Abstract

Dominant vegetation species of two structurally and functionally different montane ecosystems were studied by means of laboratory and field spectroscopy and remote sensing image data: (1) a homogeneous human-influenced evergreen coniferous forest represented by a Norway spruce forest in the Krušné hory Mountains and (2) a heterogeneous natural ecosystem of a relict arctic-alpine tundra in the Krkonoše Mountains with predominance of grasses.

The first part dealing with the Norway spruce forest is especially focused on the methods of laboratory spectroscopy. The assessment of Norway spruce stands on a regional and a global scales requires detailed knowledge of their spectral properties at the level of needles and shoots in the beginning, but ground research is very time-demanding. Open spectral libraries could help to get more ground-truth data for subsequent analysis of tree species in forests ecosystems. However, the problem may arise with the comparability of spectra taken by different devices. The present thesis focuses on a comparability of spectra measured by a field spectroradiometer coupled with plant contact probe and/or two integrating spheres (Paper 3) and proves the significant differences in spruce needle spectra measured by the contact probe and integrating sphere, spectra of broadleaved plants (tobacco) also differ but the mean values of indices calculated using these spectra are in the range of the corresponding standard deviations, while spectra of homogeneous materials (colored papers, Spectralon) are comparable. Furthermore, data on different scales (laboratory retrieval of photosynthetic pigments and water content, the spectra of the needles measured by the contact probe, the spectra of crowns derived from airborne hyperspectral image acquired by an APEX sensor) are evaluated for the purpose of the detection of the differences in the physiological status of the Norway spruce stands among various factors - needle age class, position in the tree crown, stands or areas (Paper 2). Two areas in Krušné hory Mountains which were affected by various intensities of air pollution during the 1970's showed only slight differences in 2013 based on the laboratory biochemical data and no differences based on the spectroscopic data. Some heterogeneity was proven among eleven studied stands in these two areas based on all three datasets. Based on the laboratory data (biochemical and also spectral), the differences among the needle age classes and positions in the tree crown were proven. The differences among the positions in the tree crown were elaborated in the next part of the thesis, where the empirical models for chlorophyll, carotenoids and water content estimations are modeled based on the spectra measured by the contact probe for three positions in the Norway spruce crown (the sunlit productive upper and lower parts, the shaded basal part) - Paper 4. The results are more accurate for the shaded basal part of the tree crown than for the sunlit upper part, which can be the consequence of the architecture of the shoots. The paper also confirms better results of the correlations when using partial least square regression (PLSR) over that of simple regressions and vegetation indices. Besides the methodological findings, the thesis has an ecological contribution (Paper 1 a 2) in the evidence of the Norway spruce homogeneous stands' regeneration after the air pollution elimination (especially in the central part of the Krušné hory Mountains) – although the stands are still not completely undamaged, the difference between the two areas located in the central and western parts of the Krušné hory Mountains are not so significant already.

The traits of the stands are one of the most important for correct function of homogeneous ecosystems, while the species composition of plant community plays an important role and also needs to be studied in the heterogeneous ecosystems. The species composition is the main focus of the thesis part dealing with the montane relict arctic-alpine tundra ecosystem (Papers 5 a 6). The accuracies of the classifications for several types of remote sensing image data with various spectral and spatial resolutions (Landsat, Sentinel-2, WorldView-2, orthoimages and airborne hyperspectral image data acquired by APEX and AISA sensors) were compared. For these data classifications, two differently detailed legends were used. The legends were design in accordance with the spatial resolution of the image data and the categories were specified to have a contribution to the monitoring and protection of the area with an emphasis being placed on the distinction among the expansively strong species (grasses *Calamagrostis villosa, Molinia caerulea* and *Pinus mugo* shrubs) and the original grass species *Nardus stricta*. The best classification results (an overall accuracy higher than 80%) were reached based on the aerial hyperspectral image data AISA with a high spatial resolution. In order to increase the accuracy of the classification of the heterogeneous ecosystems, such as the tundra in the Krkonoše Mountains, spatial resolution appears to be the most important based on our results. This was demonstrated by good accuracies of the orthoimages with a spatial resolution of 12.5 cm and only 4 spectral bands classifications (an overall accuracy 71.96% in the case of a detailed legend and 80% in the case of a simplified one). In the tundra ecosystem of Krkonoše Mountains, the traits of the vegetation cover (height, plant covet and fAPAR) were investigated using field spectroscopy along the elevation and nutrient gradient stretching from the Luční bouda hut to the Luční hora Mountain in two periods during the 2015 season (Paper 7). Different vegetation indices were tested for empirical modeling. The best results were achieved for the plant cover, while the worst were for fAPAR. The study of the vegetation traits in the tundra has so far yielded the first results and will continue intensively (the analysis of the chlorophyll content, the green percent vegetation cover (PVC) determined from the ratio of the green and dry biomass, LAI, etc.).

Keywords: Laboratory spectroscopy, Field Spectroscopy, Remote Sensing, Norway Spruce, Montane Ecosystems, Relict Arctic-Alpine Tundra, The Krušné hory Mountains, The Krkonoše Mountains, Leaf Optical Properties, Reflectance, Grass sp., Foliage Traits.