A decision support system for management of mires in the forest

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Summary

For successful restoration of forest mires, a wide range of different ecological conditions have to be considered. Therefore the Deutsche Bundesstiftung Umwelt (DBU) supports the development of a decision support system (DSS) for management of forest mires. Based on the identified decision relevant parameters the basic structure (model component) of the decision support system has been elaborated. The model part of the DSS has a modular concept and is divided in two decision sections to derive main restoration objectives and measures. In each module a sectoral decision making is supported using a dichotomous decision tree ensuring easy handling and high transparency of the decision-making process. The management strategy submits proposals for optimal rewetting methods, measures to increase water supply from catchment area and best methods to reduce undesirable afforestation.

Key index words: decision support system, forest mires, mire restoration, rewetting, management strategy

Introduction

In the extensive woodland of Central Europe a large quantity and a wide range of fens and transitional mires are located. Many 'forest mires' have been negatively impacted by humans in the past. For a successful restoration measure, in regard to the development potential as to the choice of proper measures, there is a wide range of different ecological conditions that need to be taken into consideration. Forest mires in this investigations are defined as fens (with or without wood) connected to forest. The catchment area is predominantly covered with wood, which has a significant impact on the water supply of the mire. They are completely or partly fed by water which has been in contact with mineral subsoil.

In many cases the hydrological regime of forest mires has been negatively impacted by direct drainage due to agriculture or commercial forestry. Many of them lost their production function meantime but though pressures like drainage are still active.

Current climate changes have an additional negative impact on the mires water balance. Especially in some parts of North East Germany with high density of forest mires, the regional groundwater table is dramatically decreasing. In addition, the nonnatural dominance of coniferous woodlands reduces the water supply from catchment area (Müller *et al.*, 2002).

In relation to the large number of forest mires that need to be restored, very often only a small budget for consulting service is provided. A suggestion to compensate the lack of consultancy and to supply local forestry offices with information is a decision support system (DSS) for management of mires in the forest. The DSS-WAMOS (**WA**ld**MO**or**S**chutz) should derive an individually adapted optimal proposal for best restoration measures. A main feature is the conversational function leading trough the decision making process and providing specific information for each decision step to make it as much transparent and comprehensible as possible (Ubbels and Verhallen, 2000; Goosen *et al.*, 2006).

Material and methods

To develop a DSS it is necessary to identify the decision relevant parameters with high indicator-value for measure selection. Therefore it is important, to figure out the most essential parameters to reduce the data-requirement. Additionally, we will apply the current expert knowledge about mire restoration to the DSS-WAMOS. So we combined several methods. At first, current technical literature and guidelines concerning the restoration of mires have been studied (BAFU, 1992-2002; Succow and Joosten, 2001; LUA Brandenburg, 2004; Kratz and Pfadenhauer, 2001; LfU, 2002; LfU, 2003; Bayerische Akademie für Naturschutz und Landschaftspflege, 2003; Zollner and Cranauer, 1997; Quinty and Rochefort, 2003). Additionally, several expert discussions about restoration with participants from science and practice had been arranged. Completed restoration projects were analysed in regard to relevant parameters and eventual causes of failure and existing DSS-components were searched and reviewed in regard to its applicability for the DSS-WAMOS. With the identified decision relevant parameters dichotomous decision trees were build up as main model elements.

Results

The model of the DSS-WAMOS (Fig. 1) is based on a modular concept adapted to the principles of ecological planning (Pfadenhauer and Zeitz, 2001). It is split in two decision sections in order to derive main restoration objectives and to determine best fitting measures.

Both sections contain several modules to handle different decision aspects. In each module the sectoral decision making is supported by a dichotomous decision tree. Sectoral decision results are summarized in an integrated management strategy with the help of matrices.

The first aspect to define the restoration objective is the availability of water, which may limit the rewetting potential, in respect of parameters like discharge, groundwater level, climatic water balance, permeability of mineral subsoil and slope of adjacent watershed.

The second important aspect is to assess the risk of impairment on protected species and habitats caused by rewetting. A rising water table can cause nutrient release, depending on the nutrient content of topsoil and inflowing water (Trepel, 2004; Zak *et al.*, 2004). Protected oligotroph habitats in the mire or downstream may be damaged. Furthermore, unadjusted rewetting can cause serious damage on protected habitats which are not adapted to inundation. For assessment, different ecological mire types and habitats including their neighbouring need to be considered as well as degree of topsoil earthyfication, intensity of agriculture and forestry, mire/watershed area ratio and mire discharge.

At last, ongoing land use in the mire can limit a full rewetting and has to be considered in determination of the restoration objective. In total 6 different restoration objectives have been formulated concerning the prospective water regime (with or without inundation) and the kind of land use or maintenance.

The second decision section 'determination of measures' calculates the measures for implementation of the restoration objective. To determine the water engineering measures, the local hydromorphological characteristics are classified by a decision tree considering the following parameters: slope of mire surface, mire depth, thickness of earthified topsoil, decomposition of peat layer in the subsoil, water permeability of mineral subsoil, afforestation, existence of confined (artesian) groundwater and type of ditches. Finally, this results in the description of 20 different hydromorphological site types with different starting conditions for rewetting. In consideration of the restoration objective the adequate water engineering measure scheme is given by a matrix.

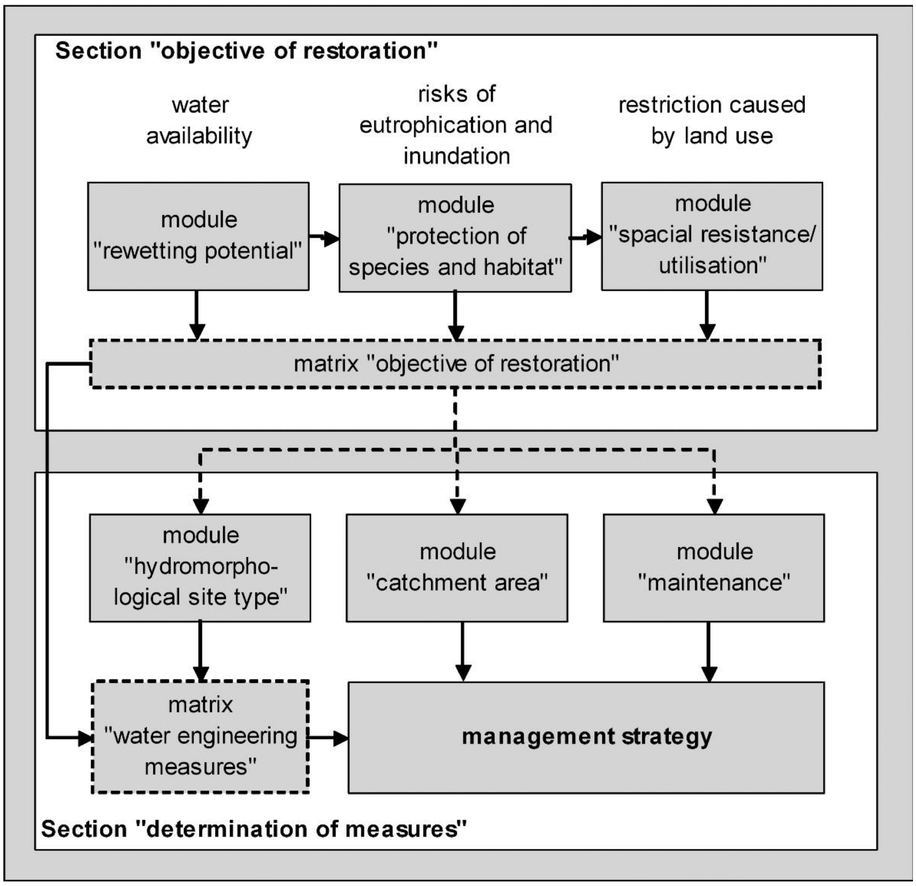

Figure 1. Basic structure of the DSS-WAMOS model.

Within the module 'catchment area' a decision can be made on measures to increase water supply from catchment area. It can be realized f. ex. by reducing the density of forest stands or by converting coniferous woodland into deciduous woodland. Relevant criteria for measurement determination are the abundance and composition of forest skirt bordering the mire, forest species composition, forestal site type of forest stand, age structure of coniferous forests in the catchment area and incidence of protected species and habitats in the mire.

The module 'maintenance' proposes how to handle undesirable afforestation in the mire depending on feasibility of water engineering measures, type of current land use, species and abundance of mire grove, abundance of Hypnum moss, incidence of specific kinds of shadowing-sensitive vegetation that need to be preserved, hydrostatic type of mire (ability of surface oscillation) and long term warrantee of maintenance.

The input parameters for all modules will be provided by a standardized field mapping method for forest mires (Luthardt *et al.*, 2004), which has been developed for evaluation of the ecological status of forest mires and enhanced for appliance to the DSS-WAMOS.

As an example, Fig. 2 shows a cutout of the dichotomous decision tree used in the module 'protection of species and habitats' to assess the risk of internal or downriver eutrophication by parameters indicating the vulnerability and potential pressures. It starts with categorising the ecological mire type in respect of different vulnerability and different nutrient release rates. Potential pressures for internal eutrophication are nutrient rich areas within the site or nutrient rich inflow into the mire which can pollute nutrient poor parts of the mire in case of inundation.

Pollution of downriver habitats can occur in case of strongly earthified topsoils and intensive former landuse in

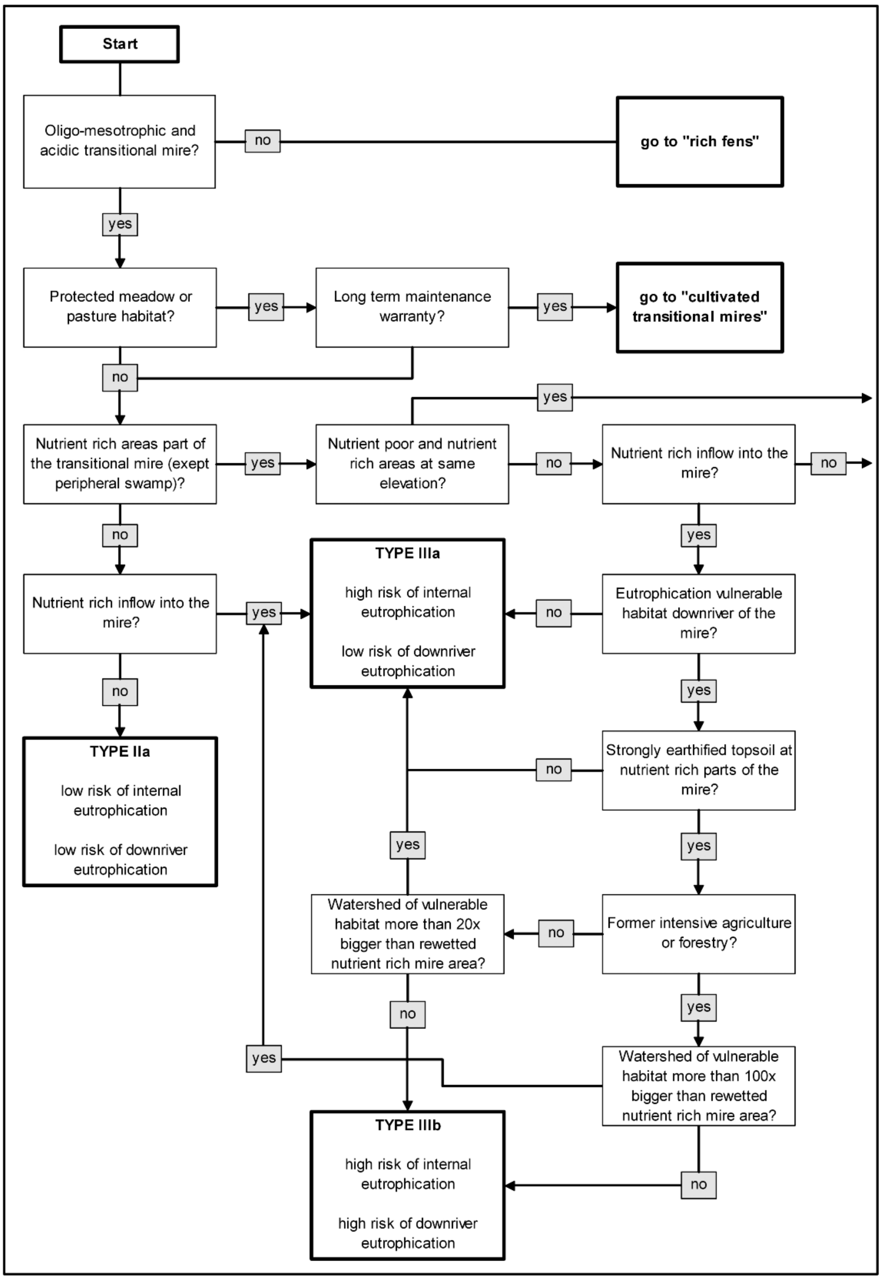

Figure 2. Cutout of a dichotomous decision tree used in the module "protection of species and habitats".

the mire but high discharge from catchment area can lower risk by dilution. Depending on average regional discharge the risk can be assessed as ratio of watershed size and rewetted nutrient rich mire area (Trepel, 2004).

Fig. 2. Cutout of a dichotomous decision tree used in the module "protection of species and habitats".

At the end of the decision tree a risk-classification is located which will be considered for determination of restoration objectives by a matrix in the form of proposals for preventing inundation or a stepwise proceeding of rewetting. Overall this decision tree is made up of 200 branches but the maximum path length is stretched just across 12 branches. The other modules need at most 4 to 8 steps for decision making with a total amount of 14 to 56 branches.

To every branching point the DSS gives a basic instruction explaining the decision relevant criteria and classification scheme and providing further information like references, weblinks or illustrating materials. The first draft of the DSS-WAMOS is in test stage and is intensively discussed in several expert forums. Until end of 2008 a final version with public access will be posted on the internet (www.dss-wamos.de).

Conclusions

The DSS-WAMOS is an appropriate instrument to derive an individually adapted proposal for restoration objectives and measures in forest mires with high reliability at rather low data-requirement, high transparency of decision making process, simple practicability by using dichotomous decision trees and provision of expertise and professional decision-relevant information. It offers established action strategies for individual mire types and different stages of degradation. This tool should offer practitioners (forestry offices, forest owners, nature conservation authorities et cet.) an easy access to apply current knowledge of forest mire restoration.

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