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RESEARCH PAPER

Distinguishing local from global climate influences in the variation of carbon status with altitude in a tree line species

Alex Fajardo[1]*, Frida I. Piper[1,3] and Lohengrin A. Cavieres[2,3]

[1]*Centro de Investigación en Ecosistemas de la Patagonia (CIEP), Bilbao 449, Coyhaique, Chile,* [2]*ECOBIOSIS, Departamento de Botánica, Universidad de Concepción, Casilla 160C, Concepción, Chile,* [3]*Instituto de Ecología y Biodiversidad (IEB), Casilla 653, Santiago, Chile*

*Correspondence: Alex Fajardo, Centro de Investigación en Ecosistemas de la Patagonia (CIEP), Bilbao 449, Coyhaique, Chile.
E-mail: alex.fajardo@ciep.cl

ABSTRACT

Aim Two alternative hypotheses attempt to explain the upper elevation limit of tree lines world-wide, the carbon-limitation hypothesis (CLH) and the growth-limitation hypothesis (GLH); the altitudinal decrease of temperature is considered the driver constraining either carbon gain or growth. Using a widely distributed tree line species (*Nothofagus pumilio*) we tested whether tree line altitude is explained by the CLH or the GLH, distinguishing local from global effects. We elaborated expectations based on most probable trends of carbon charging with altitude according to both hypotheses, considering the alternative effects of drought.

Location Two climatically contrasting tree line ecotones in the southern Andes of Chile: Mediterranean (36°54′ S) and Patagonia (46°04′ S).

Methods At both locations, 35–50 trees of different ages were selected at each of four altitudes (including tree line), and stem and root sapwood tissues were collected to determine non-structural carbohydrate (NSC) concentrations. NSC accumulates whenever growth is more limited than photosynthesis. An altitudinal increase in NSCs means support for the GLH, while the opposite trend supports the CLH. We also determined stable carbon isotope ratios ($\delta^{13}C$) to examine drought constraints on carbon gain.

Results NSC concentrations were positively correlated with altitude for stem tissue at the Mediterranean and root sapwood tissue at the Patagonia site. No depletion of NSC was found at either site in either tissue type. For both tissues, mean NSC concentrations were higher for the Patagonia site than for the Mediterranean site. Mean root sapwood NSC concentration values were five times higher than those of the corresponding stem sapwood at all altitudes. Values for $\delta^{13}C$ were positively correlated with altitude in the Mediterranean site only.

Main conclusions We found support for the GLH at the site without drought effects (Patagonia) and no support for the CLH at either site. It is suggested that drought moderated the effects of low temperature by masking the expected trend of the GLH at the Mediterranean site.

Keywords

Carbon balance, carbon isotope composition, Chile, drought, Mediterranean climate, non-structural carbohydrates, *Nothofagus pumilio*, Patagonia, tree line ecotone.

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