Multi-criteria modeling of forest vegetation zones

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Forest altitudinal (vegetation) zones and their modeling form part of forest typology and in general represent an important fundamental material for landscape, forest or environmental activities. The knowledge of their spatial distribution is also essential for biotope mapping, designing area systems of environmental stability and many other environmental works. In the Czech Republic forest altitudinal zones were defined, which bear the name of the dominant tree in the potential natural state. These zones are modeled by phytocoenological studies using bioindicator species of plants. Their incidence is affected by many abiotic factors. **By effective modeling of factors, which affect the site requirements of bioindicator species, it is possible to make a comprehensive modeling of altitudinal zonation**. As the potentially influential factors the average temperature, precipitation, solar radiation, topographic exposure, aspect, slope, curvature, stream distance, soil and geology were chosen and their spatial distribution was modeled using GIS analyzes and Python regression code. Resulting rasters were subjected to discriminant analyzes to identify really influential abiotic factors. Results are merged into the comprehensive analytical models of studied phenomenon based on the maximum likelihood classification.

Evaluation of the ratio of individual abiotical factors impact was statistically processed in several experimental areas (Beskydy, Bílé Karpaty and University Training Forest). All factors were combined by means of ArcGIS software with the raster of altitudinal zonation from typological map in the Regional Plans of Forest Development (OPRL). The resultant matrix was further analyzed by discriminant analysis which applies the value of **Wilk's lambda to determine the power of individual classes** to correctly classify objects into desired groups.

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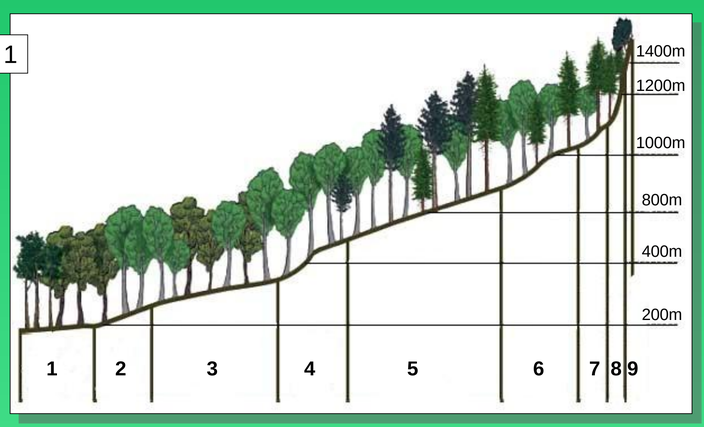
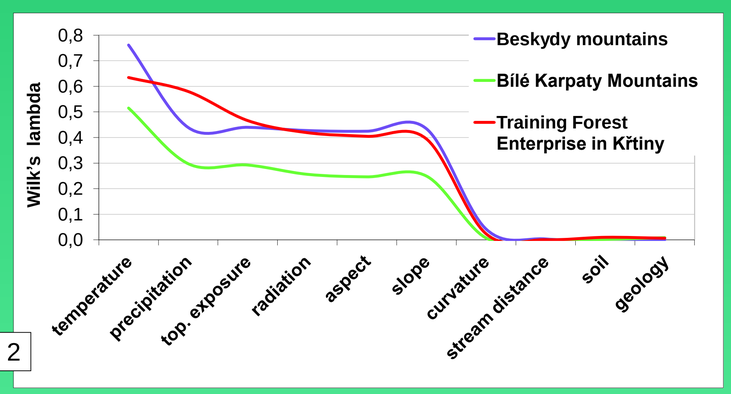


[1] Forest altitudinal zones in the Czech Republic

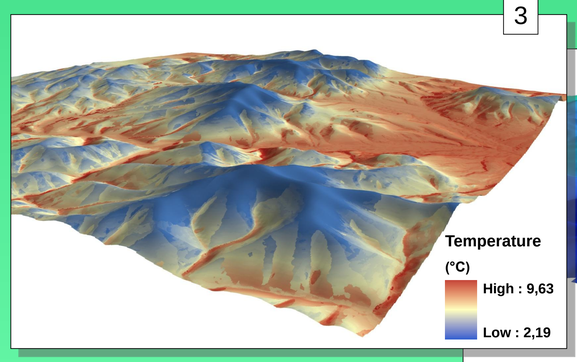
Forest altitudinal zones in the Czech Republic: 1. oak, 2. beech-oak, 3. oak-beech, 4. beech, 5. fir-beech, 6. spruce-fir-beech, 7. spruce, 8. dwarf pine and 9. alpine.

2



[2] Ratio of influence of abiotical factors on altitudinal zones

3



[3] Average temperature (Beskydy)

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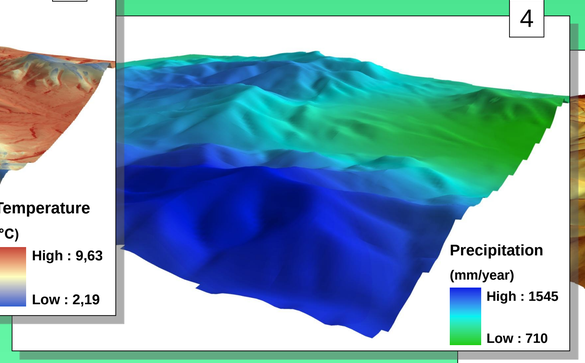

[4] Annual rainfall (Beskydy)

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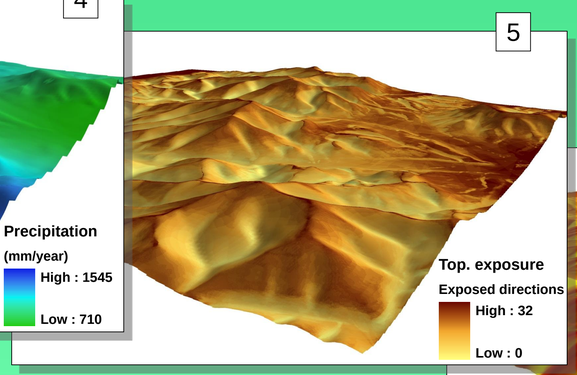

[5] Topographic exposure (Beskydy)

The calculation of annual global radiation combines its direct and diffuse form. The impact of climatic inversion was expressed as a factor of topographic exposure.

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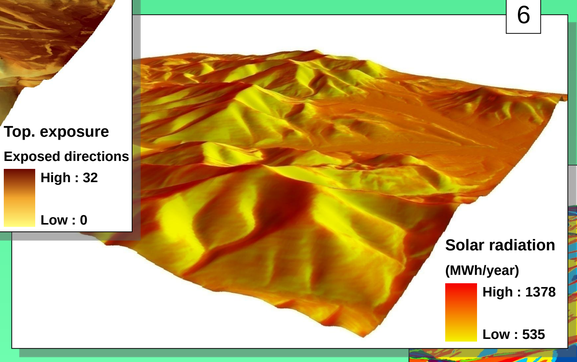

[6] Solar radiation (Beskydy)

The factors of slope and aspect were obtained from the digital terrain model.

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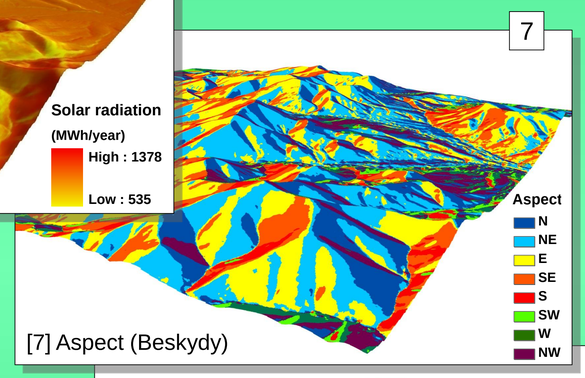

[7] Aspect (Beskydy)

The temperature mostly fluctuates in relation with the changing altitude of the area. Regression script was written to statistically analyze the average annual values and thus was found out the equation of the dependence of temperature on altitude in areas of interest. The map of average precipitation was created by interpolation of values of precipitation-gauge station.

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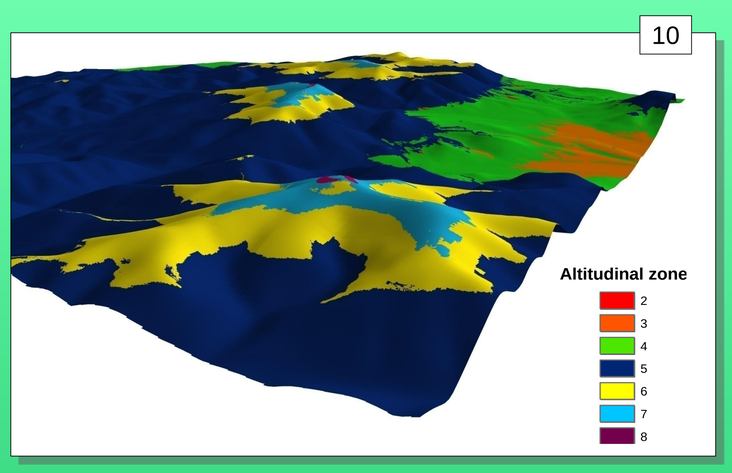

[10] Model of forest altitudinal zones performed by MLC

MLC

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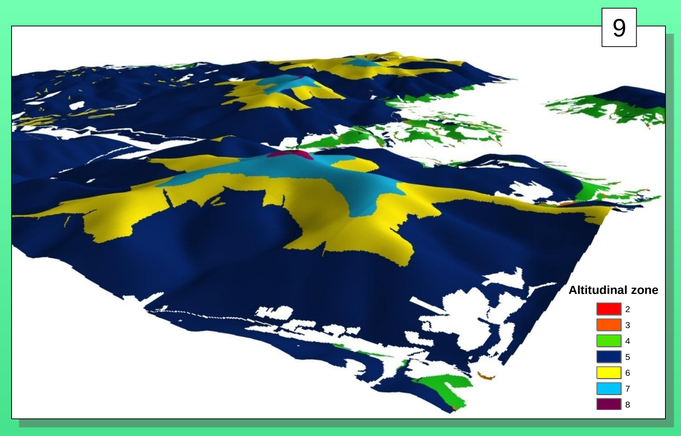

[9] Altitudinal zones in Regional Plans of Forest Development

Covariance matrices

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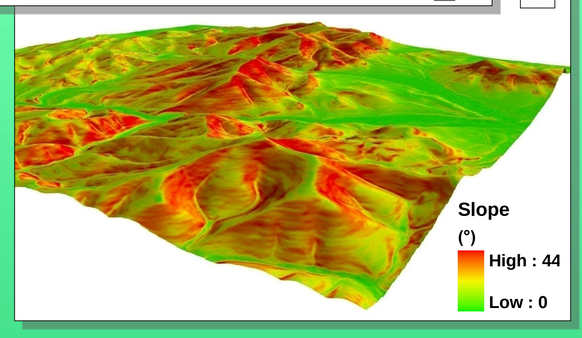

[8] Slope (Beskydy)

Altitudinal zones modeling was performed by using two different methods: (1) classification tools of **Maximum Likelihood Classification** (MLC) and (2) classification function of **discriminant analysis**. Both procedures resulted in creating a new raster depicting spatial distribution as an outcome of geospatial match of influential abiotic factors with OPRL typology data as a training set.

Model of forest **altitudinal zones of entire Czech Republic** simulates the spatial distribution of studied phenomenon at forest stands and even at the non-forest stands. As expected areas of 1st 2nd and 3rd forest altitudinal zones in contemporary forest habitats are in comparison to their areas nationwide markedly lower due to their agricultural usage. This ratio is reversed between 4th and 7th zone. Forest altitudinal zones response to the warming by 1 °C is shown by [14] and [12]. Area of 1st, 2nd and 3rd zone dramatically increases with warming up the average temperature by 1 °C. Since that the 4th zone is the opposite process.

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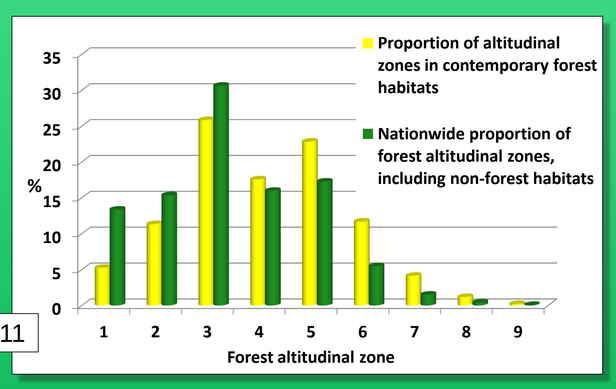

[11] Proportion of forest altitudinal zones in contemporary forest and nationwide habitats

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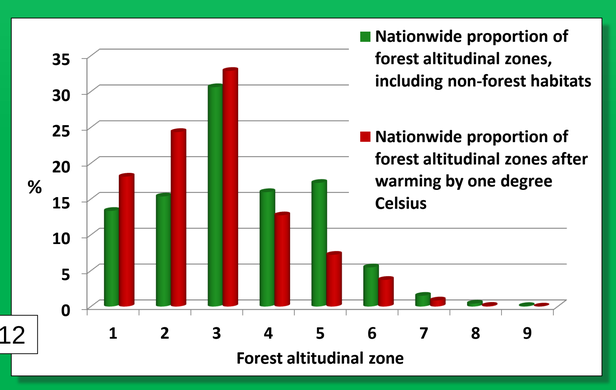

[12] Nationwide proportion of forest altitudinal zones before and after warming by 1 °C

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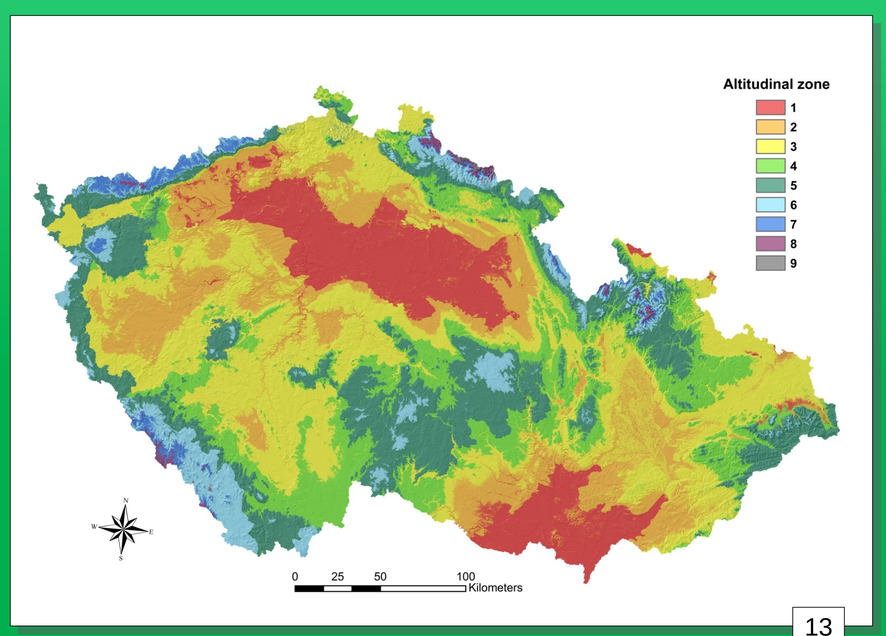

[13] Spatial distribution of forest altitudinal zones in the Czech Republic

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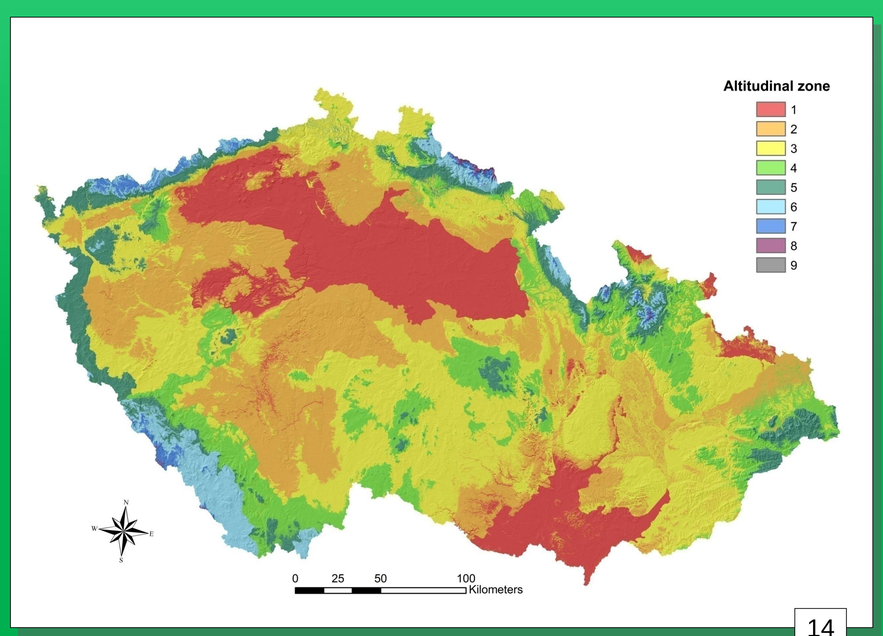

[14] Forest altitudinal zones in the Czech Republic after warming up by 1 °C

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Input data: Forest Management Institute, Fundamental Base of Geographic Data, Czech Hydrometeorological Institute, Czech Geological Survey
Software: Microsoft Windows 7 Pro (64-bit); ESRI ArcInfo 10 + Spatial, 3D and Geostatistical Analyst; Statistica 9
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