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CHARACTERISATION OF VEGETATION DISTRIBUTION FROM INTREGALDE (ALBA COUNTY, ROMANIA) IN RELATION TO DEM-DERIVED DATA

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Abstract: The present paper is aimed at determining the topographical range of vegetation in Întregalde (Alba county) using GIS. Topographical range was characterised in relation to elevation, slope and aspect. 454 vegetation samples (releves) were classified by means of hierarchical clustering (SYNTAX, 2000), using the alliance as the main unit. Topography was derived from a Digital Elevation Model (20 m of pixel size) obtained by scanning, geo referring and digitising a 1:25 000 topographical map. DEM allowed to asses the main topographic features to vegetation distribution: grasslands and beech forests have a wide topographic range, while the limestone vegetation develops over narrower altitudinal ranges, on steep slopes and prevailing upon certain aspects.

Introduction

Vegetation distribution is determined by a complex web of factors, including physical attributes (climate, soil, topography, altitude, moisture), natural disturbances, species autecology, life-history traits, competition and others.

Topography is considered the major factor affecting vegetation distribution in mountain areas. Therefore, it can be assumed that most of the topographic factors determining vegetation distribution can be indicated by landform parameters like elevation, slope and aspect [4]. Topography shapes the vegetation mosaic indirectly, through its influence on disturbance and successional pathways, and directly, by creating permanent breaks in vegetation pattern. Slope configuration, slope position and aspect have a strong influence on the spatial distribution of solar radiation, air and soil temperature, moisture, nutrients and human impact. Studies carried out over a large altitudinal range showed that elevation is the main factor controlling vegetation distribution, but aspect and slope could be also determinant [13].

GIS technique has been largely used for vegetation mapping, but also for integrating and analysing of spatial data on vegetation and environmental factors. The major advantage of a GIS approach is that provides spatially referenced data on topography and vegetation. Moreover, a number of parameters (among which water flow accumulation, moisture indexes, roughness, radiation, curvature, slope, aspect, sky view factor) can be derived from a Digital Elevation Model [1, 4, 7, 9]. The aim of this work was to analyse using GIS techniques the distribution of vegetation of Întregalde area, at alliance level, in relation to main topographic factors derived from a GIS.

Study Area

The study was carried out within an area of about 60 km^2 around Întregalde village (5° 20' - 5° 28' E; 46° 16' - 46° 12' N), at 41 km from Alba Iulia. The village is situated in Trascău Mountains, in a famous place for its karstic landscape. The region exhibits a diverse topography and the prevailing rocks are flysh, limestone and volcanic rocks (mainly riolits).

Land cover is dominated by extended semi-natural grasslands and beech forests, the latter representing the natural potential vegetation. Human settlements are concentrated mostly along the Galda Valley and only a few dispersed villages are found in the area. Due to the karstic relief, the land is not proper for cropping use and only a few, small patches with cultivated fields can be found close to Popeşti village.

Two natural reserves are found in the area: Întregalde Gorges and Găldiței and Turcului Gorges.

Material and Methods

Vegetation analysis

The study area (60 km^2) was divided into 240 grid squares of 0.25 km^2 each (500×500 m). Land surveys were conducted systematically in all grid squares and geographic locations of the sampling points were determined using a GPS. Field sampling was stratified within each grid square, according to the vegetation type estimated from satellite images.

A random location was chosen to perform one floristic releve within each vegetation type. Cover values were visually estimated, using the ordinal scale of BRAUN-BLANQUET [2]. Field sampling was performed between March and September (2000-2003). Plants that could not be identified in the field were collected for further identification at the Herbarium of "Al. Borza" Botanical Garden from Cluj-Napoca, where sample specimens were deposited. The distinction of the main vegetation units (at alliance level) was based upon the methods of the School from Zűrich-Montpellier [2]. The phytosociological nomenclature followed Coldea, 1991.

Relevees were classified by means of hierarchical cluster analysis using the average linkage method for clustering (UPGMA) and an input matrix of similarities based on the Bray-Curtis coefficient. The analysis was carried out using SYN-TAX 2000 (Podani).

Digital Elevation Model

The topographic map of Întregalde (scale 1: 25,000; contour lines interval: 20 m) provided the basic information for the construction of a DEM. The map was scanned and georeffered (ortorectified) using the 4 corner coordinates of the map as ground points, with an error of 3.40 m. In order to verify the ortorectification, the corrected map was overlaid upon the CORINE Land Cover map. The rasterized document had a resolution (pixel size) of 20 m. The map projection (Gauss-Kruger, long: 5° 24' 1.4256" lat: 46° 14' 23.29824") was changed to UTM using a geodesic calculator (680040, 5126660; 690100, 690100).

Through on screen digitizing and labelling of contour lines, a map that provided the basis for a Digital Elevation Model (hereafter called DEM) was created. The DEM (scale 1: 25,000; 20 m pixel size) was inferred by linear interpolation and ranges from 469 to 1211 m altitude.

The DEM allowed a suite of variables to be derived and tested against observed variables in the field [5, 9]. Two more layers of topographic variables (aspect and slope) were generated from the DEM.

A data layer containing the sampling points was overlaid on the DEM, obtaining a digital data base containing the elevation, slope and aspect for each point.

Results and Discussion

The land cover map allowed identifying the extension of each land cover type in the area: semi-natural grasslands (53%), forests (44%), rock outcrops, pine plantations and built-up areas (of 1% each) (Fig. 1).

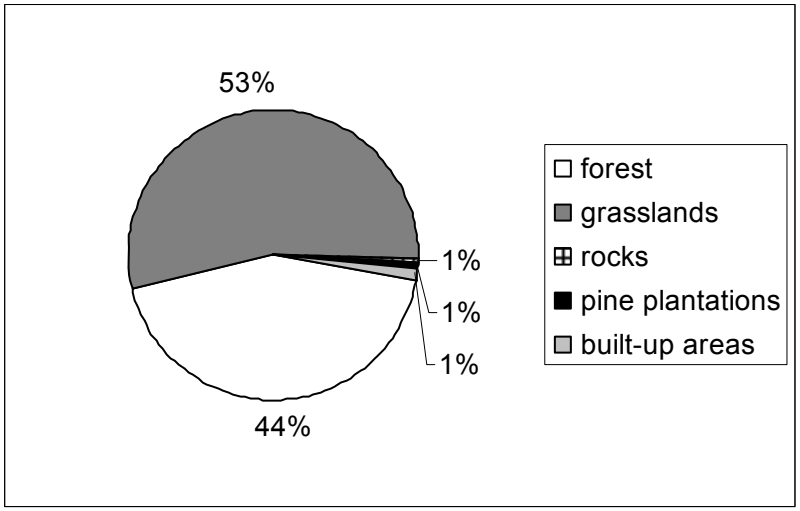

Fig. 1: Land cover distribution in Întregalde area

The 454 vegetation releves (totalling 563 species) were classified into 8 phytocoenological communities (alliances).

Semi-natural grasslands

All. *Cynosurion* Tx. 1947

It is characteristic for hilly and mountainous, mesophilous grasslands, growing on well drained and nutrient-poor soils. Among the dominant and characteristic species there are *Agrostis capillaris*, *Cynosurus cristatus*, *Lolium perenne*, *Trifolium repens*, *Festuca pratensis*, *Leontodon autumnalis*, *Phleum pratense*, *Festuca rupicola* etc. In the flora of these grasslands, there have been identified 397 species of vascular plants, based on 214 releves. Several plants included in the *Red List* [8] have been found: *Dactylorhiza maculata, Gladiolus imbricatus, Gymnadenia conopsea, Herminium monorchis, Iris aphylla, Muscari neglectum, Orchis morio, O. ustulata, Trollius europaeus*.

The alliance develops over a large altitudinal range (520-1174 m), on slopes varying between 1º and 48º in Intregalde area (Fig. 2).

All. *Genistion* Böch. 1943

It is characterised by acidophilous species, such as: *Calluna vulgaris, Vaccinium myrtillus* or *Genista sagitallis*. It contains one association, found at 1142 m, on a smooth slope (17 degrees), with a SW aspect (Tab. 1). *Calluna vulgaris* also appears in other places (near Ivăniş), but rarely forms coenosis in Întregalde area.

Table 1: Vegetation characterisation according to topography (for categorical data, the predominant value is shown)

Alliance	Altitude (m)	Aspect	Slope (°)
Cynosurion	520-1174	S	2-48
Genistion	1142	SW	17
Seslerio-Festucion pallentis	590-1100	S-SW-W	13-47
Seslerion rigidae	690-736	N	40-48
Seslerio-Pinion	634-892	N-SE-S	40
Symphyto-Fagion	538-1143	N	2-50
Lathyro-Carpinion	740-953	W	20-30

Limestone outcrops

All. *Seslerio-Festucion pallentis* Klika 1931

The alliance shelters associations developed on sunny limestone and scree from the mountain belt of the Meridional and Occidental Carpathians. The characteristic species are represented by *Festuca pallens, Sedum hispanicum, Thalictrum foetidum, Melica ciliata, Centaurea pinnatifida, Sempervivum marmoreum* and also by dacic and daco-balcanic elements such as *Sempervivum marmoreum* and *Thymus comosus* [3]. The floristic composition (based on 8 releves) includes 74 species. The alliance shelter an important number of endangered species: *Centaurea atropurpurea, C. pinnatifida, C. triniifolia, Cephalaria radiata, Seseli gracile, S. rigidum, Teucrium montanum.*

Helictotrichon decorum was also found inside this alliance in Întregalde Gorges and Capra Hill. It is a dacic paleoendemit, spread on limestone and screes, on steep slopes and rendsinic soils. *Helictotrichon decorum* can also develop alone coenosis [10].

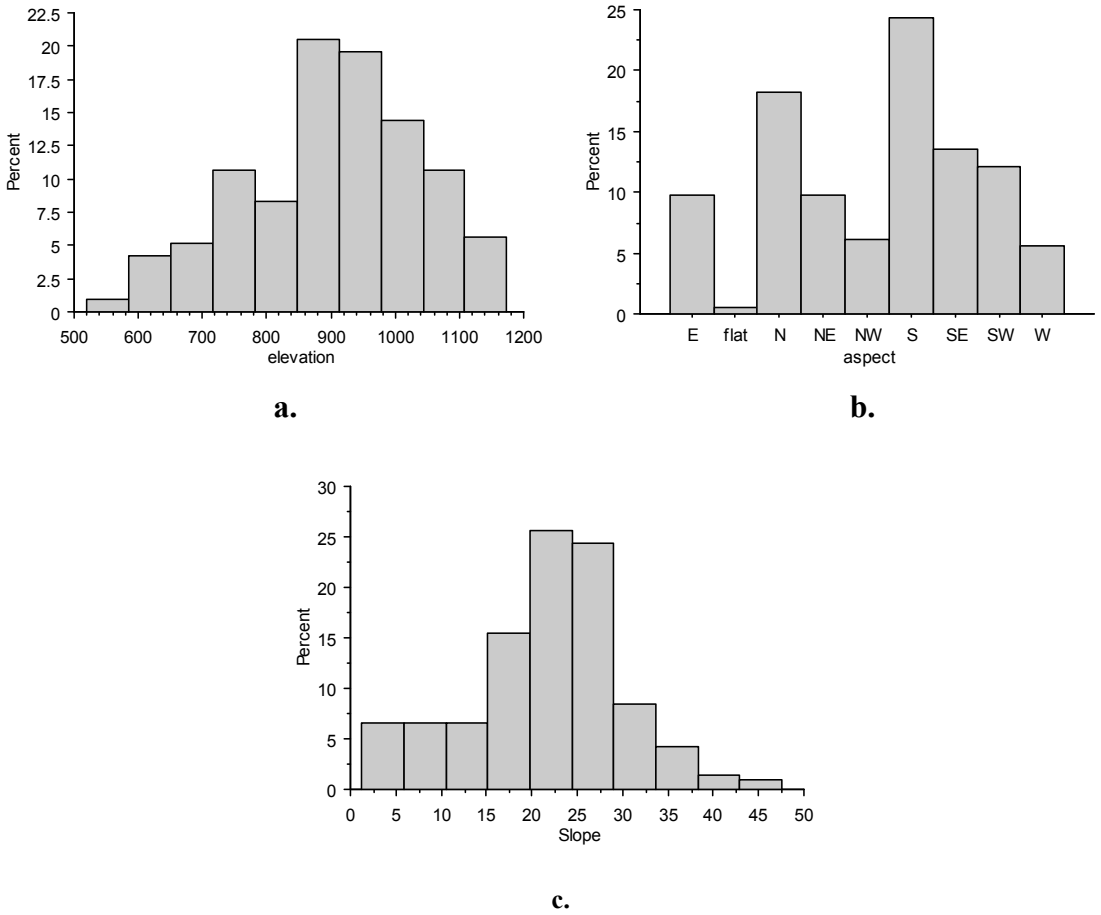

Fig. 2: Distribution of the alliance *Cynosurion* according to elevation (a), aspect (b) and slope (c)

In Întregalde area, the alliance is developed between 590 and 1100 m on a wide range of slopes (between 13 and 47 degrees). In most of the cases, it grows on S, SW or W facing slopes. The alliance was found all over the gorges, in sunny places, at lower altitudes (close to Galda Valley and Turcului rivulet), as well as higher (on Capra Hill).

The association *Seseli gracile-Festucetum pallentis* belong to this alliance. Coldea, 1991 considers the association as being synonymous with *Stipetum calcicolum pulcherrimae*. Its

opinion contradicts the nomenclature given by Pop et Hodişan, 1985, who separated the two associations. Moreover, the clustering results clearly disentangle them.

Pop *et al*., 1960 described for the first time the association *Stipetum calcicolum pulcherrimae* in Întregalde. Further coeno-taxonomic reconsiderations of the authors [10] led to a new nomenclature, *Stipetum eriocaulis*. In order to avoid any confusion, we will briefly describe its synecology, in agreement to the findings of Pop et Hodişan, 1985.

The association contains xerophilous grasslands which grow on sunny and rocky slopes. Two releves containing 31 species were performed on the left side of the Întregalde Gorges. Among the characteristic species there are *Stipa eriocaulis, Carex humilis* and *Festuca valesiaca*.

The association spreads over 721 and 916 m altitude, on smooth slopes (19 to 24 degrees), facing S and SW. contains a high number of thermophilous species (which is characteristic for this vegetation type): *Stipa eriocaulis, Carex humilis, Allium flavum, Cephalaria radiata, Helianthemum hirsutum* and *Inula ensiflora*. The soil has a moderate deepness and many rock outcrops, so that the rocky species are well represented: *Asplenium ruta-muraria, Aster amellus, Centaurea pinnatifida, Festuca pallens, Lembotropis nigricans, Melica ciliata* and *Sempervivum marmoreum*.

According to these authors, the coenoses of the association is likely to develop also in the Mada and Ardeu Gorges; Şuteu, mentioned it in Râmeţ Gorges [12].

All. *Seslerion rigidae* Zoly. 1939

This alliance is spread on the limestone from the Carpathians in the mountain belt and it is well developed in Ampoiţei, Turzii, Aiudului Gorges, in Colţii Trascăului or Scărişa-Belioara [11]. It is individualised by the following characteristic species: *Sesleria rigida, Asperula capitata, Helictotrichon decorum, Dianthus spiculifolius, Seseli gracile, S. rigidum* etc. The three releves revealed 43 species, many of them found on the Red List: *Aquilegia nigricans* ssp. *nigricans, Centaurea pinnatifida, Dianthus spiculifolius, Helictotrichon decorum, Leontopodium alpinum, Pinus sylvestris, Seseli gracile, S. rigidum, Sorbus dacica, S. graeca.*

The alliance spreads over 690 and 736 m altitude on limestone, mostly on the right side of Intregalde Gorges. It develops on steep (40-48 degrees), shadowed slopes, N facing (Tab. 1). *Leontopodium alpinum* f. *intregaldense* Borza and f. *laxiflorum* (Roch.) Borza is found on the rocks, scree and even on the over-grazed grassland, close to the Galda Valley. Apart of the small corridor that climbs down from the gorges to the valley, there is no other trace of this species throughout the gorges.

Otherwise *Seslerio-Festucion pallentis*, this alliance develops in shadowed places and shelter more mountain and alpine species, such as: *Aquilegia nigricans ssp. nigricans, Leontopodium alpinum, Saxifraga adscendens, S. paniculata* or *S. cuneifolia*.

All. *Seslerio rigidae-Pinion* Coldea 1991

The characteristic and dominant species of this alliance are: *Sesleria rigida, Sorbus dacica, Juniperus sabina, Teucrium chamaedrys, Rhamnus saxatilis, Lembotropis nigricans*. Although the alliance is well-represented on the steep rocks of Întregalde Gorges, the difficult accessibility allowed the performance of only 3 releves. 51 species were identified, among which several are included in the Red List: *Juniperus sabina, Pinus sylvestris, Sorbus dacica, Teucrium montanum, Viola jooi*.

The alliance is present exclusively on limestone, between 634 and 892 m altitude. It is developed over steep slopes (with a mean of 40 degrees) and N, SE and S aspects (Tab. 1).

Forests

All. *Symphyto-Fagion* Vida 59

This coenosis shelter a typical mesophilous beech forest, well-developed in Întregalde, covering more than 40% of the study area. The main characteristic species are: *Symphytum*

cordatum, Cardamine glanduligera, Hepatica nobilis, Aconitum moldavicum, Festuca drymeia, Pulmonaria rubra. 150 species were identified in 217 releves, several being found on the Red Lists: *Corralorhiza trifida, Neottia nidus-avis, Sorbus aria, Tanacetum macrophilum*.

A few disturbance patches (in secondary succession) are present near Scorobaia Valley and Tecseşti, as a result of the recent forests cuttings. Species such as *Silene viridiflora, Rosa canina, Salix caprea, Mycelis muralis* are found in these patches.

Beech forests lie between 538 and 1143 m, on slopes varying from 2 to 50 degrees and prevailing over massifs with N and NW aspect (Fig. 3).

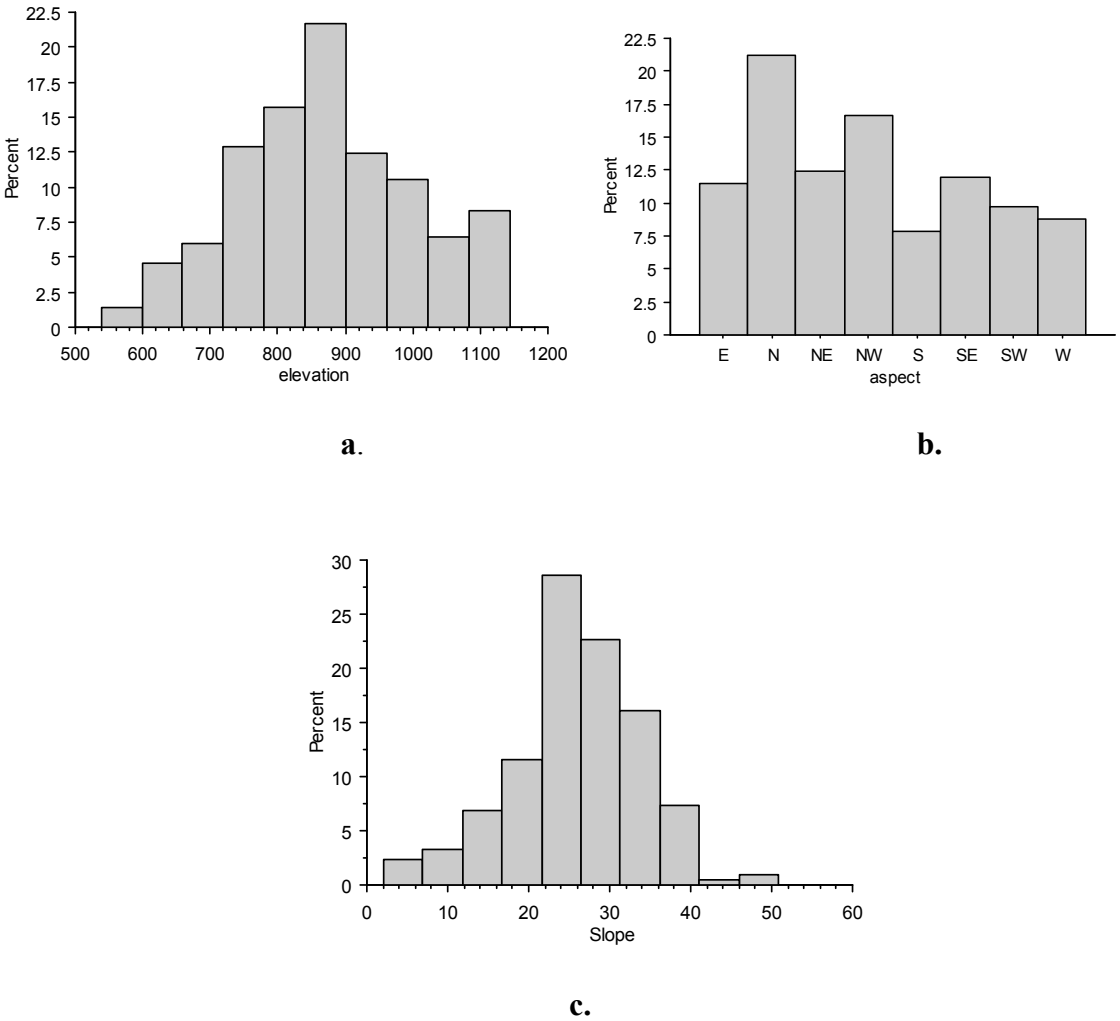

Fig. 3: Distribution of the alliance *Symphyto-Fagion* according to elevation (a), aspect (b) and slope (c)

All. *Lathyro-Carpinion* Boşcaiu 1974

The alliance consists of hornbeam forests, most of them inhabiting shadowed slopes, at the border of the beech forests, so that *Fagus sylvatica* is codominant with *Carpinus betulus*. Among the dominant and characteristic species there are: *Carpinus betulus, Corylus avellana, Cornus mas, Galium schultesii, Brachypodium sylvaticum, Stellaria holostea.*

The *Carpinus* forests belonging to this alliance are poorly represented (the sampling revealed only 4 releves, containing 40 species), and does not exhibit such a wide altitudinal range (740-800 m). The alliance is found over smooth slopes (around 20-30 degrees), with N, NE and W aspects.

Conclusions

The study shows that the semi-natural grasslands (*Cynosurion*) and the beech forest (*Symphyto-Fagetum*) have the largest ecological amplitude. They are spread along a wide elevation, aspect and slope range. The particularity of the beech forests from Întregalde is that they are found at low altitudes. The explanation might be the thermal inversion: the cold air is maintained close to in the Galda Valley, between the gorges, at appreciatively 500-600 m. Hornbeam forests lie mostly on western slopes and reach a lower altitude than the beech forests (953 m). The comparative tables from fig. 2 and 3 reflect that grasslands and beech forests develop upon wide ranges in Întregalde, but without showing preferences for certain topography.

Stipion eriocaulis alliance develops always on sunny slopes (S or SW) and reaches more than 900 m.

The alliance *Seslerio-Festucion pallentis* developes over a wider altitudinal range, preferring always sunny slopes. The other two alliances (*Seslerion rigidae* and *Seslerio-Pinion*) develop over very steep slopes.

In summary, the ability to overlay maps over DEMs has much practical applicability, i.e. for depicting vegetation patterns as a function of elevation. However, the choice of the main cartographic unit depends on the map scale, but also on the pixel resolution in the case of a DEM.

The DEM-derived data can be much larger [4], allowing a quick and accurate description of ecological factors. The method can be also applied for characterising the ecology of the alliances that shelter endangered taxa and can be a departure point for modelling the distribution of rare species. Multivariate methods can be applied for indicating the relationship between vegetation distribution and ecological factors or for emphasising the most important factors that influence vegetation pattern [6].

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CARACTERIZAREA DISTRIBUȚIEI VEGETAȚIEI DIN ÎNTREGALDE (JUD. ALBA), CU AJUTORUL DATELOR DERIVATE DIN DEM

(Rezumat)

Lucrarea caracterizează distribuția vegetației din zona Întregalde (județul Alba), în funcție de topografie (altitudine, pantă, expoziție), cu ajutorul GIS-ului. Cele 454 de relevee au fost clasificate cu ajutorul programului SYNTAX (Podani, 2000), folosindu-se alianța ca şi unitate de bază. Au fost identificate 8 alianțe: *Cynosurion, Genistion, Stipion eriocaulis* (pajişti), *Seslerion rigidae, Seslerio-Festucion pallentis, Seslerio-Pinion* (stâncării), *Symphyto-Fagion* şi *Lathyro-Carpinion* (păduri).

Topografia a fost derivată dintr-un DEM (*Digital Elevation Model*), un Model digital al altitudinii (scara 1: 25 000; rezoluția pixelului: 20 m), obținut în urma digitizării hărții topografice (scara 1: 25 000).

Folosirea modelului digital al altitudinii a permis descrierea principalelor tipuri de alianțe, în funcție de topografie, astfel: pajiştile cuprinse în alianța *Cynosurion* şi pădurile de fag se dezvoltă într-un un rang altitudinal mai amplu, fără preferințe pentru un anumit tip de pantă sau orientare, iar vegetația saxicolă apare doar la anumite altitudini, pe pante mai abrupte.