Mapping for Red Data Books
in the Czech Republic

Evaluating of vegetation and environmental diversity in landscape level:

Connecting releve database with environmental maps in GIS Idrisi

Tomas Kucera, Darwin Fellow
Foresta SG, Prague

in collaboration with

Milan Chytry
Masaryk University, Brno

Julian Dring & John Rodwell
Unit of Vegetation Science
Lancaster University

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Unit of Vegetation Science
Lancaster University
United Kingdom

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Acknowledgements

All this work done was possible to the DARWIN INITIATIVE project. Our thanks are to *Lubos Ursta* for the grateful support with preparing map layers, to all contributors of the Czech National Database for the training releves received from, and to all members of the Unit staff and colleagues from other countries, for their inspirative comments contributing to finish this work.

Introduction

Processing of large phytosociological data sets in database systems (i.e. TURBO(VEG) and MEGATAB; Hennekens 1994) enables new and most detailed synthesis of vegetation releves from larger areas (Ermakov, Dring & Rodwell 1997). The distribution of communities is a main information, for construction of distribution maps are used both geographical oriented and specialised softwares (i.e. DMAPW; Morton 1997). This type of software has no excellent abilities for the computation and visualisation of relationships between communities (phytosociological releves or distribution of communities) and their environments. The best tools for that questions are **Geographical Information Systems** (GIS; see i.e. Burrough 1986, Burrough & McDonell 1998). The principles and methods of GIS are well-known (Maguire et al. 1991) and GIS extremely expanded into practically all fields of human activities in the last few years. There are many specialised software applications (see International Journal of GIS, European GIS, ITC Journal, etc.). In ecological sciences are two prevailing demands: (i) visualising and (ii) modelling data and processes.

The spatial thematic data are (i) points, (ii) lines and (iii) areas, in GIS systems processed as points, vectors and polygons. There are two main types of GIS: (1) vector oriented [i.e. ArcInfo, Intergraph, GenaMAP, MapINFO], (2) raster oriented [GRASS, SPANS, IDRISI] and hybrids [last version of SPANS, etc.]. The data attributes are in database form (Database Management System, DBMS).

Aims and methods

The study area of this project was the Czech Republic and all training date were from this region. The main aims were:

(1) import maps with the global abiotic factors (i.e. climate, soils) to Idrisi;
(2) import points of the releves distribution from Turbo(VEG) database to Idrisi;
(3) calculate main abiotic characteristics for each vegetation type from the map of entire distribution (in this case we used generalised form of the schematic map of potential natural vegetation, Neuhäuslová et al. 1997);
(4) calculate main abiotic characteristics for the sets of releves;
(5) visualise in GIS the main community-environment relations.

(6) open in Idrisi database management system (DBMS) for GIS analysis of database with header data of releves

Software: in this case-study we have used the raster oriented GIS Idrisi for Windows v. 2.0 (Eastman 1997). The graphical outputs were prepared in Excel 5 for Windows.

Original maps were in 1:1,000,000 level (climate and soils: Atlas of the Czechoslovakia, 1966; phytogeographical areas: Skalicky et al. 1988) and 1:500,000 level (map of the potential natural vegetation: Neuhäuslová et al. 1997; geomorphological map: Demek et al. 1965), respectively. The maps were previously digitised and next rasterised (the final resolution was 1 pixel = 1 sq km). The all maps were imported to Idrisi as *.BMP files (IMPORT: BMPIDRIS), than georeferenced to lat/long coordinates (procedures PROJECT & RESAMPLE) and reclassified (RECLASS & OVERLAY) with the common flag (value 0). Finally the legend categories were added. For example the structure of one description file (GEOL.DOC) follows:

```
file title : Geology
data type : byte
file type : binary
columns : 480
rows : 305
ref. system : latlong
ref. units : deg
unit dist. : 1.0000000
min. X : 12.0000000
max. X : 18.8999996
min. Y : 48.5000000
max. Y : 51.0999985
pos'n error : unknown
resolution : km
min. value : 0
max. value : 3
value units : unspecified
value error : unknown
flag value : 0
flag def'n : none
legend cats : 4
category 0 :
category 1 : Typ 1 - rich
category 2 : Typ 2 - poor
category 3 : Typ 3 - sediments
```

Training phytosociological data

Both the distribution pattern and ecological gradients (esp. abiotic factors) were studied on the data set of beech woods (*Fagion*, *Luzulo-Fagion*) from the Czech Republic. The data were exported from the Czech national database (Chytry 1998). Total number of successfully imported releves was 411, from 12 associations:

Fagion, Eu-Fagenion		No of releves
TpF	Tilio platyphylli-Fagetum	11
TcF	Tilio cordatae-Fagetum	41
MF	Melico-Fagetum	12
CpF	Carici pilosae-Fagetum	27

DeF	Dentario enneaphyllidi-Fagetum	106
DgF	Dentario glandulosae-Fagetum	3
MaF	Melico altissimae-Fagetum	50
VrF	Violo reichenbachianae-Fagetum	13
Aceri-Fagenion		
AF	Aceri-Fagetum	8
Cephalanthero-Fagenion		
CF	Cephalanthero-Fagetum	18
Luzulo-Fagion		
LF	Luzulo-Fagetum	69
CvF	Calamagrostio villosae-Fagetum	53 releves

The coordinates of releves were exported from TURBO(VEG) in format:

`No ddmmss ddmmss code` {dd: degrees, mm: minutes, ss: seconds}

and `mmss` were recomputed to decimal form with the formula

```
dd.dec = dd+(mm+ss/60)/60
```

in Excel environment. Input format for Idrisi is very simple XYZ:

```
dd.dec dd.dec code
```

to be processed in IMPORT: XYZIDRIS procedure. For the succeed computation the point data were transformed to raster (Reformat: Raster/Vector Conversion: POINTRAS) and from integer to byte data type (Reformat: CONVERT).

```
file title : Beech forests - samples
category 1 : TpF
category 2 : TcF
category 3 : MF
category 4 : CpF
category 5 : DeF
category 6 : DgF
category 7 : MaF
category 8 : VrF
category 9 : AF
category 10 : CF
category 11 : LF
category 12 : CvF
```

Environmental data layers

We had imported totaly 15 map layers, with good information contents in 10 of them (description of map legends):

Altitudinal data

```
file title : Altitude (m a.s.l.)
category 1 : < 300 m {planar belt}
category 2 : 300-500 {colline belt}
category 3 : 500-800 {submontane belt}
category 4 : 800-1000 {montane belt}
```

```
category 5 : > 1000 {supramontane, subalpine belts}
```

Climatic data

```
file title : Mean annual temperatures (degrees C)
category 1 : < 4
category 2 : 4-5
category 3 : 5-6
category 4 : 6-7
category 5 : 7-8
category 6 : 8-9
category 7 : > 9

file title : Precipitation (mm / year)
category 1 : <500 mm
category 2 : 500-600
category 3 : 600-700
category 4 : 700-800
category 5 : 800-900
category 6 : >900 mm

file title : Growing season (days)
category 1 : < 60 days
category 2 : 60-100
category 3 : 100-120
category 4 : 120-140
category 5 : 140-150
category 6 : 150-160
category 7 : 160-180
category 8 : > 180

file title : Snow depth (cm)
category 1 : < 20 cm
category 2 : 20-30
category 3 : 30-40
category 4 : 40-60
category 5 : 60-80
category 6 : 80-100
category 7 : > 100

file title : Climate zones
category 1 : CH2-CH4 {very cold}
category 2 : CH5-CH6
category 3 : CH7
category 4 : MT1-MT2 {middle}
category 5 : MT3
category 6 : MT4-MT5
category 7 : MT6-MT7
category 8 : MT8-MT9
category 9 : MT10-MT11
category 10 : T1 {warm}
category 11 : T2
category 12 : T4
```

Soil data

```
file title : Soil texture
category 1 : earth-clay
category 2 : stony
category 3 : alluvial
category 4 : clay
category 5 : earth
category 6 : earth-sandy
```

```
file title : Soil types
category 1 : alluvial soils
category 2 : chernozem & braun soils
category 3 : podzolic mountain soils
category 4 : podzolic & braun soils
```

Vegetation data

```
file title : Forest zones
category 1 : flooded
category 2 : pine and oak
category 3 : oak
category 4 : oak and beech
category 5 : sM beech
category 6 : M beech
category 7 : M spruce
category 8 : krummholz
category 9 : none
```

```
file title : Potential natural vegetation
category 1 : Alnion incanae
category 2 : Carpinion
category 3 : Tilio-Acerion
category 4 : Eu-Fagenion
category 5 : Cephalanthero-Fagenion
category 6 : Galio-Abietenion
category 7 : Luzulo-Fagion
category 8 : Quercion pubescenti-petraeae
category 9 : Aceri tatarici-Quercion
category 10 : Quercion petraeae
category 11 : Genisto germanicae-Quercion
category 12 : Erico-Pinion
category 13 : Dicrano-Pinion
category 14 : Piceion excelsae
category 15 : Athyrio alpestris-Piceion
category 16 : Pinion mughi, Juncetea trifidi, etc.
category 17 : Scheuchzerio-Caricetea fuscae, Oxycocco-Sphagnetea
category 18 : anthropic vegetation
```

Results

The results were examined in two conceptual levels: (i) area crosstabulations of the map of potential natural vegetation with environmental factors and (ii) point [releves] extract and crosstabulations with the environmental factors.

The application with the generalised map of potential vegetation

The crosstabulation files were imported to Excel and the simple graphical outputs were prepared (file VEGETACE.XLS). The map was overlaid with mean annual temperatures, total annual precipitation, climatic zones, snow depth, vegetation season, altitudinal belts, soil type and texture zones and potential forestry zones. Simple expression of that crosstab processes is as follows:

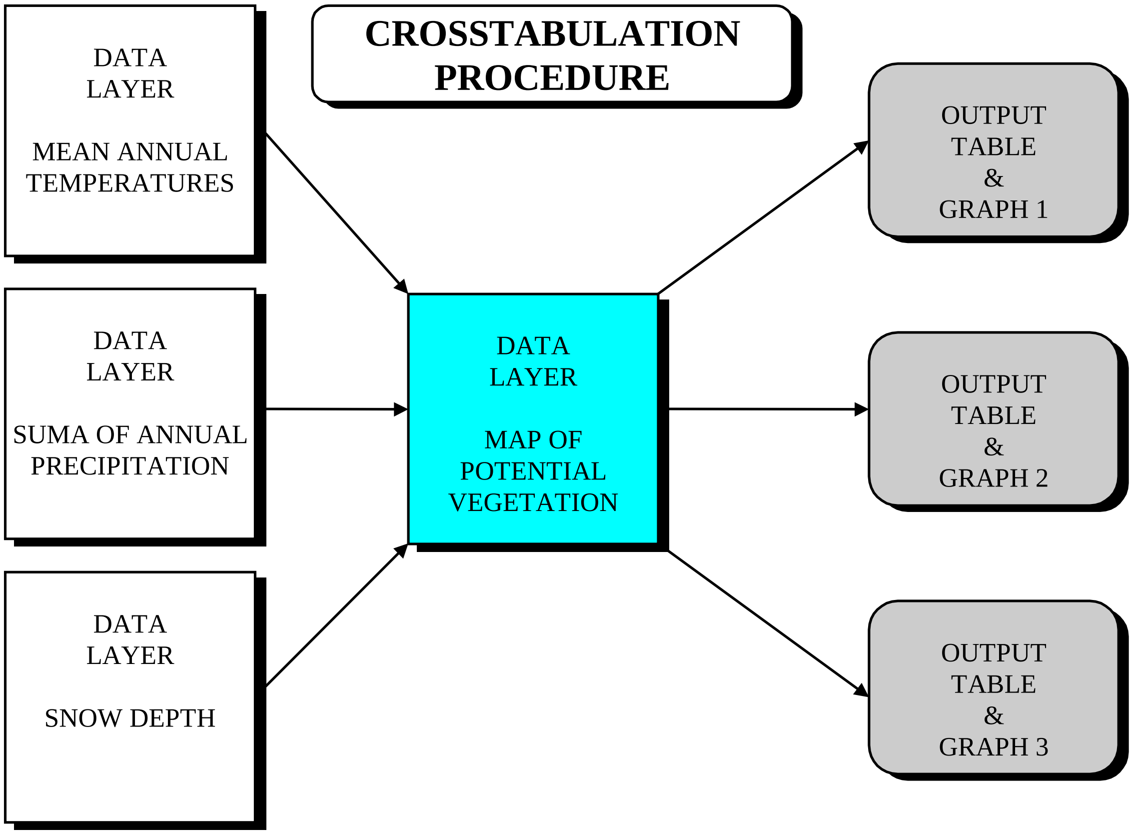


Fig. 1. – Schematic example of crosstabulation procedure in geographical information system (GIS) environment.

Table 1. – Example of tabular output: result of crosstabulation of the map of potential natural vegetation with mean annual temperature (°C)

	< 4	4-5	5-6	6-7	7-8	8-9	> 9	Total
Aln	0	0	9	1003	1387	2467	28	4894
Carp	0	0	94	2741	10906	10469	48	24258
TAc	0	0	6	6	2	0	0	14
EuFag	218	1015	4030	5401	2196	60	0	12920
C-Fag	0	0	0	6	22	0	0	28
GAb	0	0	0	44	32	0	0	76
LFag	334	1057	3221	7986	2374	587	0	15559
Qpp	0	0	0	9	23	56	0	88
AtQ	0	0	0	351	54	429	0	834
Qpetr	0	0	2	6	178	381	0	567
Qac	0	0	177	5836	12472	1067	13	19565
EPin	0	0	0	0	2	0	0	2
DPin	0	0	19	2	0	0	0	21
Pic	368	254	241	92	1	0	0	956
APic	6	1	0	0	0	0	0	7
Pmug	46	0	0	0	0	0	0	46
SchC	3	9	6	5	39	3	0	65
antr	0	0	0	53	75	86	0	214
Total	996	2367	7867	23622	29823	15628	89	80114

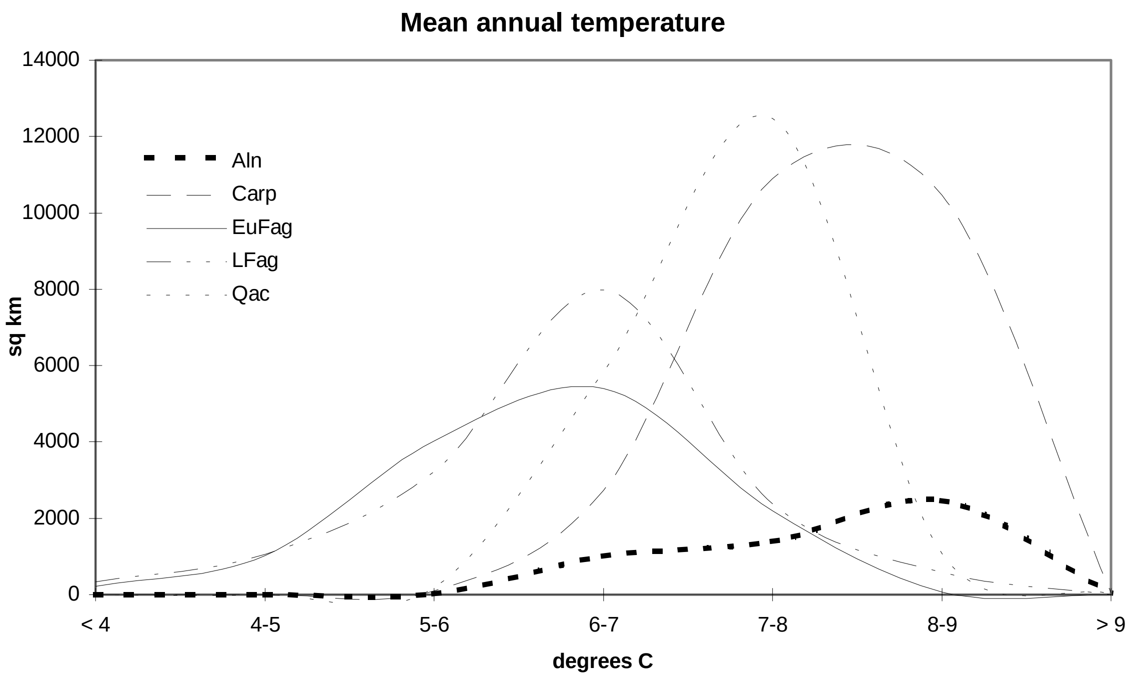


Fig. 2. – Example of temperature differentiation of the main vegetation units

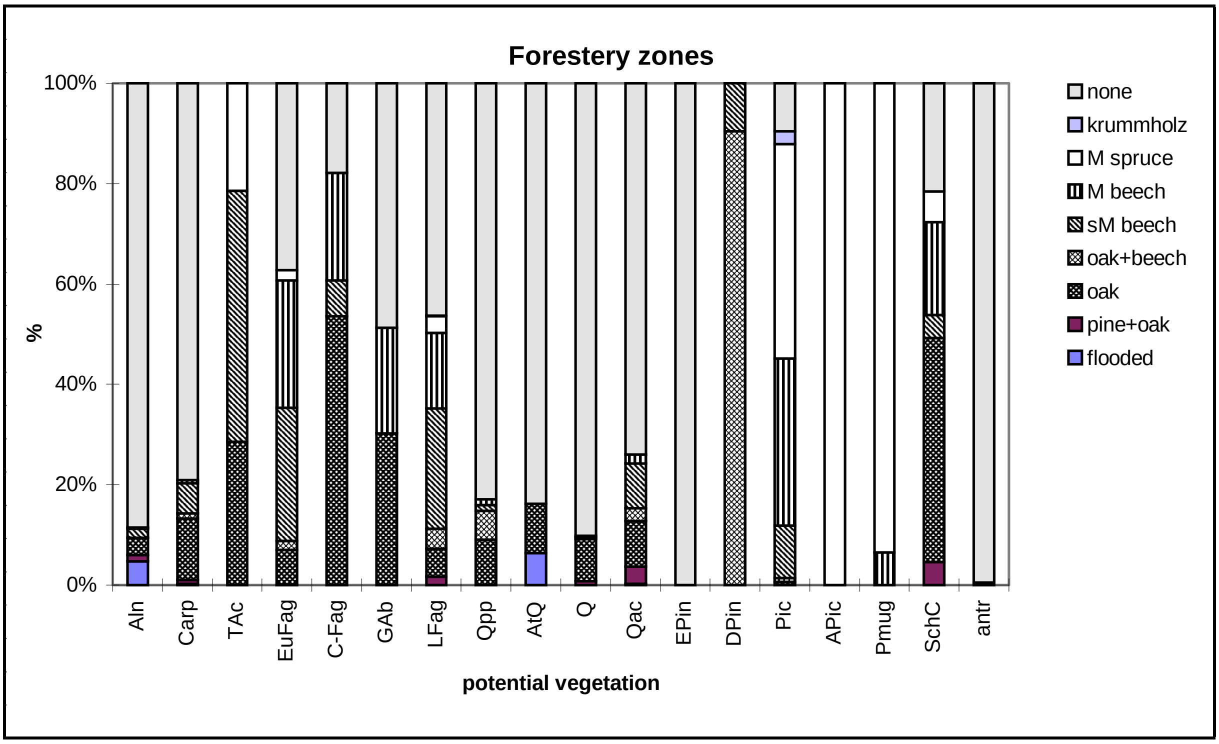
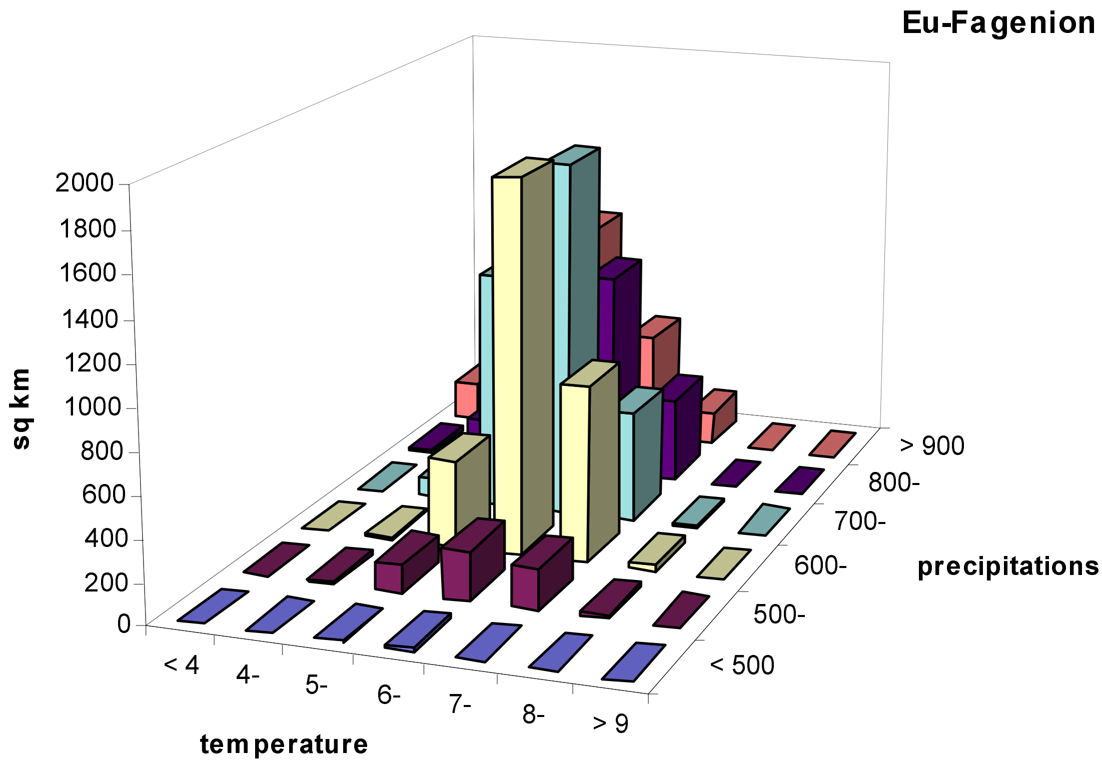


Fig. 3. – Example of the relations of potential forestry zones and potential natural vegetation. Note the proportion of deforested area (none) in the units of map of potential vegetation

The training data for more detailed study were from alliances *Fagion* and *Luzulo-Fagion*. For these two units were prepared the separate crosstabulations with some environmental data: the climatic and soil relationships were computed for both temperature and precipitation data (fig. 4), soil type and soil texture zones (fig. 5), and vegetation season and snow depth (fig. 6), respectively.



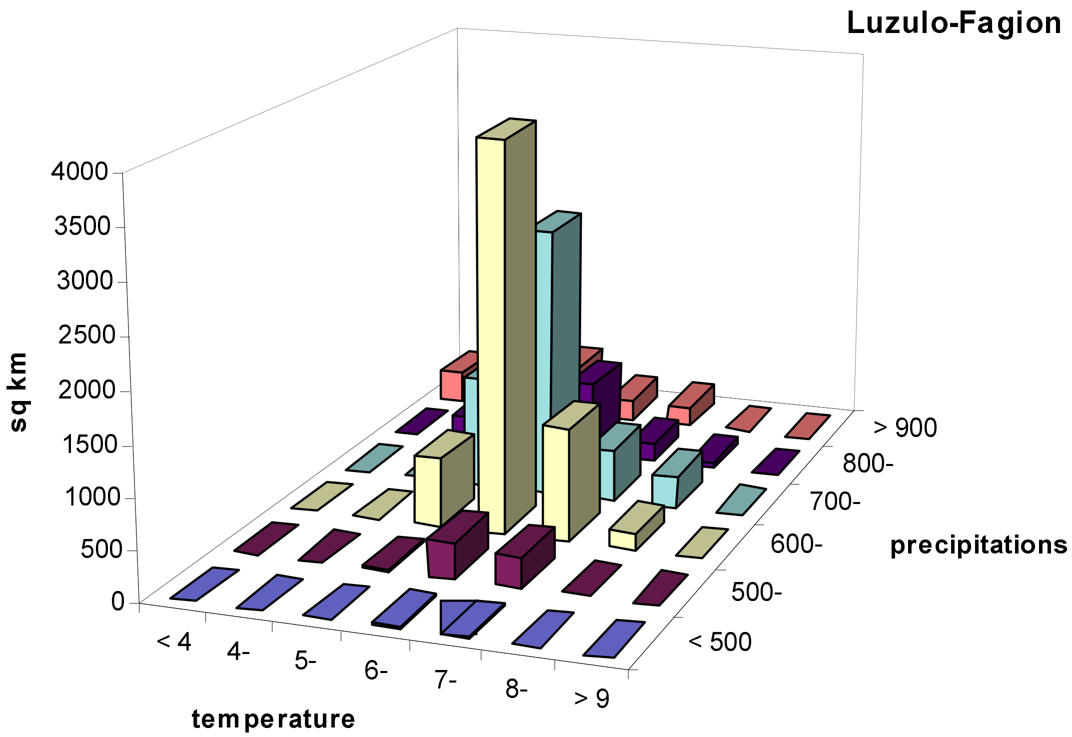
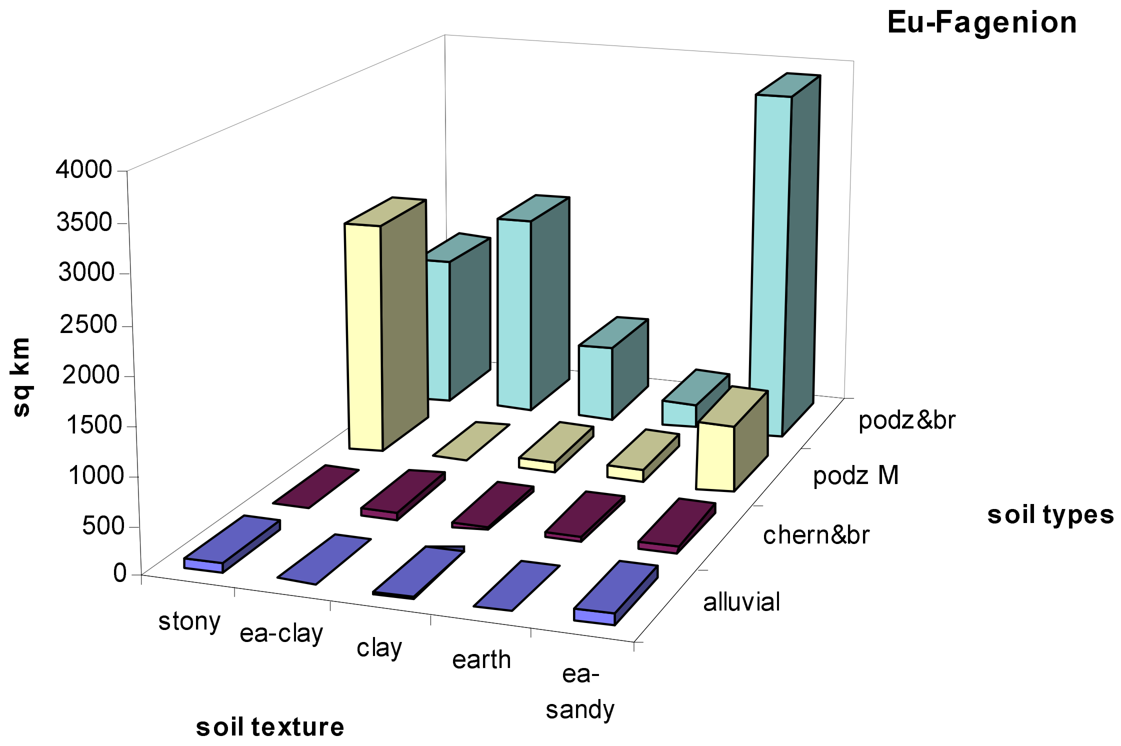


Fig. 4. – Climatic differentiation of the potential distribution of beech woods in the Czech Republic (based on the Map of potential natural vegetation 1:500,000; Neuhauslova et al. 1997): (A) mean annual temperatures and sum of annual precipitation.



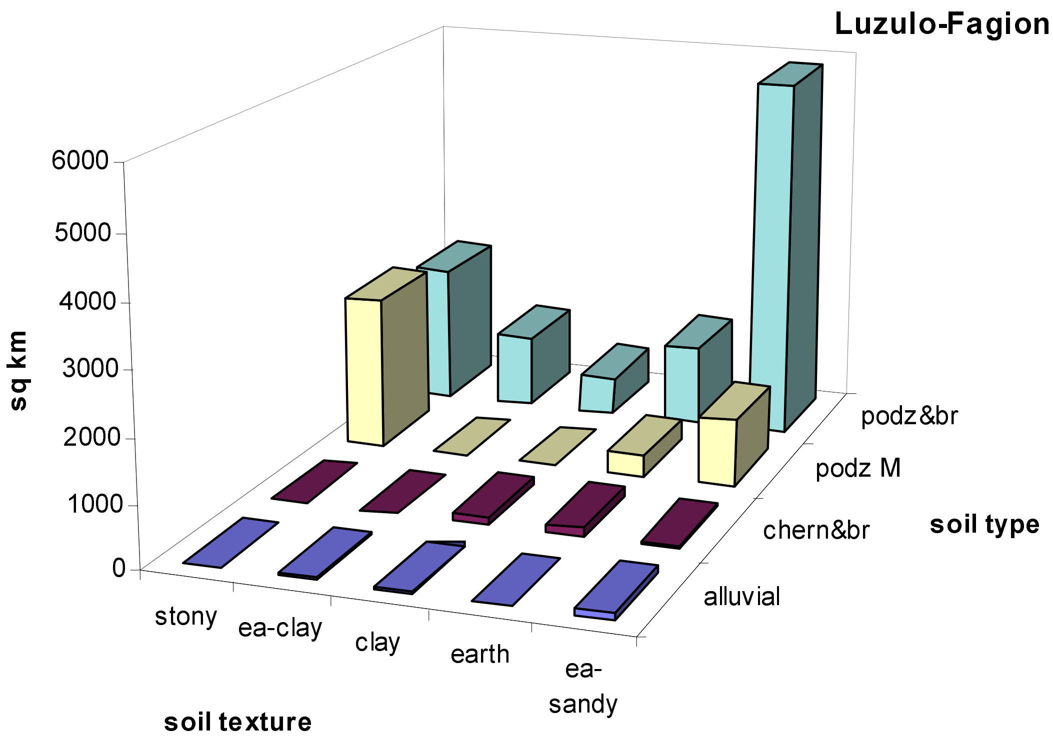
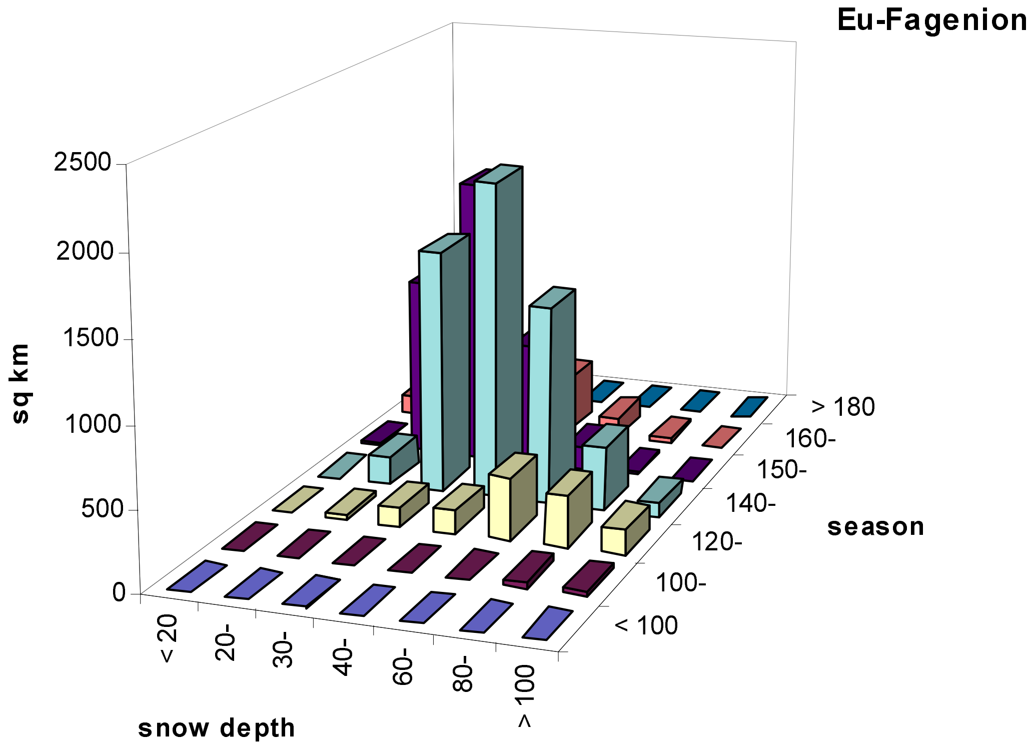


Fig. 5. – Climatic differentiation of the potential distribution of beech woods in the Czech Republic (based on the Map of potential natural vegetation 1:500,000; Neuhauslova et al. 1997): (B) mean snow depth and vegetation season.



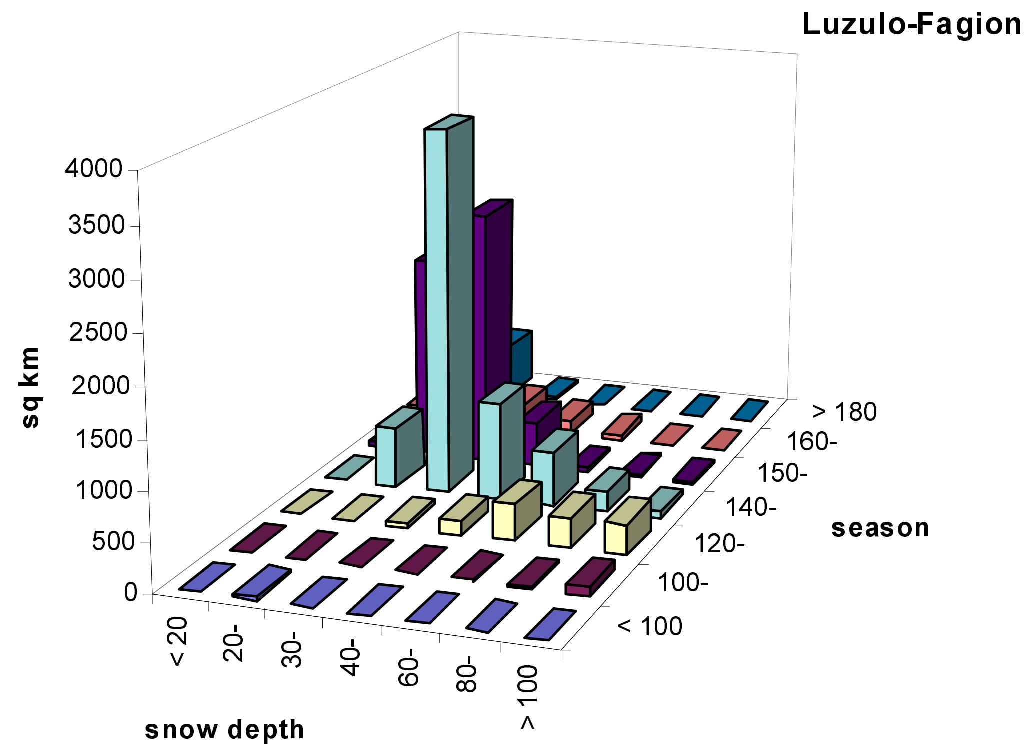


Fig. 6. – Soil differentiation of the potential distribution of beech woods in the Czech Republic (based on the Map of potential natural vegetation 1:500,000; Neuhauslova et al. 1997).

Linking the releves points with header database

The heads of releves were exported from TURBO(VEG) separately into two files, first with the identificator and long/lat coordinates as space delimited text, second in dBase IV format with the first number of identificator and any other fields. Identificator number has to be changed (in Access) to *integer* format.

1. In the step of import of point data to Idrisi and following rasterisation were prepared raster layers for next crosstabulation with some restrictions: (i) the raster grid resolution 1 sq km fuse more releves into one pixel (it should be advantageous in the case of high number of releves with special local trends); (ii) more releves from more communities are fused into one unit, for each community should be prepared one raster.
2. In the step of linking header database to the points are restrictions with special codes used for syntaxa (the database management doesn't work with combined text and numbers variables).

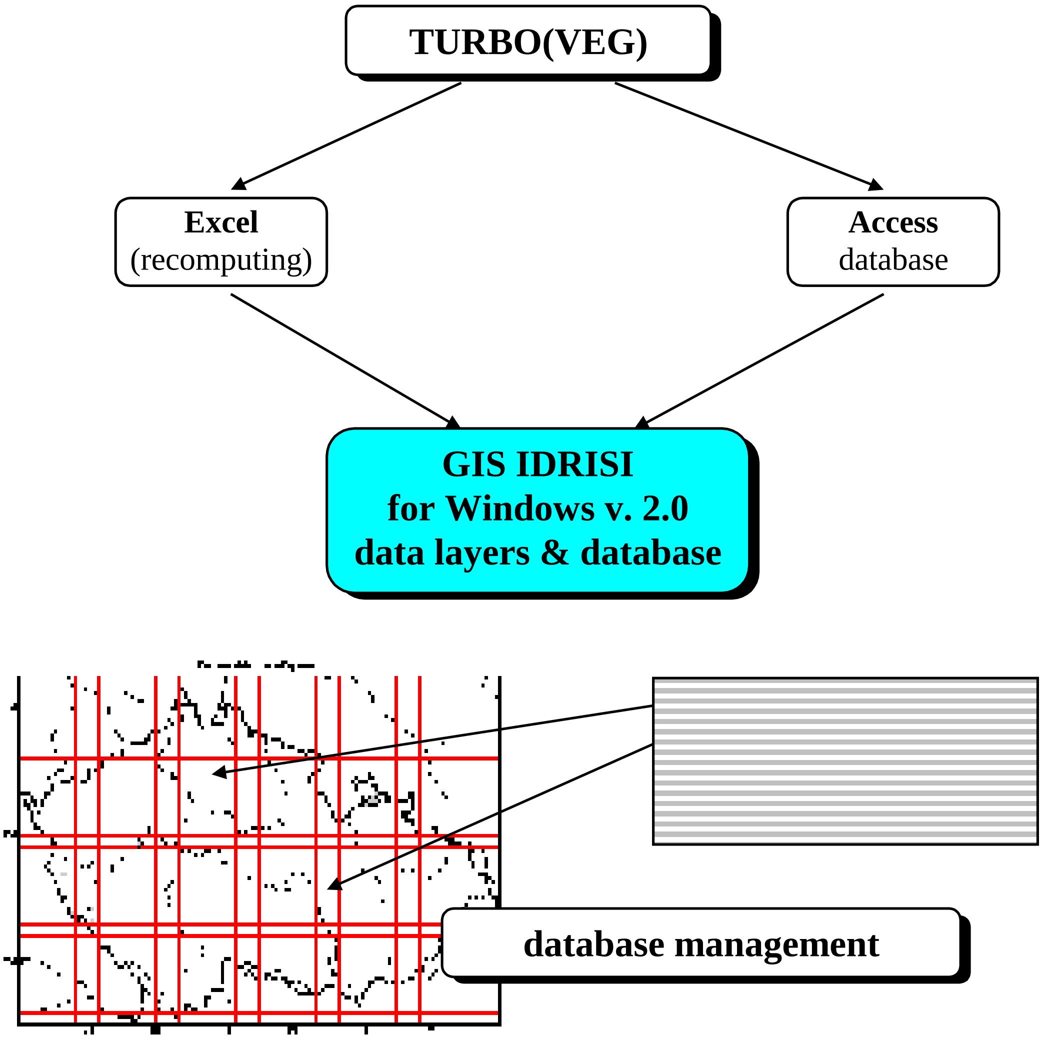
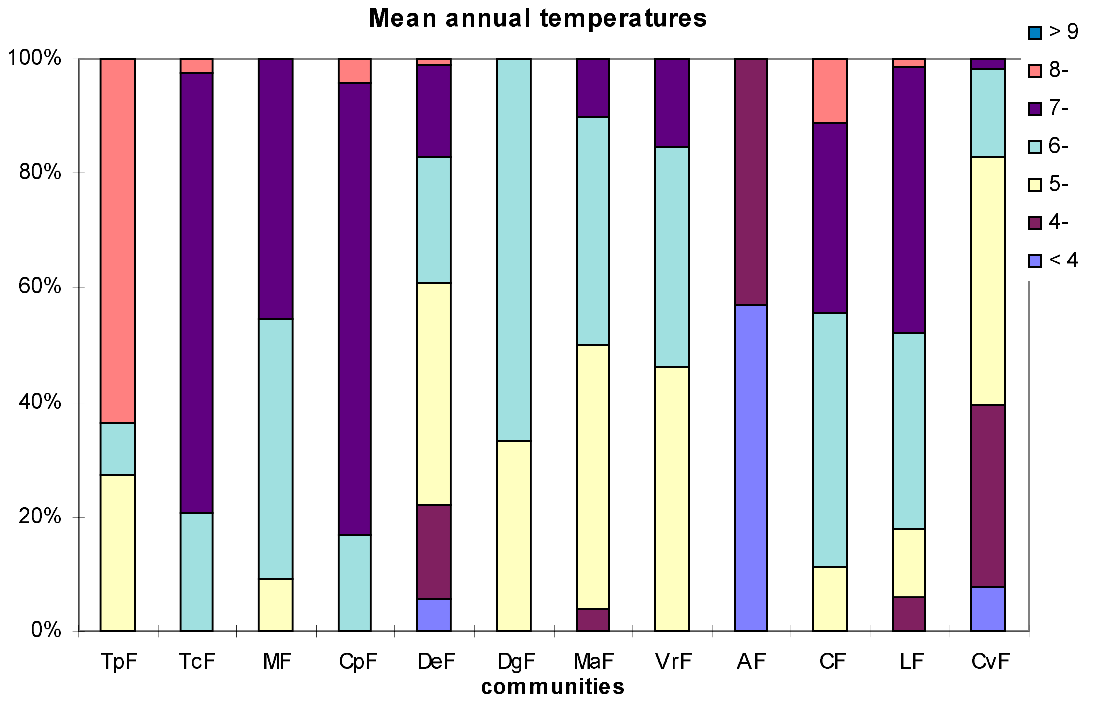


Fig. 7. – Schema of database processing in IDRISI



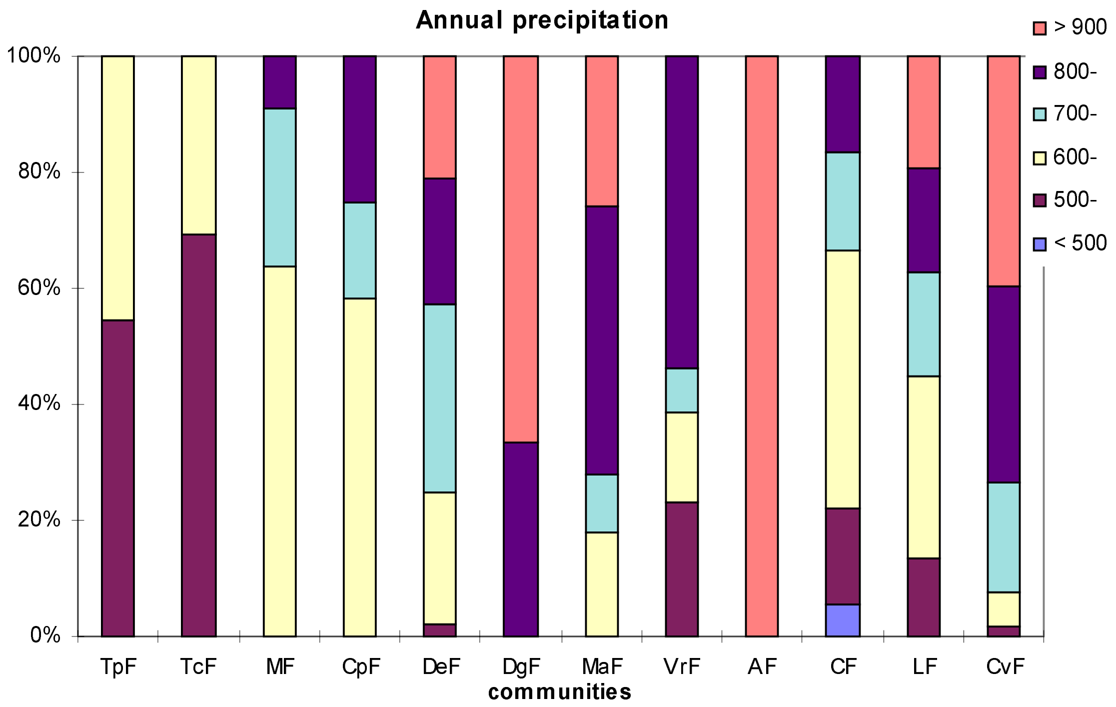


Fig. 8. – Training data: example of community differentiation in beech woods. Explanations: *Fagion/Eu-Fagenion*: TpF – Tilio-platyphyllae-Fagetum, TcF – Tilio cordatae-Fagetum, MC – Melico-Fagetum, CpF – Carici pilosae-Fagetum, DeF – Dentario enneaphylli-Fagetum, DgF – Dentario glandulosae-Fagetum, MaF – Melico altissimae-Fagetum, VrF – Violo reichenbachianae-Fagetum; *Aceri-Fagenion*: Aceri-Fagetum; *Cephalanthero-Fagenion*: Cephalanthero-Fagetum; *Luzulo-Fagion*: LF – Luzulo-Fagetum and CvF – Calamagrostio villosae-Fagetum.

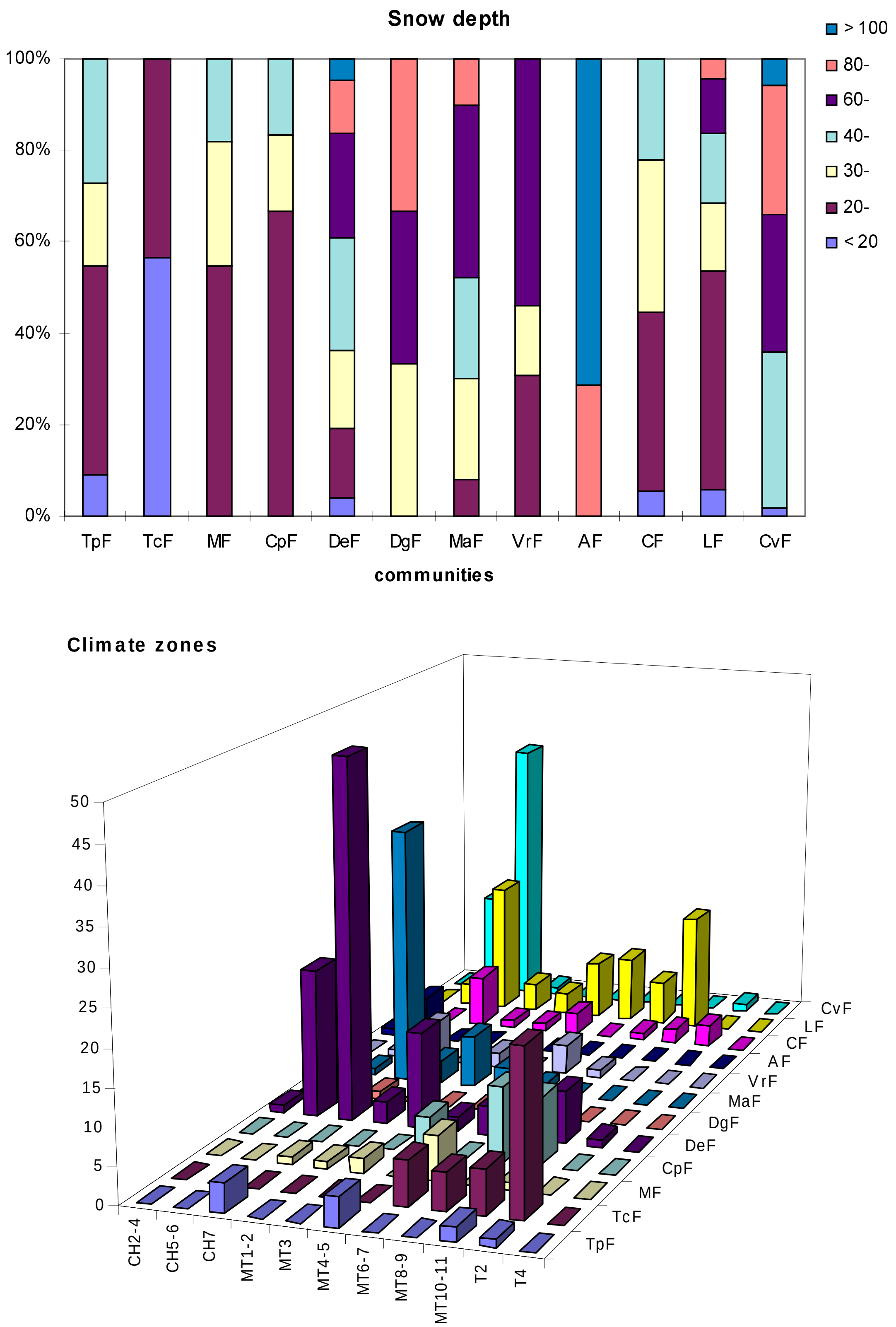
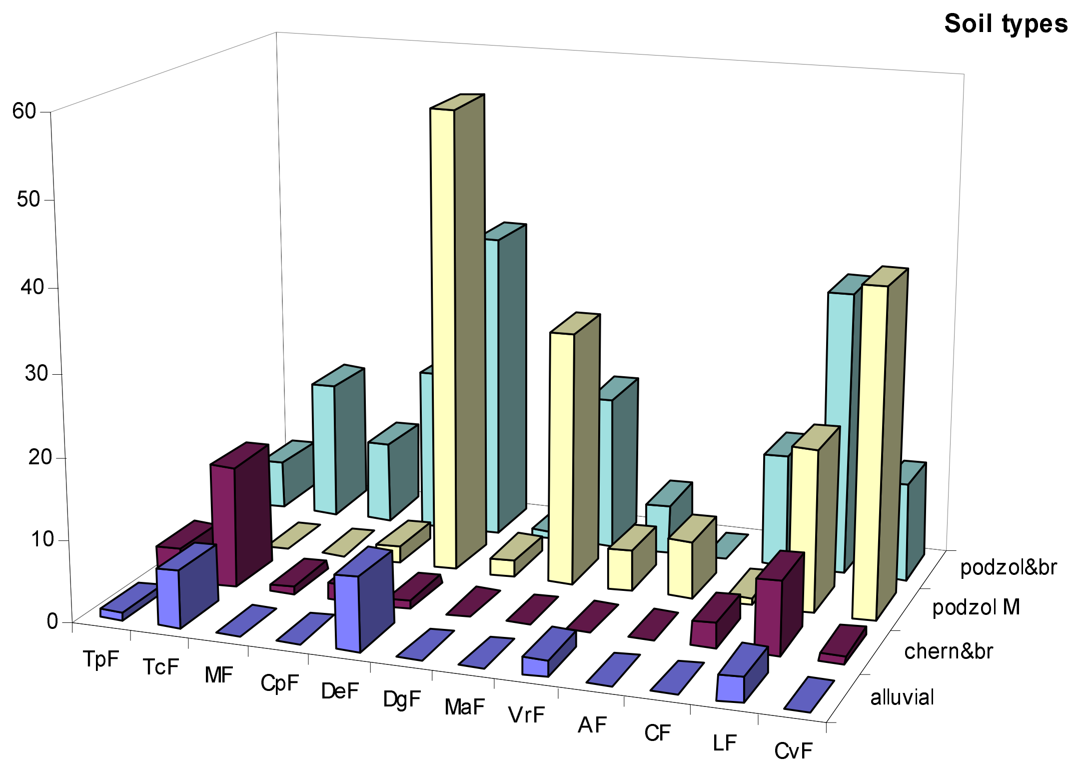


Fig. 9. – Training data: example of community differentiation in beech woods. For explanations see fig. 8.



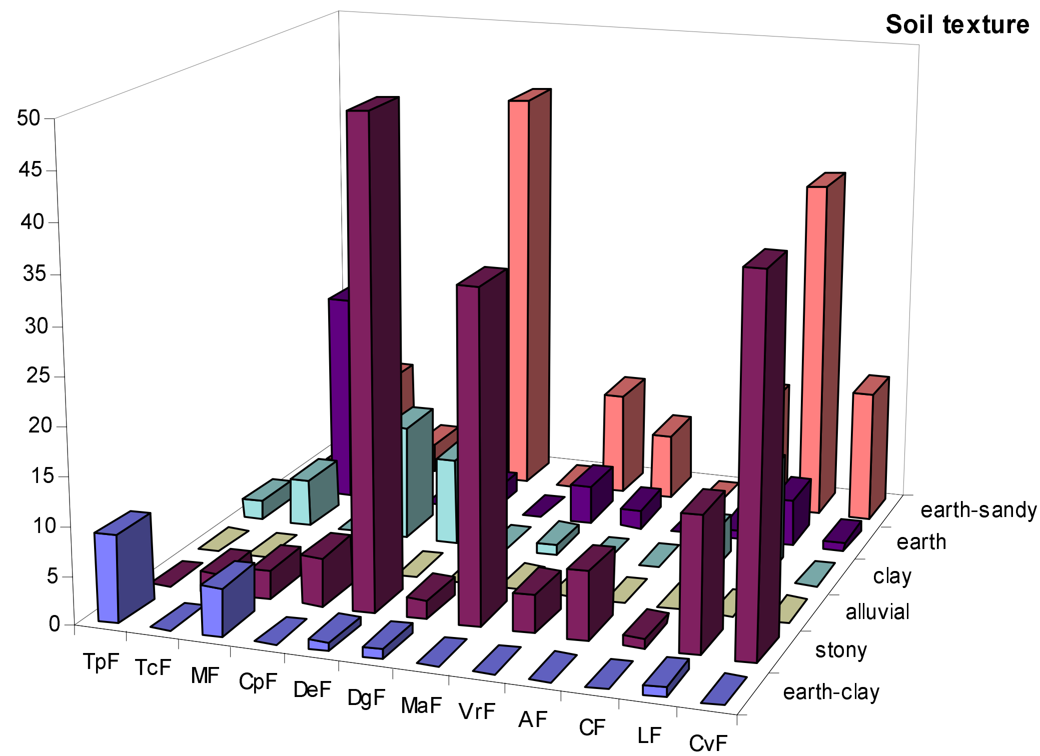
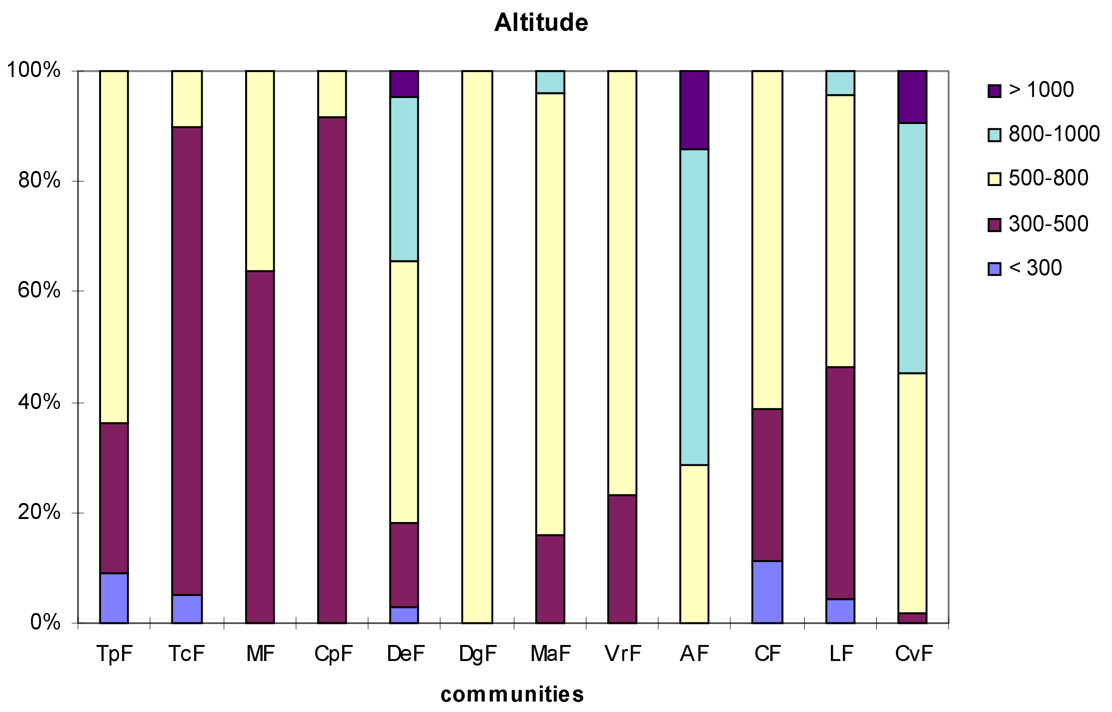


Fig. 10. – Training data: example of community differentiation in beech woods. For explanations see fig. 8.



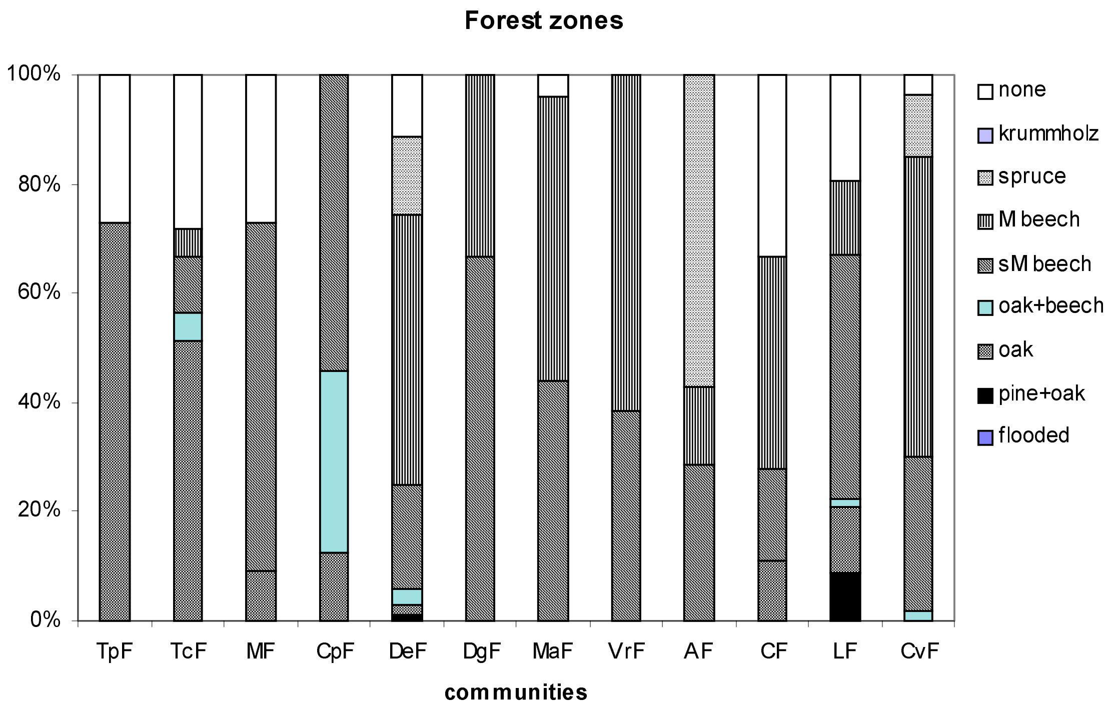


Fig. 11. – Training data: example of community differentiation in beech woods. For explanations see fig. 8.

Possibilities for the vegetation mapping and modelling

Using both large sets of releves covering main vegetation types and more environmental layers gives the possibility for mathematical simulation of more thematic maps, i.e. the map of potential vegetation. The basic information for simulation algorithm are climatic data, geological substratum, soil characteristics, altitude, orientation, slopes and solar radiation (Davis & Goetz 1990, Brzeziecki et al. 1993, Fischer 1994). Next data needed for the mapping of actual vegetation cover are land use and agriculture (Palmer & Van Staden 1992). For the simulation process the most important layers are ecological stress-factors, like precipitation deficient (South Africa; Palmer & Van Staden 1992), snow cover and absolute temperature minima (Canadian taiga; Leninhan 1993), frequencies of inundations (Netherlands; van de Rijt et al. 1996), etc. In the study of the global warm effect the altitudinal data were changed with the temperature (Brzeziecki et al. 1995). The simulation algorithm are based upon multiple regression models, multiple probability statistics (Bayesian probability theory) a o. (Davis et Goetz 1990, Brzeziecki 1993, Fischer 1994, Lindacher 1996, Tichy 1997). The Markov matrices were used for simulation of successional floodplain development (Guth & Prach 1996).

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van de Rijt C.W.C.J., Hazelhoff L. et Blom C.W.P.M. (1996): Vegetation zonation in a former tidal area: A vegetation-type response model based on DCA and logistic regression using GIS. – J. Veget. Sci. 7: 505–518.

List of additional figures

Figs. 12 and 13. – Training data: distribution of releves visualised in DMAP software package.

Fig. 14. – Training releve data imported to GIS IDRISI.

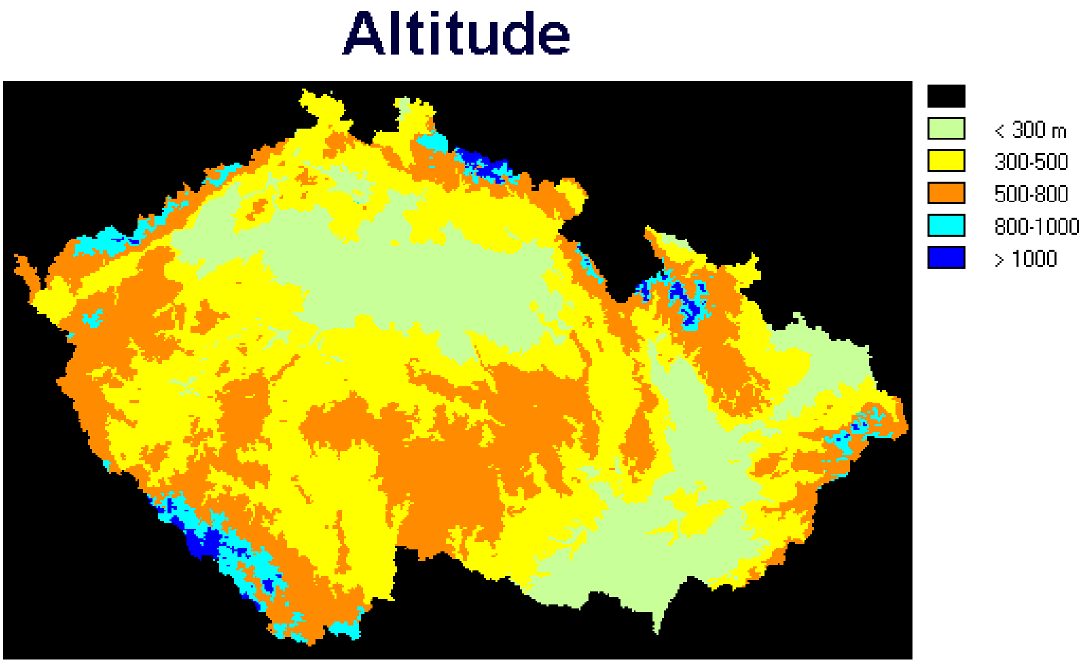

Fig. 15. – Environmental layers: altitudinal belts: < 300 m – planar, 300–500 m – colline, 500–800 submontane, 800–1000 montane, and > 1000 m – supramontane, subalpine and alpine belts.

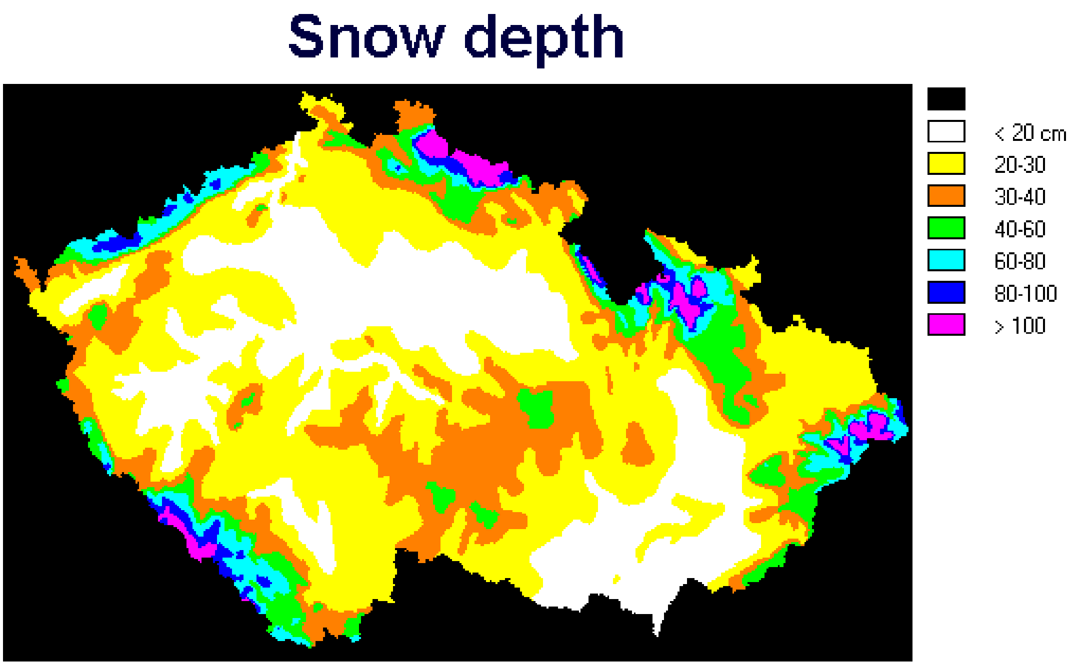

Fig. 16. – Environmental layers: map of middle snow depth.

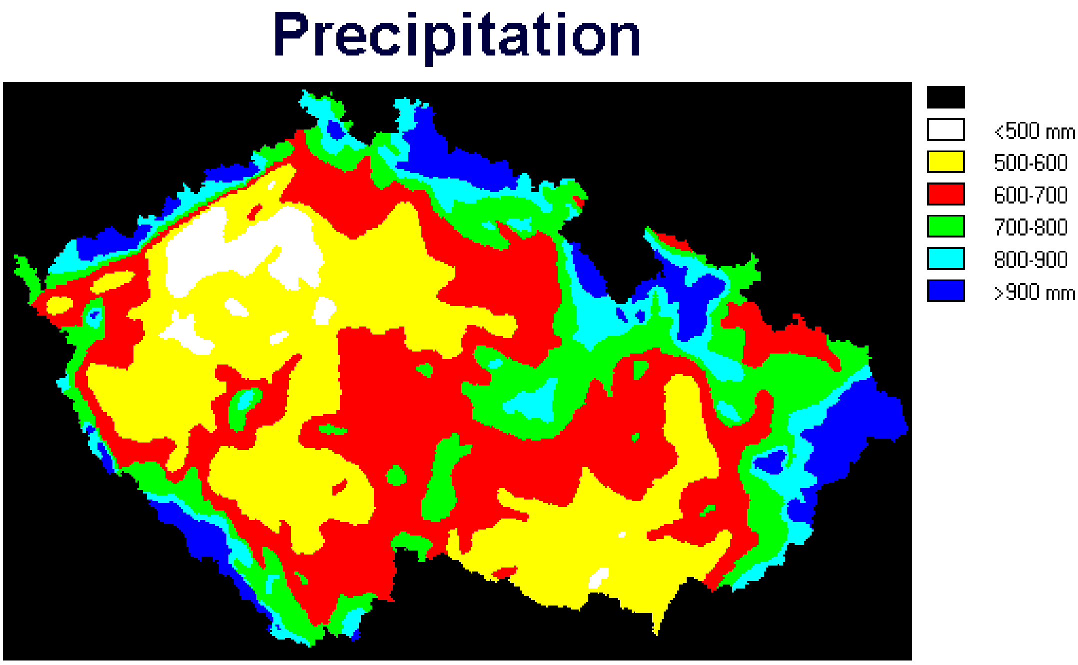

Fig. 17. – Environmental layers: sum of annual precipitation.

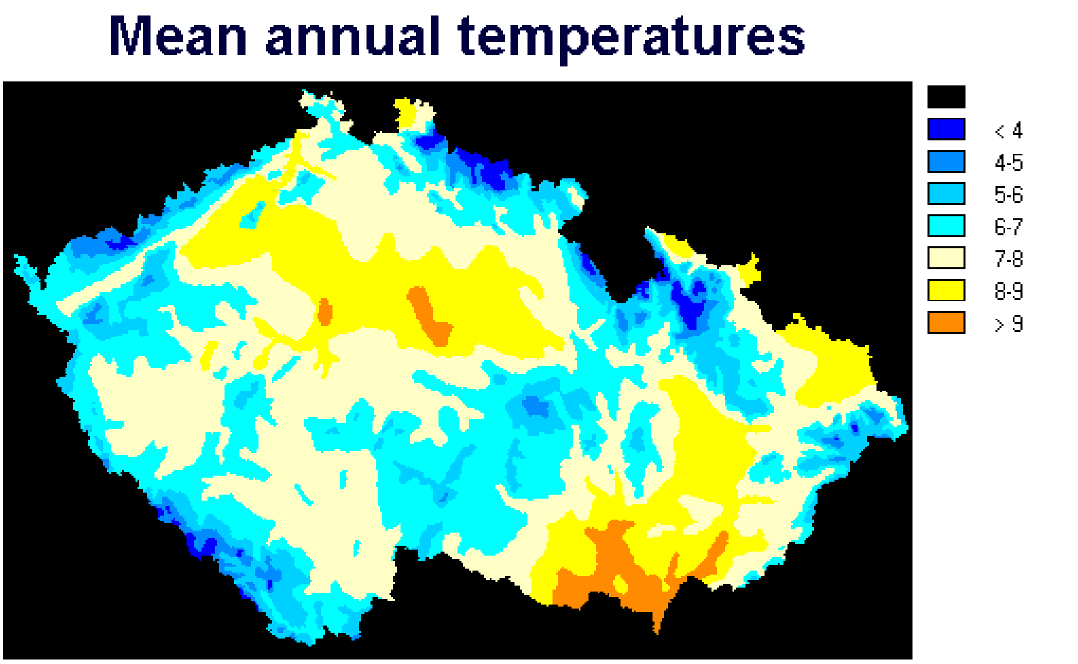

Fig. 18. – Environmental layers: mean annual temperatures.

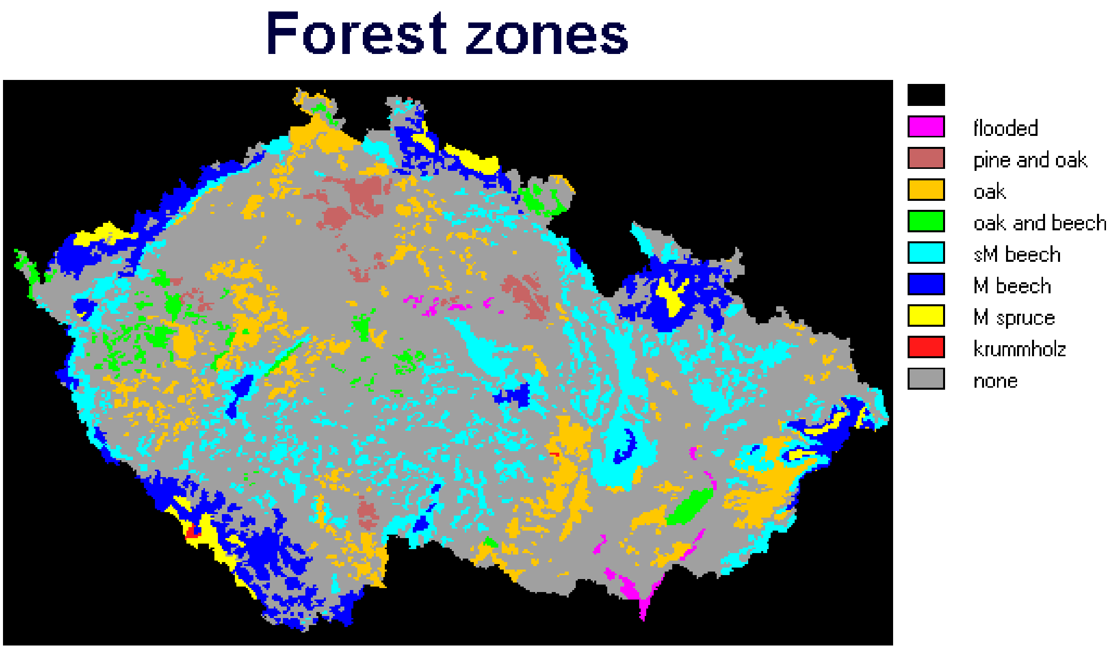

Fig. 19. – Forest zones (potential forest management). Note grey colour: deforested area.

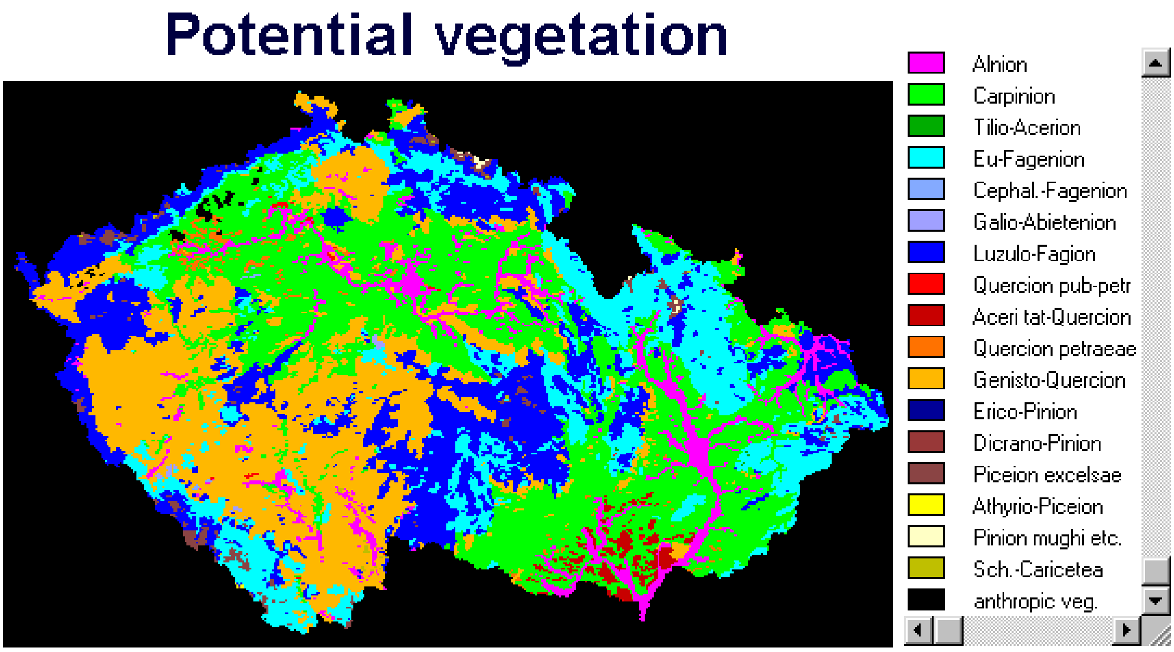

Fig. 20. – Generalised map of the potential natural vegetation.