THE GRAS-MODEL (GRASSLAND-SUCCESSION-MODEL)

A simulation model for the succession of grassland biotopes under various management regimes (developed for the Eifel National Park)

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Abstract: The GraS-Model was developed to support decision making concerning goals and perspectives for the grassland areas of the former military training site Vogelsang in Eifel National Park. The focus of the model is to simulate the development of the landscape under different management regimes, starting from the current situation of biotope type, land use, wildlife, etc.. Besides current maintenance (hay-making, grazing by sheep), the impact of additional megaherbivores (wisent, Heck cattle and konik horse) and undisturbed succession is included.

Accounting for neighbourhood relationships, the model is set up as a cellular automaton. For this purpose, the modelled area of approximately 1,500 ha is divided into 10 m x 10 m cells in which all processes included take place. The succession is modelled using simple ecological rules, which were extracted from our own data analysis based on the coexistence of different succession stages within the Eifel National Park and on the knowledge of former land use. The results of the simulation are displayed in spatially explicit maps using the software ArcGis.

Applying this approach, we are able to predict the development of the landscape in the former military area Vogelsang under different management regimes for up to 100 years.

Keywords: land use change, identifying appropriate conservation and restoration objectives, restoration of grazing and other traditional management techniques, modelling

Introduction

When the Eifel National Park was established in 2004, the GraS-Model was developed to support decision making concerning goals and perspectives for the semi-natural grasslands of the former military training site Vogelsang. The focus of the model is to simulate landscape dynamics under different management regimes, starting from the current situation of biotope type, land use, wildlife, etc.. Considered scenarios are undisturbed succession including wild game such as roe deer and wild pig, undisturbed succession with megaherbivores being introduced to the area (wisent, Heck cattle and konik horse) and two forms of active management (hay-making and grazing with sheep).

Because a model can only be as good as its database, relevant processes were extracted from our own data analysis based on the coexistence of different successional stages in the Eifel National Park and on the knowledge of former land use. We analyzed the species composition and extracted the most relevant succession stages (LENNARTZ et al. 2006). Information about the speed of processes was gained from data about historical land use in the area (historical maps and aerial photographs). The model is intended to illustrate the impact of different management techniques on the vegetation.

Materials and methods

Study site:
The Eifel National Park covers 10,800 ha of forests and grasslands. The simulated former military training site Vogelsang lies in the centre of the National Park, containing about 1,500 ha of semi-natural grasslands. A climate gradient runs through the site because the area rises from about 400 m in NE to about 580 m above sea level in SW. Mean annual temperature and precipitation range from 8 °C and 700-800 mm in NE to 6.5 °C and 1000-1200 mm in SW, respectively (LENNARTZ & RÖÖS 2006). Acid brown soils (pH_{CaCl2} 4-5) of shallow soil depth predominate. Prevalent plant communities are mountain hay meadows and mountain pastures, shrubberies of *Cytisus scoparius* or *Rubus* spp. and spruce, beach or oak forests.

Model description:
Accounting for neighbourhood relationships between different habitats, which are a major factor for vegetation succession (SCHREIBER 1993, ELLENBERG 1996, GLAVAC 1996, DIERSCHKE & BRIEMLE 2002), the model is build up as a cellular automaton (Fig 1). The modelled area (approximately 1,500 ha) is divided into cells in which all processes included take place. Each cell is defined by its position, its width and its length. A size of 10 x 10 m was chosen to avoid artefacts which might result from a wider grid (BITHELL & MACMILLAN 2007). Each cell contains a set of plant species with a dynamically modelled coverage. Within each cell, species compete against each other. New species may immigrate from neighbouring cells or may spread further distances via seed dispersal. As not all occurring species can be modelled, a set of representatives was chosen: ten grasses/herbs, three bushes and four trees. We distinguish between grasses/herbs, shrubs and trees because the mechanisms of competition differ between these types.

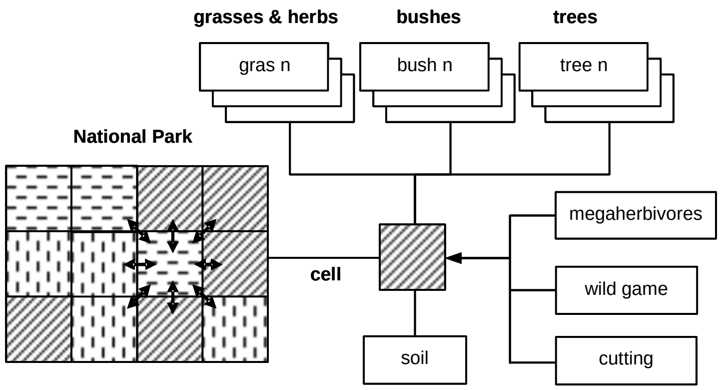
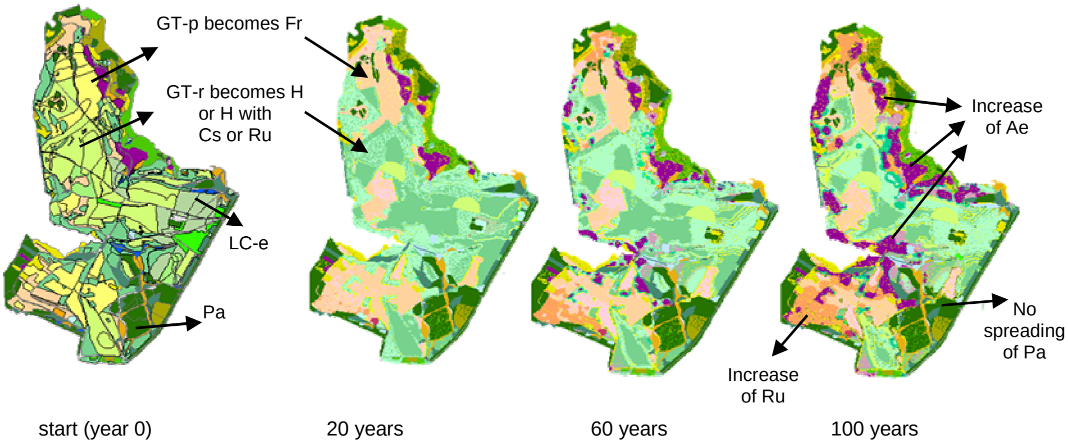


Figure 1. Concept of the GraS-Model

The competition strength of each species in relation to others varies depending on soil properties and land use. The actual relative competition strength is calculated using indicator numbers for cutting, grazing and stamping which are available for each species (BRIEMLE et al. 2002). The animals influence vegetation succession by herbivory (roe deer, wisent, Heck cattle, konik horse and sheep) and by disturbance of the sward (wild pig), promoting the germination of seeds. Important input data is spatially detailed data of vegetation distribution, land use and soil properties of the modelled area. Output data consists of vegetation units which are derived from the coverage of each species. It can be presented in spatially explicit maps using ArcGis.

Results and discussion

The vegetation succession in an area of approximately 1,500 ha was simulated. As an example for one scenario in the southern section of the former military training site (380 ha) we show the development of vegetation at non-interference (including existing wild game) over 100 years (Fig. 2).



	GT-p	nutrient poor mountain meadow (*Geranio-Trisetetum*)
	GT-r	nutrient rich mountain meadow (*Geranio-Trisetetum*)
	Fr	dominance of *Festuca rubra*, nutrient poor, abandoned grassland
	H	dominance of Hemicryptophytes like *Dactylis glomerata, Holcus lanatus*, nutrient rich, abandoned grassland
	Ae	dominance of Tall oat-grass (*Arrenatherum elatius*), abandoned grassland
	LC-e	Mountain pasture (*Lolio-Cynosuretum*), nutrient rich, extensively used
	Cs	common broom (*Cytisus scoparius*)
	Ru	black- and raspberries (*Rubus* spp.)
	Pa	spruce forest

Figure 2. Simulation of vegetation dynamics at non-interference

At non-interference the mountain hay-meadows and pastures in the southern part of the former military training site become fallow grasslands dominated by either *Festuca* *rubra* at nutrient poor sites or *Holcus lanatus* and *Dactylis glomerata* at nutrient rich sites. These abandoned grasslands further evolve into dominances of *Arrenatherum elatius*. Though *Cytisus scoparius* does not go extinct, it is slowly repressed by *Rubus* spp.. Because of a high density of red deer (about 22 animals / 100 ha) and the abandoned grasslands' dense sward, the forests in the area cannot spread. Seeds either do not reach the ground so that they are not able to germinate, or young seedlings are eaten up by the red deer.

Conclusions

The GraS-Model provides plausible predictions of vegetation dynamics for up to 100 years with a high spatial resolution. The processes included are appropriate to simulate interspecific competition. Neighbourhood relationships are integrated using the cellular automaton.

Because the GraS-Model gives a high spatial resolution of the outcome from a chosen management procedure, one can easily accomplish an efficiency control of ecological restoration. It provides the opportunity to analyse the relevance of single processes. For example, the impact of red deer on forests formation can be analysed by simply turning it off.

The GraS-Model is still under development. Further goals are to integrate a better representation of wildlife behaviour and the impact of soil properties.

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