Juurola, E. 2005. Photosynthesis, CO_2 and temperature – an approach to analyse the constraints to acclimation of trees to increasing CO_2 concentration. Dissertationes Forestales 4. 48 p. Available at http://www.metla.fi/dissertationes/df4.htm

The aim of this thesis was to analyse the effects of temperature and increasing CO_2 concentration on the processes involved in photosynthesis and on acclimation of the photosynthetic machinery within the constraints set by three-dimensional (3D) leaf structure. These processes include both the transport of CO_2 into and within a leaf and the photosynthetic CO_2 sink in the chloroplasts.

A detailed 3D model of silver birch leaf photosynthesis was constructed to study the transport of gases into and inside a leaf as well as the light attenuation inside a leaf. To understand the role of temperature in apparent CO_2 assimilation, the temperature dependencies of essential biochemical reactions in photosynthesis were experimentally determined for silver birch and for boreal conditions utilising a conventional model of photosynthesis.

The role of temperature dependent physical phenomena in the apparent CO_2 assimilation was analysed in detail using the 3D model. Based on these results, new chloroplast related temperature dependencies describing the biochemical processes were determined that take into account the specific effects exerted by leaf structure and CO_2 diffusion. Finally, the patterns of acclimation of photosynthesis to increasing CO_2 concentration were experimentally studied in silver birch and Scots pine.

The developed model is a powerful tool for studying photosynthesis in a 3D leaf. The results showed clearly that the physical phenomena together with leaf structure play an important role in leaf CO_2 assimilation and that these have to be included in the analysis of photosynthesis in a changing environment. It was also concluded that besides other factors, leaf structure may significantly influence the acclimation patterns of different tree species when atmospheric CO_2 concentration is increasing. Due to the structural differences, in contrast to silver birch, Scots pine may be able to take full advantage of increased CO_2, at least temporarily.

Keywords: climatic change, CO_2 diffusion, leaf structure, modelling, temperature dependence