Summary

Grassland yield, which is influenced by many factors, can be estimated by different models, mapping certain natural processes in a simplified way. The prerequisite for a state-wide analysis of grassland yield is the integration of these models into a Geographic Information System (GIS), since the model parameters have a well-defined spatial reference.

Grassland with its different characteristics (extensive and intensive) covers an area of 1.61 million hectares, which represents more than 50 % of the Austrian agriculturally used area. Grassland is managed by 115,000 grassland and cattle farmers, mostly running small structured enterprises. It is the most important forage resource for cattle (more than two million heads), horses, sheep and goats. Beside of forage production, grassland plays a specific role for shaping an attractive cultural landscape and is part of important processes in the ecosystem.

Over the past years, the global climate change has affected parts of Austria by the occurrence of intensive drought periods, which caused heavy drought damages on agricultural areas, especially in the Northeast, East and Southeast of Austria. For example in the year 2003, the drought damages on grassland amounted to about 300 million Euros. An appropriate insurance against drought damages on grassland is not yet available, because qualified, scientifically based models do not exist so far.

The Austrian Federal Ministry of Agriculture and Forestry, Environment and Water Management (BMLFUW) reacted on that situation and charged the Federal Research and Education Centre for Agriculture Raumberg-Gumpenstein (HBLFA) with the development of a model aiming at the determination of drought damages on grassland. In the year 2002, an integrated project has been started with the installation of exact grassland field trials on 27 different sites throughout Austria. The data from these grassland trials, particularly yield and forage quality, are the main basis for growth and yield modelling.

The Institute of Meteorology at the University of Natural Resources and Applied Life Sciences in Vienna (BOKU) is responsible for developing a growth and yield model and furthermore provides the necessary model equations, whose coefficients are being harmonized with the results of the grassland field trials.

This master thesis entitled “Yield analysis for Austrian grassland with GIS, particularly taking into account climate changes” exclusively deals with the GIS implementation of these models in

a modular bottom-up way. The applied GIS software was ESRI ArcGIS 8.3 with several extensions and individual programs on Visual Basic for Applications (VBA), additionally using the class library of ArcObjects.

The soil water balance is the basis for the simulation of growing processes. The precipitation is compared with the potential evapo-transpiration and the soil water balance model is developed according to the FAO method, considering the field capacity. First of all the potential evapo-transpiration for grass surfaces was determined on a daily basis for the entire country. The most important parameters of this model are the global radiation, respectively the daily radiation balance, the saturation deficit based on temperature and relative humidity as well as the wind. For this master thesis, the weather measurements from official stations of the Central Institute for Meteorology and Geodynamics (ZAMG) were available for the year 2003, providing the basis of all meteorological analyses.

The global radiation was modelled depending on topographic characteristics, normalized with a value, calculated on a horizontal and shadow-free area. The resulting global radiation factor represents the topographically caused changes and is both correcting the potential evapo-transpiration which is calculated at the weather stations and their elevation-dependent interpolation. This elevation dependency of the potential evapo-transpiration was calculated by a regression und the resulting equation was applied to the Digital Elevation Model (DEM). The residuals of estimated and calculated evapo-transpiration at the several weather stations were interpolated by Kriging and afterwards combined with the elevation-dependent part of the evapo-transpiration (modified DEM).

The calculation result of the potential evapo-transpiration was included into the soil water balance model. Together with the field capacity the soil water ratio and the effective evapo-transpiration of the soil layers 0 to 10 cm, 0 to 20 cm, and 20 to 40 cm could be determined in this way. For the calculation of the different soil layers, the change of soil water balance compared with that of the day before was included as well as the possible drainage of the soil layers located above. The precipitation considering the interception was integrated into the balance calculation. In order to identify drought, it is necessary to examine a longer period and not only a cutoff date. Hence the accumulation of results of the soil water balance calculation for a certain period is an important pre-condition to simulate growth. The net potential evapo-transpiration as the difference of precipitation and the potential evapo-transpiration is an important indicator for drought. In this master thesis it was worked out as a state-wide grid of yearly minimums.

Another important parameter for the soil water balance is the plant factor, which indicates the development status of plants. The plant factor is used for the calculation of interception and transpiration and describes a linear increase of biomass production from the beginning of the vegetation period to the first utilisation and in the same way from the next to the following utilisation. The basic requirement for this calculation is the exact determination of the vegetation period with its temperature-sensitive and elevation-dependent begin and end as well as the elevation-dependent duration of growth stages for the several utilisations.

The growth and yield model is based on the data of the soil water balance and results in a multiple regression in order to calculate the quantity of grassland yield in dt dry matter per hectare. For that purpose it is necessary to calculate a growth factor, which is generated from the water stress factors and further from the water availability factor. The model also considers the cultivation intensity concerning fertilisation. Using the INVEKOS data, the stocking rate in livestock units (LU) per hectare was calculated and used for the estimation of the N-fertilisation as another parameter of the yield equation.

All calculations are based on the grid data model and were performed as local grid operations in ArcGIS VBA programs. Most of the intermediate and particularly the final results had to be generated in a resolution of 50 meters. These state-wide operations with a high resolution scale on a daily basis resulted in a geodata set of more than 1.5 TByte. Beside this fact, the intensive computing time brought the standard PC system which was used for the work nearly to its capacity limit.

The results of this work will be the fundamentals of an insurance model for drought damages on grassland and will therefore help to protect the existence of grassland and cattle farmers in drought endangered regions. Many of the geodata generated in the course of this work can be used for further research projects.