During the past few years, environmental conditions in the Czech Republic have improved considerably but they still remain among the worst in the world. The most heavily polluted area of the country is in the north, where most of the forest ecosystems in the Krušné Hory Mountains have been heavily damaged. Monitoring of symptoms of forest decline is usually based on the visual characteristics such as needle yellowing and foliar loss, canopy degradation and tree death. Although this assessment can be sufficiently precise, it is often biased being observer-dependent. Moreover, this approach does not reveal the early previsual stages of damage to conifers. Metabolic and microscopic changes occur long before any morphological (visible) injury can be detected and, therefore, give potential for improvement of stress detection.

Induced deposition of phenolic compounds and lignification has been documented for various stress factors including atmospheric pollutants (Lewis & Yamamoto, 1990). Foliar damage can be also assessed from plant spectral reflectance data (Rock et al., 1992) at certain wavelengths or by use of different spectral indexes (Entcheva, 2000). Moreover, spectral reflectance of leaves can be also used as an estimate of the concentration of photosynthetic pigments, water content, and chemical composition of plants (Martin & Aber, 1997).

Goal of the research, conducted in summer 1998, 1999 and 2000, was to assess changes in the amount, localization, and composition of phenolic compounds, photosynthetic pigments and spectral parameters of Norway spruce (Picea abies) needles of representing four different degrees of visual damage. Additionally, health conditions of damage of adjacent plots of Colorado blue spruce (Picea pungens L.) and Norway spruce were studied in order to determine if Colorado blue spruce is more tolerant to pollution effects and climatic conditions in the Krušné hory Mts. Biochemical and histochemical tools as well as analyses of needle spectral reflectance in visible and near infrared portion of spectrum were used.

It was found that the biochemical changes of damaged Norway spruce needles comparing to healthy ones included: (1) decrease of lignification particularly in mesophyll cells walls, (2) increase of soluble phenolics as well as changes in composition of phenolic compounds, (3) decreased concentration of chlorophylls and carotenoids and (4) increased activity of soluble peroxidases.

Despite that we proved that spectral signatures of lignin and tannin are very similar and it seems that spectral reflectance in near infrared spectral region can give the information about total amount of those two compounds in needles. Wavelengths that were connected
with the absorbance of phenolics were previously associated with increasing levels of foliar
damage. It seems likely, that changes of spectral reflectance at those wavelengths reflect
changes of tannins in affected mesophyll cells and, therefore, needle damage.

Spectral indexes, calculated from spectral reflectance and referring to the amount of
photosynthetic pigments, stress and water status of needles, were proved to be useful for the
determination of differences in needle damage. The only spectral parameter useful for the
determination of inter-species differences in health status was standardized red edge
inflection point.

Based on the study of phenolic compounds as well as spectral reflectance it seems, that
health conditions of comparable 20-year old stands of Norway and Colorado blue spruce are
similar. However, in further phases of tree life, recorded better morphological adaptations of
needles of Colorado blue spruce can cause a higher resistance to atmospheric pollution.

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Entcheva P. 2000. Remote Sensing of Forest Damage in the Czech Republic Using
Hyperspectral Methods, 277 pp, PhD. Dissertation, University of New Hampshire.
Lewis NG, Yamamoto E. 1990. Lignin: occurrence, biogenesis and biodegradation. Annual
Revue of Plant Physiology and Plant Molecular Biology 41, 455-496.
Martin ME, ABER JD. 1997. High spectral resolution remote sensing of forest canopy
of forest decline in branch segments of Norway spruce (Picea abies) in the Sudety Mountains