Predicting the distribution and succession changes of grassland vegetation in the selected model region of the Devínska Kobyla Mt. in GIS

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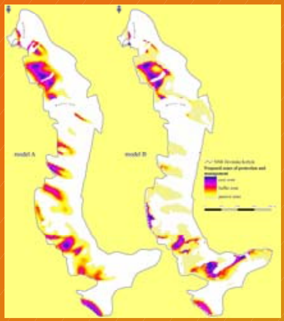
Fig. 1: Localization of the Devínska Kobyla Mt.

Introduction

The model region of the Devínska Kobyla Mt. is situated near the Bratislava, Slovakia, between the Morava and Danube rivers, where the Carpathian Mountains meet with the Pannonian Basin (Fig. 1). This unique geographical position resulted in the extraordinary physical-geographical conditions, such as topography and climate, with specific, rare and rich species steppe flora and fauna. The protected area of the National Nature Reserve (NNR), of 114.38 ha, is part of the NATURA 2000 network and is classified as an Important Plant Area. Since the mid-20th century this area was gradually loosing its economic importance. The present state of vegetation in the Devínska Kobyla NNR is conditioned predominantly by succession (Hegedüšová 2009).

Prediction of the vegetation

➢ Using the two algorithms for the calculation of a three-dimensional potential model for the maintenance of xero-thermophilous vegetation we received two very similar results.



➢ The differences are especially in the central and southeastern parts of the reservation. This is crucial for the selection of more appropriate model.

➢ Model B describes the slow succession areas mapped by field research. These are sites, where abiotic characteristics of the c ountry in the mutual coincidence form the ideal conditions for the development of the xero-thermophilous communities. Therefore the Model B was found to be more suitable for prediction of vegetation.

➢ The darkest colour in the diffusion range represents a"core", which has the highest potential for the conservation of the xero-thermophilous communities. Their long-term occurrence will not depend on the presence of the management interventions.

➢ For the buffer area of the core, we propose a controlled active management, which should consist of cutting and removing of volunteer plants and non-native plants. We recommend to leave the rest of the area undisturbed to allow the free flow of secondary succession. We suppose that the territory is not suitable for the long-term and stable presence of the xero-thermophilous grasslands communities. After the long term succession the climax communities of the xero-thermophilous oak woods *Corno-Quercetum* and *Pruno mahaleb-Quercetum pubescentis* will develop here. The communities of the *Carpinion* alliance will prevail on the ridge part of the reservation.

Threats

The xero-thermophilous grassland vegetation is strongly threatened by changes in the management and soil conditions, the first of all by the abandonment of the traditional use of the landscape and an inappropriate human intervention. The absence of grazing and meadow cutting resulted in spreading of the competitively strong grasses such as *Bromus erectus*, *Arrhenatherum elatius* and shrubs *Crataegus* sp., *Rosa* sp. div. and *Prunus spinosa*. The diversity of the plant communities is declining and many species have disappeared. The non-native species, mostly *Pinus nigra*, *Robinia pseudoacacia*, *Prunus serotina* and *Aesculus hippocastanum* represent another big problem. They grow in the surrounding of gardens, spread to the protected area and outcompete the native species.

Aim

➢ to define the rate of secondary succession (find places with slow succession) using the analysis of the chronological sequence of aerial photographs and predict changes of grasslands communities with regard to the abiotic potential of the territory (ideal conditions for the occurrence of xero-thermophilous communities)

Material and methods

➢ Digital elevation model - *v.surf.rst* GRASS GIS (Regularized Spline with Tension, Mitasova & Mitáš 1993) – we compared the accuracy of various input data:

a) contour lines 1:10 000 with elevation points and
b) data from photogrammetric mapping (3D elevation points and break lines as ZM polylines), were made stereofotogrametricly by ortorectification of measurement survey images.

➢ Insolation of georelief - *r.sun* GRASS GIS (Hofierka & Šúri 2002) – we calculated beam, diffuse, reflected, global solar irradiation and time duration of the beam irradiation during the annual cycle (1st January – 31st December, 365 days = 8 760 hrs) with 15 min. time increment. The output power grids of solar radiation received per unit area per day ($Wh \times m^2 \times day^{-1}$).

➢ Topoclimatic research digital meteostations – parallel measurements of soil temperature (°C, at a depth of 10 cm at intervals of 5 min).

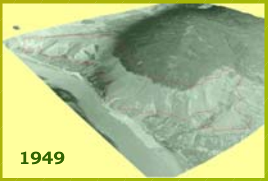
➢ The model of spatial distribution of soil temperatures - was obtained by multiple linear regression and has the following form: $TPa - TPb = 0.532392 - 0.0311999 \times NVa + 0.0172281 \times NVb + 0.178537 \times UDa - 0.115657 \times UDb + 0.147367 \times URa - 0.0885646 \times Urb$, $R^2 = 81.10\%$, where a and b are sites, TPA – TPB is the difference in temperature between soils, NV is the elevation, UD is the angle of incidence angle of solar radiation and UR is the delta of incidence sun angle.

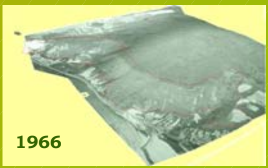
➢ The model of spatial distribution of vertical atmospheric precipitation - $Zj = (Zs + ZG(\Delta Hsj) \times \cos \gamma j$, where $ZG(\Delta Hsj)$ is the increase (decrease) of precipitations fallen on a horizontal plane in the unit j due to the difference of altitude of the station and geoecological units (ΔHsj).

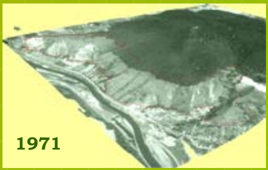
➢ Gully erosion model - $V = (S \times D)/L$, where V is the relative value of the threat of gully erosion, S is the slope gradient factor, D is factor of the length of the slope and L is the resistance factor of rocks.

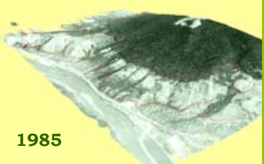
Results and conclusions

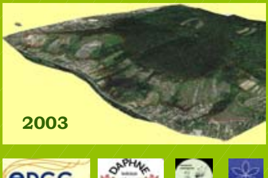
➢ Since 1949, a continuous area of xero-thermophilous pastures (at the time 85.8% of the total area) has been greatly fragmented into the present mosaic vegetation of rocky and dry grasslands (33.4%) – steppe communities along with sub-Mediterranean xero-thermophilous oak woods *Corno-Quercetum* and *Pruno mahaleb-Quercetum pubescentis.* Nowadays, the forests communities represent 50.7% of the NNR and the shrub communities 15.9%. The *Poo badensis-Festucetum pallentis*, *Festuco pallentis-Caricetum humilis*, *Festuco vallesiacae-Stipetum capillatae*, *Polygalo majoris-Brachypodietum pinnati* and Pannonian fringe vegetation *Geranio sanguinei-Dictamnetum albae* and *Peucedanetum cervariae* are the prevailing vegetation types of the dry grasslands communities.



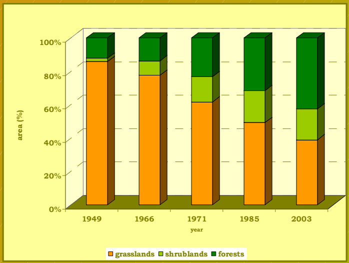


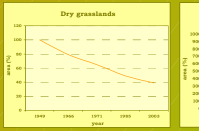


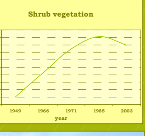


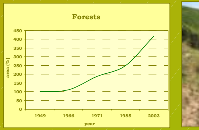


Dynamics of vegetation changes over the period 1949 - 2003









➢ The evaluation of the secondary succession is based on the chronological sequence of aerial photographs. The first period of seventeen years falls within the years 1949 – 1966. The second period is between the years 1966 – 1985 (nineteen years). The last third period (eighteen years) determines the difference between the images from the years 1985 – 2003.

➢ The succession was the slowest in the first reporting period. Non-forest vegetation largely follows the edges of the forests. The area retains the character of the period before the abandonment of grazing.

➢ The most significant change is visible in the central part of the reservation during the years 1966 – 1985. Particularly visible is the transition from a compact flat pastures to the forest communities. At the borders of the area interested by this change we observed a shift towards shrubs, which in the next period changed into forests. The area is on the basis of their abiotic potential, at least suitable for long-term preservation of the xero-thermophilous grasslands.

➢ The third period brought the fragmentation of the former wood-steppe communities. The change of the shrub and forest vegetation is uniform across the whole ridge, but not as significant as in the xero-thermophilous vegetation. Succession areas are incoherent.

➢ We suppose that process of the succession will be slower under uncontrolled management. The areas, in which the xero-thermophilous communities have preserved to the present, have a high potential for long-term preservation in term of the abiotic characteristics.

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