensive use for pasture or arable led to large amounts of P stored in the soil, parts of which were bound to Al, Fe, and Mn oxides and hydroxides. (2) After re-wetting the increased moisture contents and lowered redox potentials resulted in dissolution of sesquioxides which released the sorbed P into the soil interstitial water. The high water table re-mobilized P, as orthophosphate ion or in dissolved organic matter (DOM).

These hypotheses were also supported by various publications: IVANOFF et al. (1998) developed a novel fractionation scheme for the investigation of organic P forms. They observed decreased proportions organic P, especially of biomass-P, after re-wetting of a Histosol. KALBITZ et al. (1999) determined a significant relationship between P concentrations in near-surface groundwater and the redox potential. Histosols in the Drömling area that were kept under wet conditions showed significantly lower P losses to the adjacent surface water. AUSBORN et al. (1997) observed basic relationships between temperature, redox potential and the contents of labile P-fractions in a few microcosm experiments. In summary, the cited publications indicated very clearly that the desired re-wetting of agriculturally used Histosols may be accompanied by an undesired P solubilisation and diffuse P losses to freshwater can cause accelerated eutrophication of downstream aquatic ecosystems. The chemical background and possible amounts of such P losses under different soil and climatic conditions were not known. The **substantial areas of Histosols** in the EC and associated countries, and **the lack of basic knowledge and conceptual models** made it difficult to predict the effects of large-scale re-wetting measures on water quality. Hence, scientifically based re-wetting strategies and a framework for political decisions (decision making system) were urgently required.

Therefore, we developed the PROWATER project to lay an improved scientific base for the sustainable management of fen peat soils in hydrologically sensitive areas. Specific objectives of the project were:

(1) to identify the chemical forms of P in native, degraded and re-wetted Histosols as one key factor for P mobilisation and P losses,

(2) to measure in some representative case studies the actual diffuse pollution with P of water that is hydrologically connected to re-wetted Histosols as a basis for modelling the P release risk in these areas,

(3) to improve or develop conceptual models of P turnover in soil by considering the special features of Histosols, and to use numerical models of fluid flow and P mass transport for predictions of P pollution from Histosols and eutrophication risk, and

(4) to develop a user-friendly decision support system (DSS) that can be used to propose re-wetting and restoration strategies for Histosols in sensitive areas that enable the prevention of freshwater resources from diffuse pollution with P and eutrophication.

The new knowledge should be generated by integrating advanced methods such as automated *in-situ* monitoring, newly developed P fractionation schemes, sophisticated spectroscopic methods, microcosm experiments and with the development and application of conceptual and numerical models, a socio-economic evaluation and the extension of research results to the end-users. Figure 1.1 illustrates the work packages and time schedule of PROWATER.

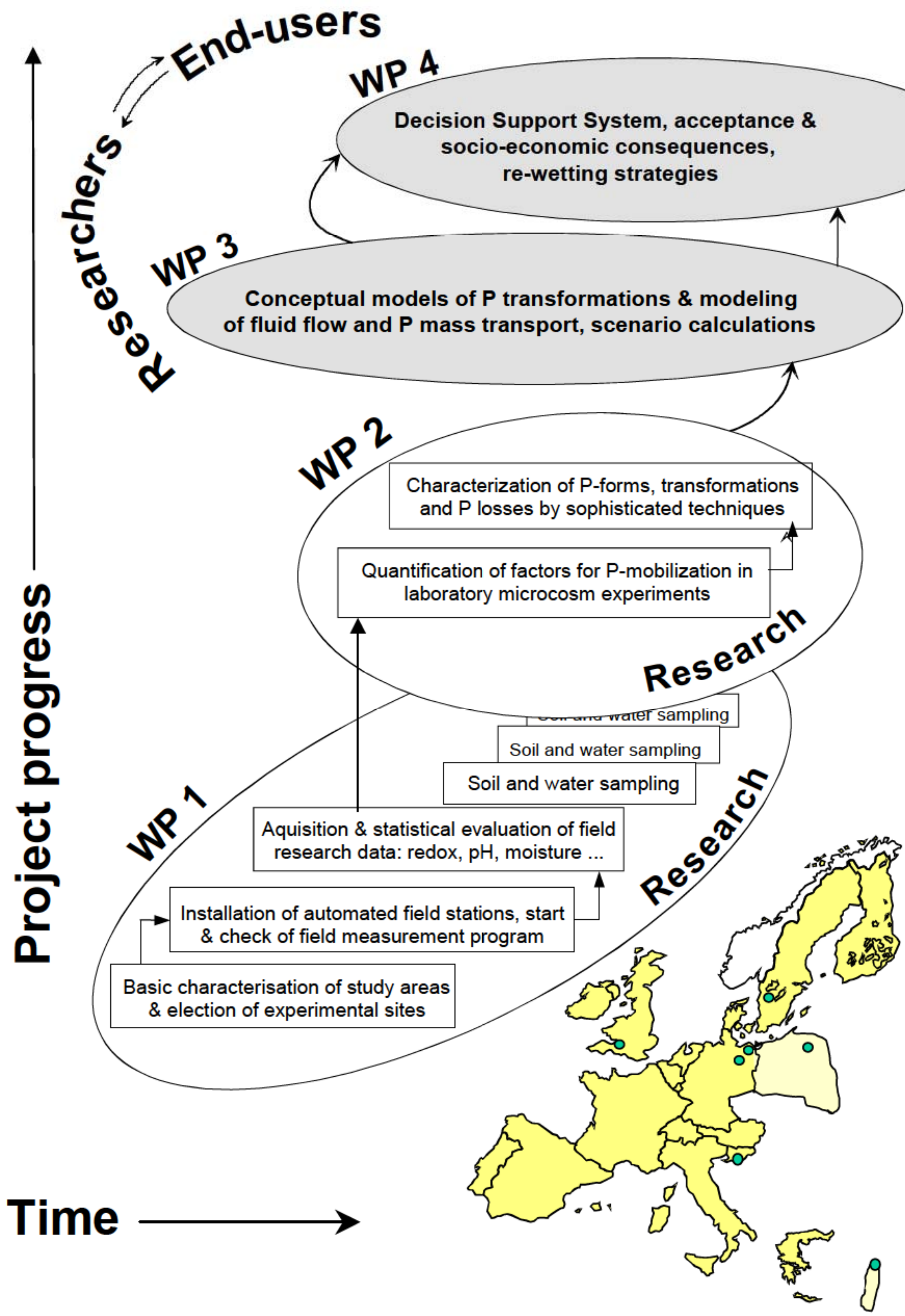

Figure 1.1 Work packages and schedule of the PROWATER project

UFZ Report

Program for the prevention of diffuse pollution with phosphorus from degraded and re-wetted peat soils

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