EFFECTS OF ENVIRONMENTAL CONDITIONS ON CO_2 / H_2O EXCHANGE OF BETULA SPECIES IN THE TAIGA ZONE OF NORTH-WEST RUSSIA

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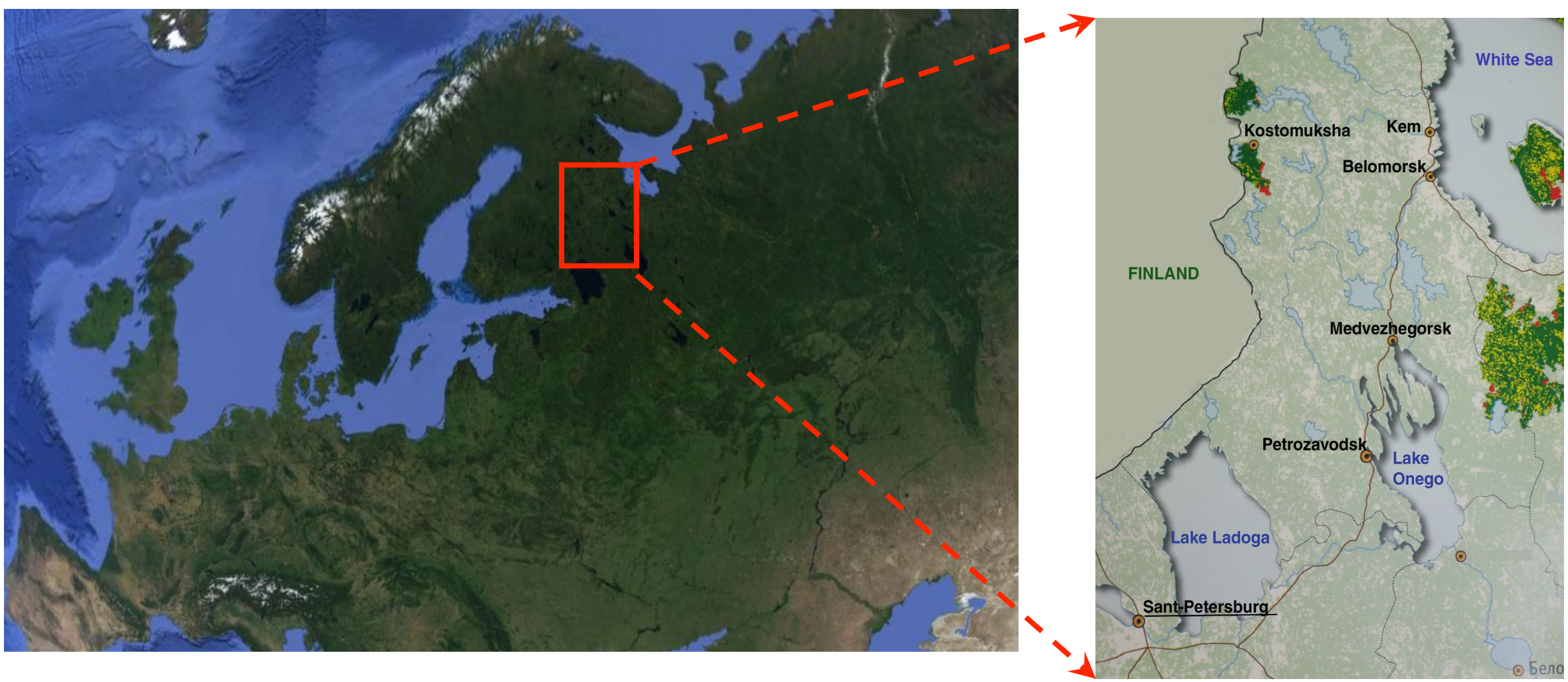
Objectives

The main goal of the study is to describe the interspecific features of CO_2/H_2O exchange of different birch (*Betula*) species growing in forests of Republic of Karelia as well as to estimate the sensitivity of photosynthesis and respiration rate of the trees to change of ambient conditions.

Material and methods

Measurements of leaf photosynthesis, respiration and stomatal conductance of *Betula pendula* Roth and *Betula pubescens* Ehrh. were provided using the portable photosynthesis system LI-COR 6400XT (Li-Cor Inc., USA) on the experimental plots of the Forest research Institute of Karelian Research Center of RAS in Karelia, Russia (61°45′N, 34°20′E)



LI-COR 6400XT allows to provide the measurements of photosynthesis and respiration rates of individual leaves at various PAR, temperatures, humidity and concentration of CO_2 in the measuring chamber. During the field campaigns in 2011-2012 the CO_2 and light response curves of photosynthesis of leaves under different air temperatures as well as the temperature response functions of dark respiration (*Rd*) of the leaves of different species were estimated.

Results

The method suggested by Sharkey et al (2007) was used to estimate the maximal velocity of Rubisco for carboxylation (Vc_{max}), the rate of electron transport at light saturation (J_{max}), photorespiratory compensation point as well as the rate of use of triose phosphates (TPU) that characterizes the availability of internal inorganic phosphates (Ci) in leaves for Calvin's cycle. The temperature dependences of Vc_{max}, J_{max} and TPU were estimated using the statistical analysis of Vc_{max} and J_{max} data set using equations suggested by Medlin et al (2002). Temperature dependence function of TPU was derived using algorithm proposed by Sharkey et al (2007).

$$A_l = \min\left\{A_V, A_J, A_P\right\} - R_l \qquad \begin{cases} A_V = V_{CMAX} \cdot \dfrac{\left(C_i - \Gamma^*\right)}{C_i + K_c \cdot \left(1 + O_i / K_o\right)} \\ A_J = \left(\dfrac{J}{4}\right) \cdot \dfrac{\left(C_i - \Gamma^*\right)}{\left(C_i + 2 \cdot \Gamma^*\right)} \\ A_P = 3 \cdot TPU \end{cases}$$

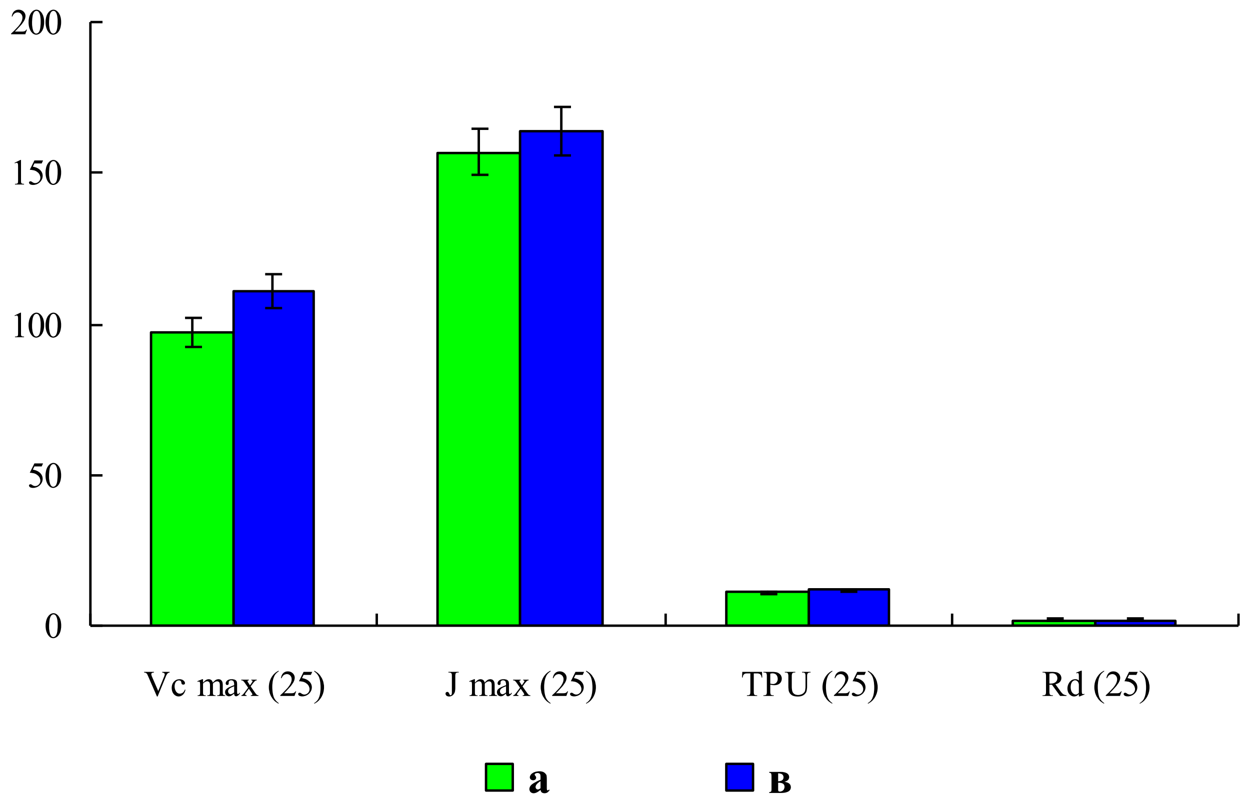


Fig. 1. The photosynthesis model parameters for silver (A) and downy birches (B).

Preliminary estimates of Vc_{max}, J_{max} and *TPU* were derived from the temperature relations for the selected reference temperature of 25°C. The results of field measurements show a relatively weak differences among Vc_{max}, J_{max}, *TPU* and *Rd* for *B. pendula* and *B. pubescens* trees (for leaf temperature T = 25^{o} C).

The analysis of nitrogen influence on H_2O and CO_2 exchange in the leaf of *B. pendula* and *B. pubescens* identified interspecific distinctions under experimental treatment. When treated with nitrogen (NH_4NO_3) both species demonstrated an increase in stomatal conductance (g_s), rates of photosynthesis (A) and transpiration (E) in the leaf. In *B. pubescens* the increase in the leaf E rate came along with an increase in the shoot water potential (Ψ) and a decrease in the available water content (WCf) and saturating water content (WCs) in the leaf. The changes accompanying the increase in leaf E rate in *B. pendula* were a decrease in Ψ of the foliated shoot and stabilization of WCf and WCs of the leaf. In both the control and the treatments the values of the leaf A rate, WCf and WCs were higher in *B. pubescens*.

Table 1. Content of N and H_2O/CO_2 exchange indices in leaf of *Betula pendula* and *B. pubescens* in control (above the line) and treatment (below the line)

Indices	*Betula pendula*	*Betula pubescens*
N, %	2.47 ± 0.07 2.77 ± 0.11	2.37 ± 0.09 2.77 ± 0.09
g_s, mol H_2O m^{-2} s^{-1}	0.22 ± 0.01 0.28 ± 0.02	0.24 ± 0.01 0.27 ± 0.01
A, µmol CO_2 m^{-2} s^{-1}	17.31 ± 0.54 19.70 ± 0.64	19.58 ± 0.46 20.83 ± 0.49
E, mmol H_2O m^{-2} s^{-1}	2.31 ± 0.14 2.71 ± 0.16	2.42 ± 0.11 2.75 ± 0.16
WUE, µmol CO_2 $mmol^{-1}$ H_2O	0.84 ± 0.05 0.78 ± 0.03	0.85 ± 0.03 0.81 ± 0.04
Ψ, MPa	-1.09 ± 0.03 -1.19 ± 0.03	-1.04 ± 0.03 -0.95 ± 0.04
WC_f, g_{water} $g^{-1}{}_{dry\ weight}$	1.59 ± 0.05 1.51 ± 0.03	2.06 ± 0.09 1.80 ± 0.04
WC_s, g_{water} $g^{-1}{}_{dry\ weight}$	0.38 ± 0.02 0.38 ± 0.02	0.52 ± 0.02 0.45 ± 0.02

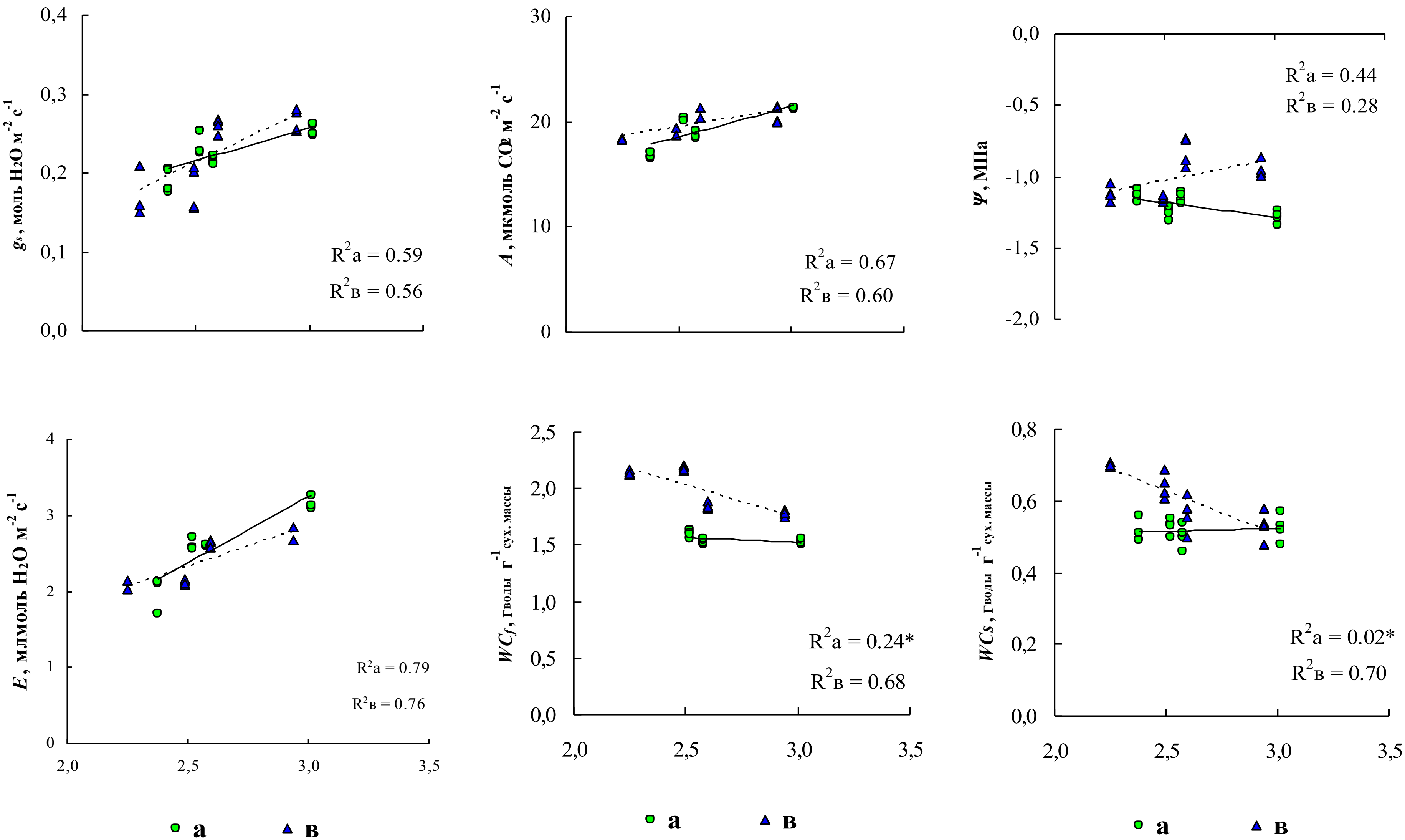


Fig. 2. Dependence of stomatal conductance (*gs*), photosynthetic rate (*A*), transpiration rate (*E*), shoot water potential (*Ψ*), water content (*WCf*) and saturating water content (*WCs*) in leaf of *B.pendula* (a) and *B. pubescens* (в) on *N* content in leaf of control and treatment trees.

On x-coordinate – the content of *N* in leaf, %; * – no significant (p>0.05).

Conclusions

- The two species differ in their functional plasticity with respect to the mineral nutrition conditions.
- The results of provided leaf photosynthesis, respiration, stomatal conductance and transpiration measurements were used in the process-based Mixfor-SVAT model (Olchev et al 2002, 2008) to derive the possible response of CO_2/H_2O budgets of Karelian forest ecosystems to future climatic changes.

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Thank you for attention!