Differential photosynthetic adaptation between size-classes of Spruce and Fir juveniles help to explain the co-existence of the two species.

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Introduction

Spruce and Fir dominate many of the boreal and alpine forests of the world. These forests hold more than 25% percent of the carbon stored in terrestrial ecosystems and are likely to be affected by global climate change (Easterling *et al.*, 2007). Therefore, mechanistic knowledge of these forests' dynamics must improve to allow reliable predictions and mitigating strategies for negative effects.

Abies and *Picea* populations have received considerable attention in Japan (*e.g.*, Kubota *et al.*, 1995; Takahashi, 1997) and it has been recently proposed that reversals in competitive superiority at different life stages could play an important role in the coexistence and co-dominance of these species (Nishimura *et al.*, 2009). Nevertheless, the majority of works on the subject concentrate in adult individuals and studies their coexistence from the population-dynamics point of view.

Therefore, in this work, we attempted to analyze juvenile trees of *Abies sachalinensis* (Sakhalin Fir) and *Picea Glehnii* (Sakhalin Spruce) from an ecophysiological perspective, specifically testing for differences between seedlings and saplings of both species, aiming to provide mechanistic background to explain the observed patterns of their coexistence in the sub-boreal forests of Hokkaido.

Materials and Methods

The study site was a hardwood-mixed forest located at the Uryu Experimental Forest of Hokkaido University (N 44º 19', E 142º 15'). The soil on the region is prevailingly Inceptisol (acidic brown forest soil) and Tertiary andesite bedrock. Hokkaido's climate is classified as Dfb after Köppen. Annual total precipitation ranges from 900 to 1400 m (Kojima, 1991).

The studied species are both considered to be shade tolerant. *Abies sachalinensis* generally grows faster and has shorter life-span than *Picea glehnii* (Uemura, 1994; Umeki, 2001).

***Abies sachalinensis* Mast.**

***Picea glehnii* Mast.**

Twenty shade-growing individuals of both species (ten of each) were divided into two height classes: seedlings, if height =<50cm; and saplings, if height =>100cm.

The measured parameters were:

Pigments

- Measured by HPLC (LC-Vp Series, Shimadzu Co., Japan);
- Three leafs of each individual were frozen at 77K, at noon on a cloudy summer day, and stored at -80ºC until the procedure.

Morphology

- Height and diameter;

Photosynthetic Rates

- P (rate of CO_2 uptake) / i (PPFD);
- Used to obtain P-max (the asymptote of the P/i curve);
- Measured once a day, in the morning;
- Using LI-6400 (Li-COR, inc.).

Chlorophyll Fluorescence

- Fo, Fm and Fv/Fm;
- Measured once, at noon;
- After 20 min. of dark adaptation in leaf clips;
- Using PAM-2000 (Heinz Walz GmbH).

Canopy Coverage

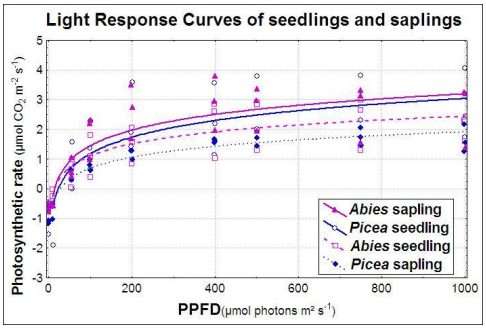
- Hemispherical pictures (Nikon Coolpicx 5400 and Nikon LC-ER2 lenses, Nikon Japan);
- Average light incidence at noon (LI-250 Light Meter).

The canopy coverage over each individual was analyzed statistically by combining hemispherical photography results (LIA32 ver.0.377e, Kazukiyo Yamamoto) to average light incidence on a factorial ANOVA (factors were: species and size-class).

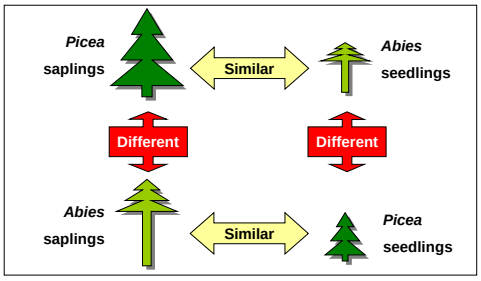
The study took place from May 2009 to June 2010.

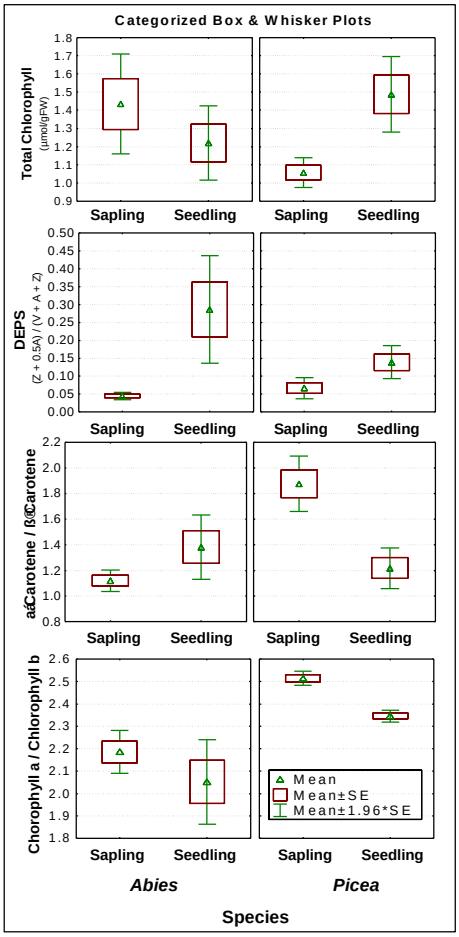
Results and Discussion

Size classes were found to be homogeneous ($p<0.01$) and height was positively correlated with diameter (Pearson's PMCC=0.6), supporting the assumption that plants in the same size class are of similar ages.



Chlorophyll fluorescence and light curves did not show significant differences between species or size classes ($0.1>p>0.05$, for both). But, results of *Abies* saplings and *Picea* seedlings were more similar among themselves than among individuals of the same species but in other size class (Bonferroni's significant differences $p<0.03$).





These results suggest an inversion on the photosynthetic regulation between seedlings and saplings, and also between both species. *Picea* seedlings and *Abies* saplings seem to have more active antenna complexes and also higher photosynthetic rates than *Picea* saplings and *Abies* seedlings.

Conclusions

Abies sachalinensis and *Picea glehnii* seem to have alternate photosynthetic characteristics in similar size classes and, as a consequence, the competition between similar sized individuals of each species is minimized during these critical periods of their development. Such relationship is comparable to the one described on Nishimura *et al.*, 2009, but it will add to complexity observed in that work if these observations are maintained throughout the seasons and also are consistent with expected growth rates.

Further investigation of these species' photosynthetic regulation at different stages of their development should prove instrumental in predicting any shift in their populations that may be caused by climate change.

Further Information

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