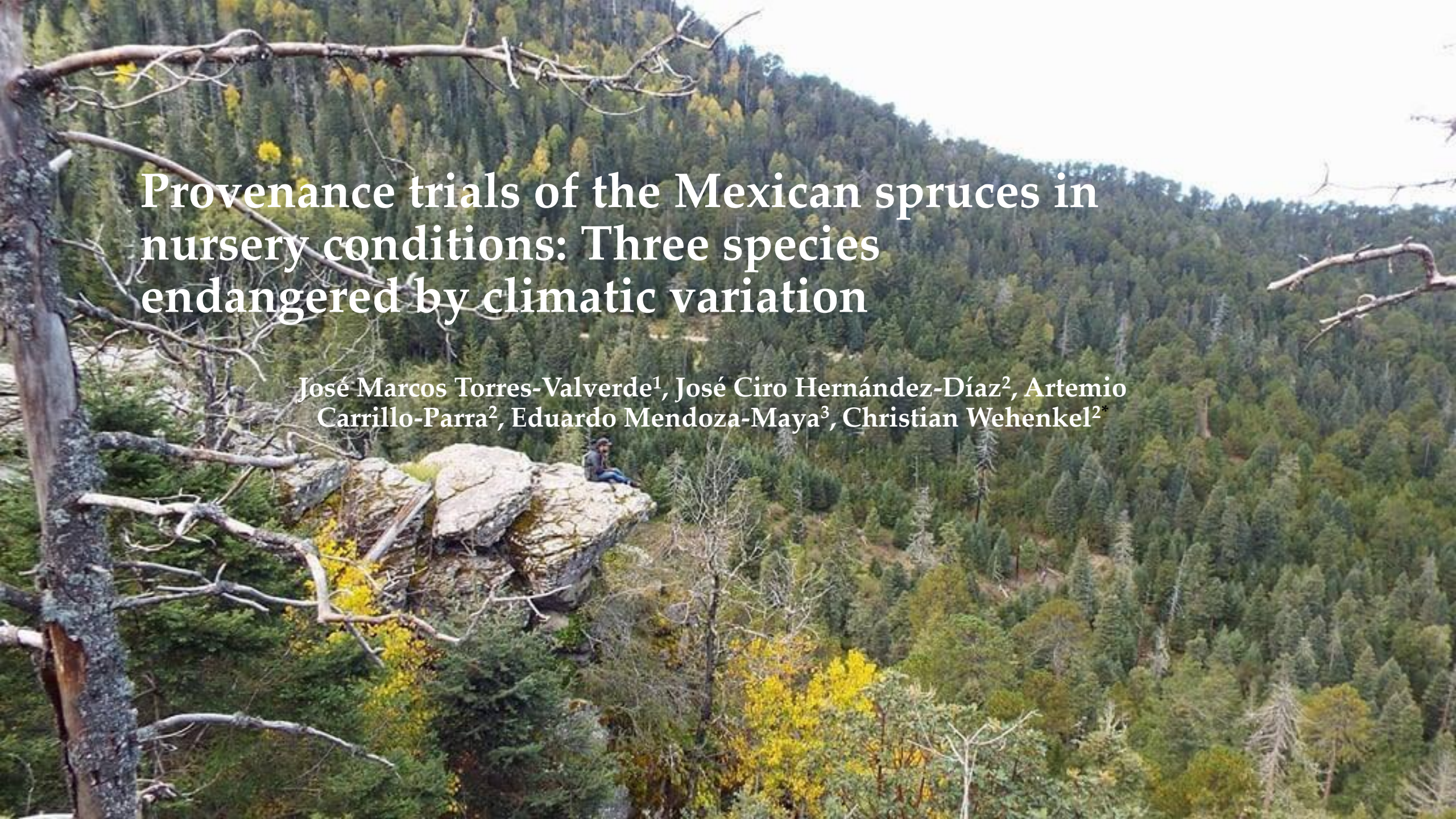


Provenance trials of the Mexican spruces in nursery conditions: Three species endangered by climatic variation

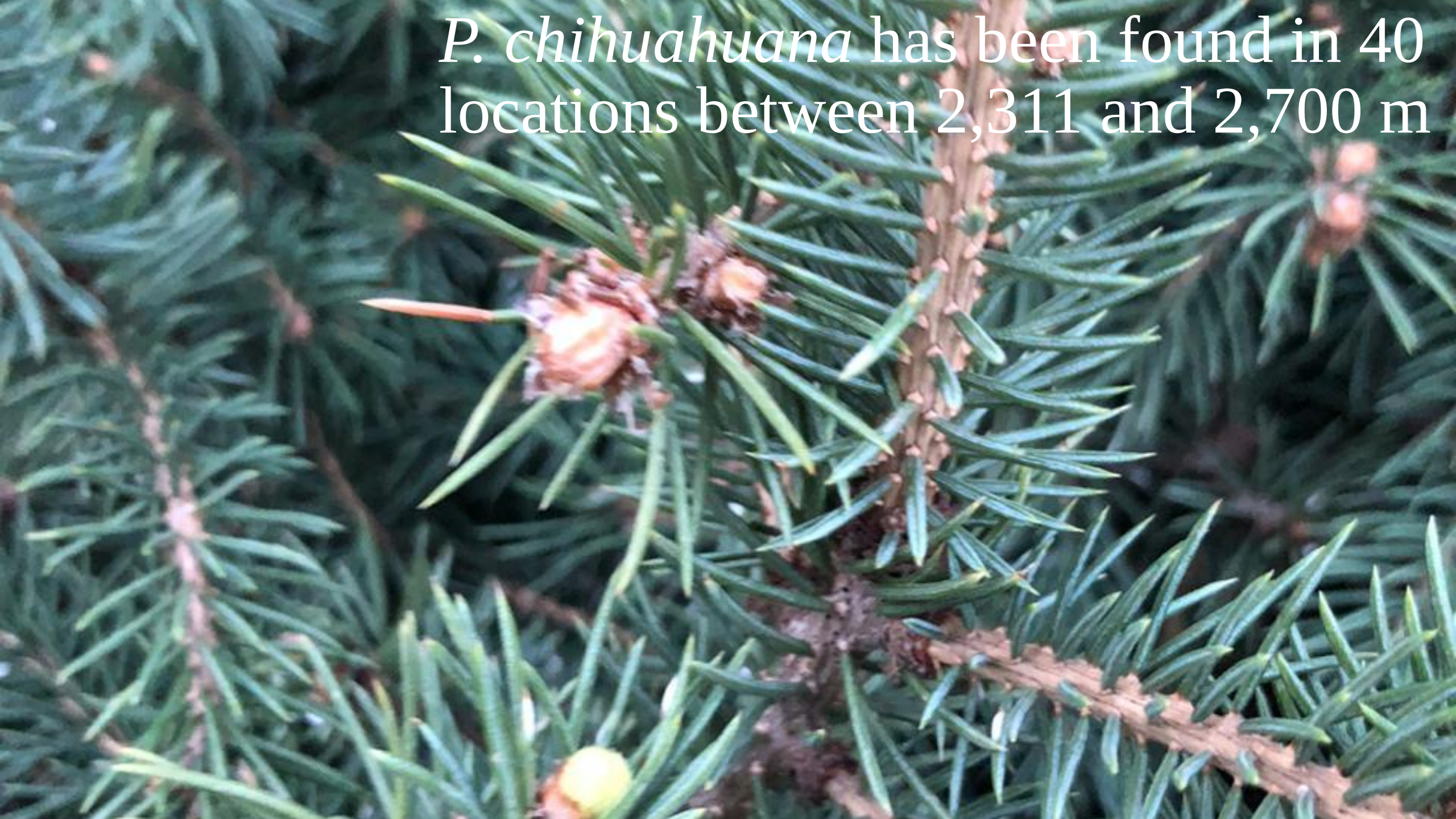
José Marcos Torres-Valverde[1], José Ciro Hernández-Díaz[2], Artemio Carrillo-Parra[2], Eduardo Mendoza-Maya[3], Christian Wehenkel[2*]

Introduction

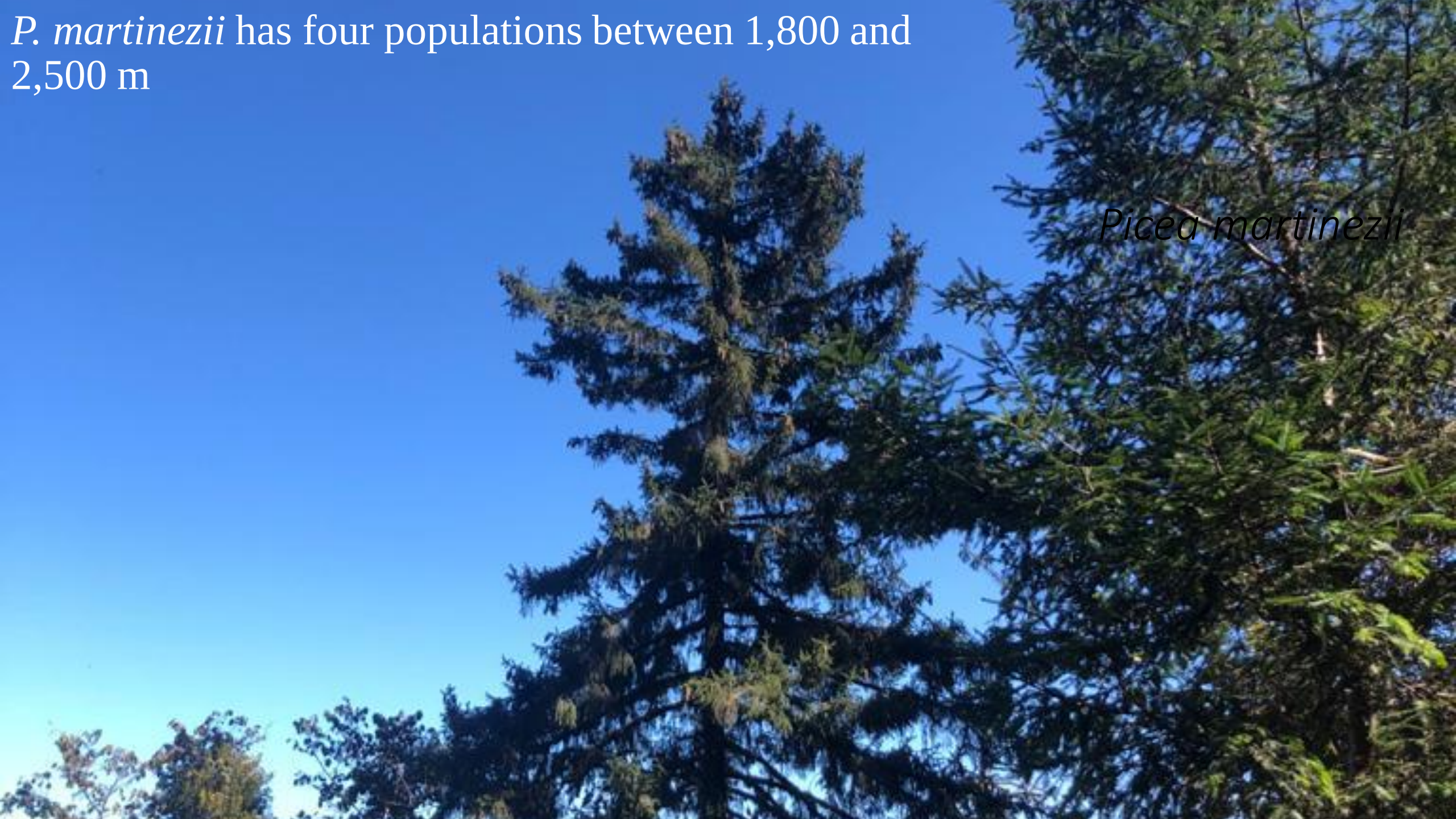
- In Mexico there are three endemic species of the *Picea* genus, living in relict populations and they are listed as “Endangered” on the Red List of the IUCN

Endemic spruce

- The three Mexican spruces' distribution is fragmented in isolated populations, which could lead to phenological, morphological and genetic differentiations, partially caused by local adaptation to different soil types and climatic variables .


P. chihuahuana has been found in 40
locations between 2,311 and 2,700 m

P. martinezii has four populations between 1,800 and 2,500 m



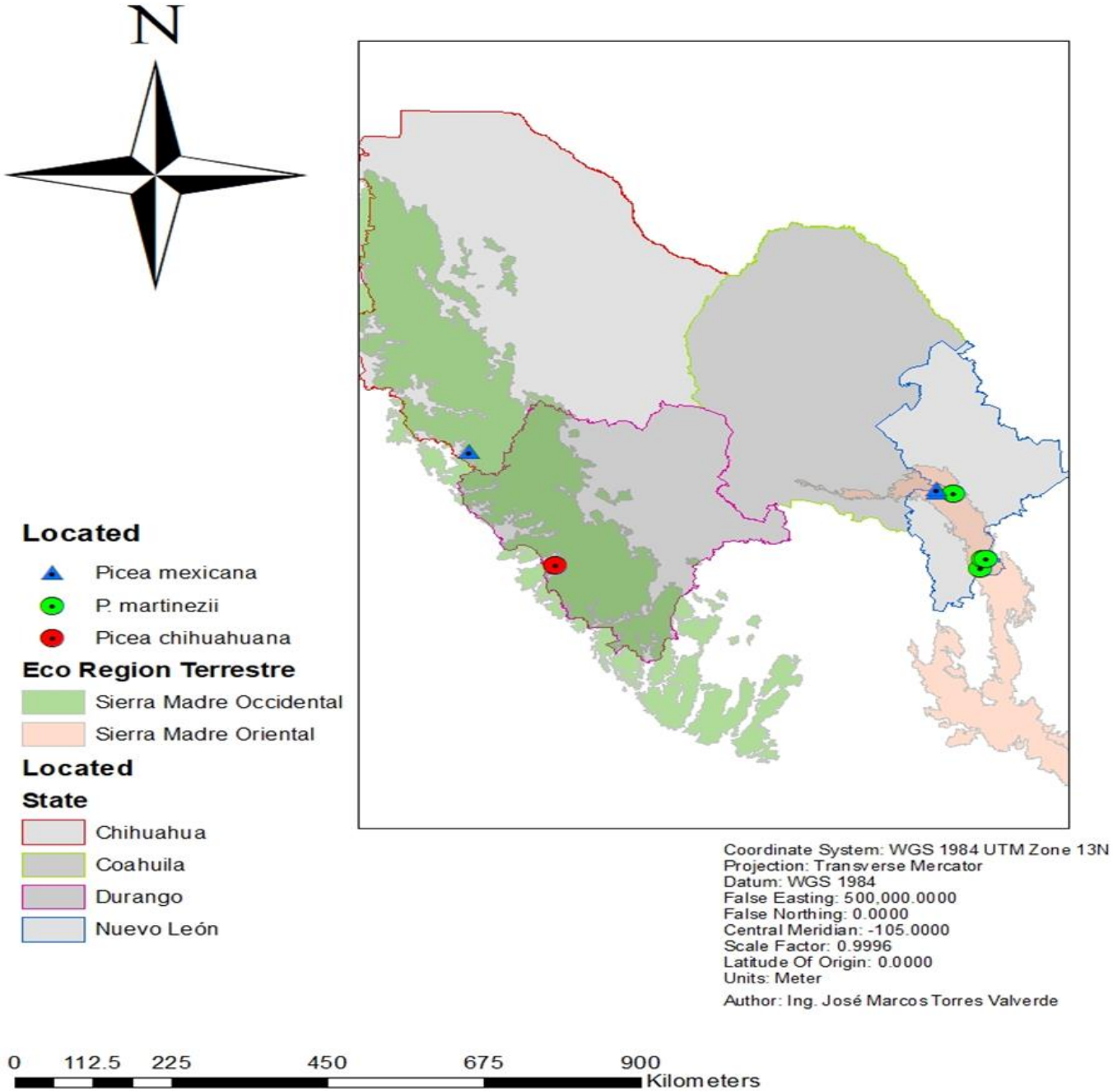

Picea mexicana has only three locations, above 3,000 m of elevation

- Therefore, it is important to identify the main factors accounting for such adaptation, which would be helpful in assisted migration programs as an option for *ex-situ* conservation.

- Provenance-progeny trials allow to design conservation programs for the conservation of genetic resources in the medium and long terms. In our experiment we studied the genetic and environmental components of the phenotypical variation between trees of different provenances

Methods

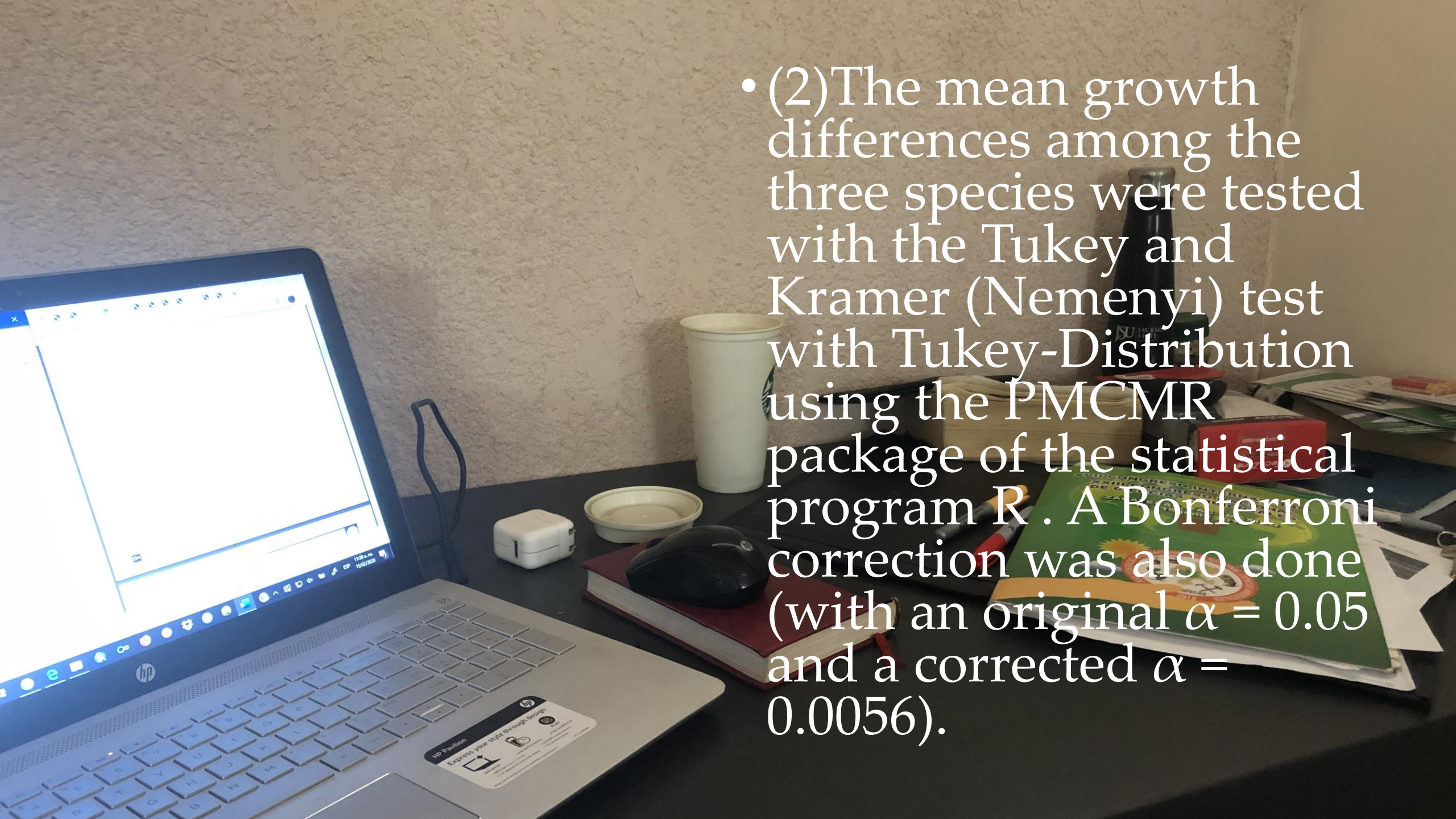
The study was based on eight provenances of three Mexican spruces, located in four states of Mexico: one provenance is from Chihuahua, one from Durango, one from Coahuila and five from Nuevo Leon



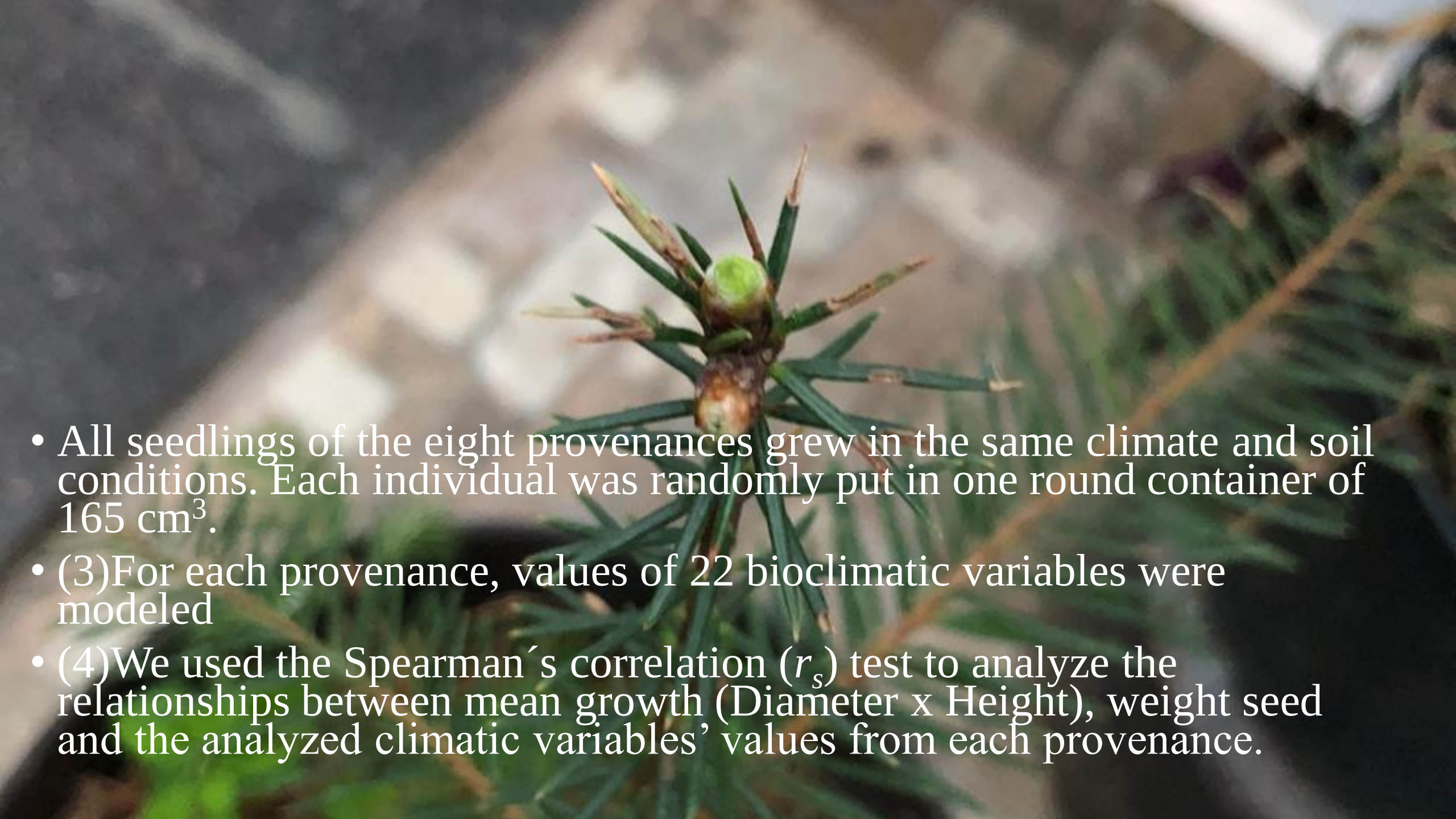
Methods

- (1) we examined the effect that climatic variables have on the growth and survival of seedlings of each Picea species' provenances, in equal nursery conditions, assuming that such response could be a proxy of the adaptation capability or the genetic differentiation among populations.

- The provenances trial experiment was established in a nursery at El Salto, municipality of Pueblo Nuevo, Durango, Mexico (in an elevation of 2,590 m). There, we measured the growth in diameter and height and the survival of 5,641 seedlings during 12 months.



- (2)The mean growth differences among the three species were tested with the Tukey and Kramer (Nemenyi) test with Tukey-Distribution using the PMCMR package of the statistical program R . A Bonferroni correction was also done (with an original $\alpha = 0.05$ and a corrected $\alpha = 0.0056$).



- All seedlings of the eight provenances grew in the same climate and soil conditions. Each individual was randomly put in one round container of 165 cm^3.
- (3)For each provenance, values of 22 bioclimatic variables were modeled
- (4)We used the Spearman´s correlation (r_s) test to analyze the relationships between mean growth (Diameter x Height), weight seed and the analyzed climatic variables' values from each provenance.

Results

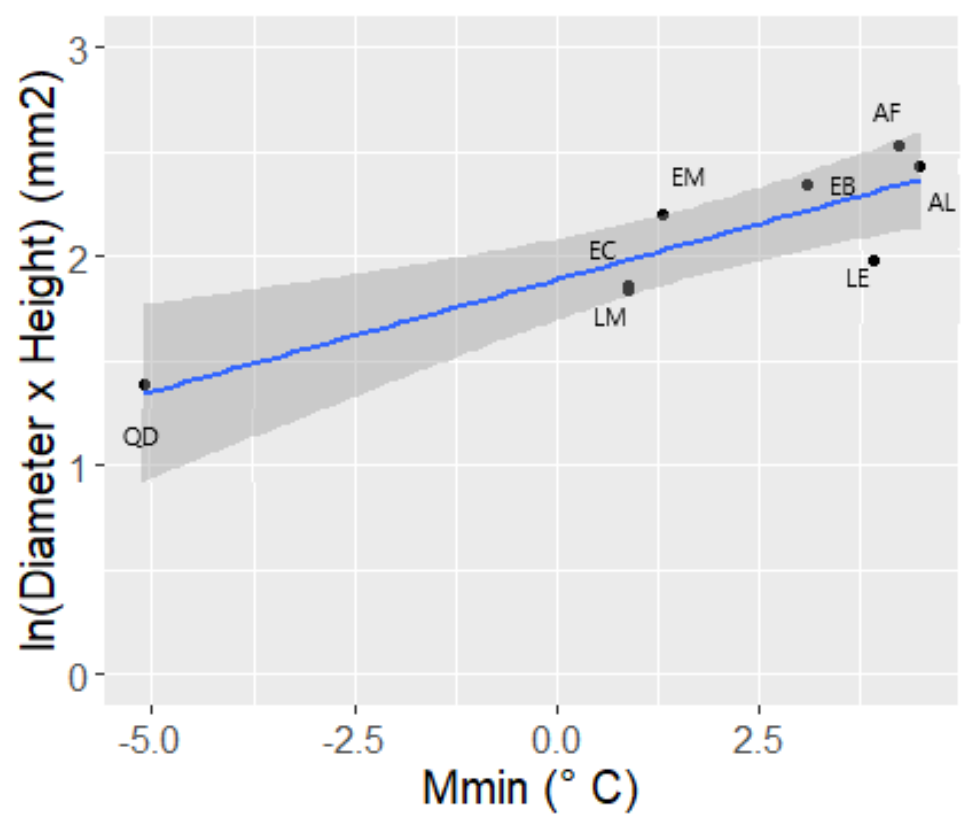
(1)Significant differences in Diameter x Height were found between the three spruces ($p < 0.0000021$).
(2)After the Bonferroni correction, significant correlations were detected between the seedling's genetic proxy, given by the quantitative trait "Diameter x Height" and some climatic variables. We did not find any significant correlation between the mean 100-seed weight and mean growth ($rs = 0.86$, $p = 0.024$) of the seedlings.

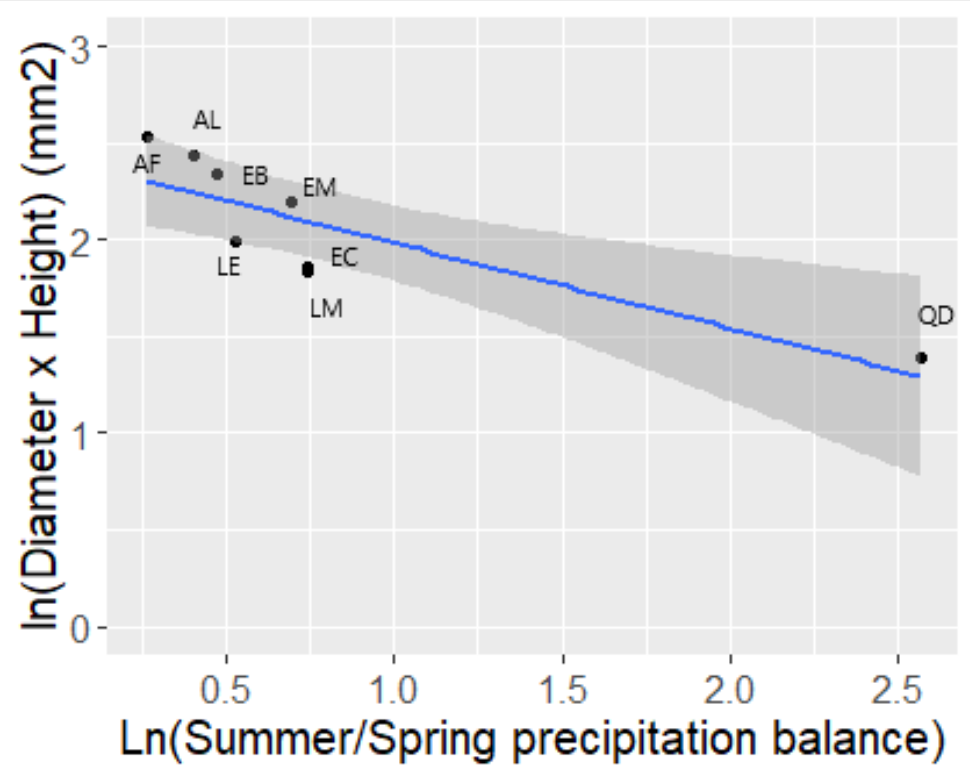
Statistically significant P values of the Tukey and Kramer (Nemenyi) test with Tukey-Distribution of the Mexican spruces of *P. martinezii*, *P. mexicana* and *P. chihuahuana*.

Species		P value
P. martinezii	*P. mexicana*	< 2e-16
P. chihuahuana	*P. martinezii*	< 2e-16
P. mexicana	*P. chihuahuana*	9.2e-08

Significant Spearman's correlations (r_s) found between growth (Diameter x Height) and climatic variables; Mmin = Mean minimum temperature in the coldest month (Celsius degrees), Smrsprpb = Summer/Spring precipitation balance: (jul+aug)/(apr+may).

Variable	Units	r_s	p value
Smrsprpb	mm	-0.97	0.00007
Mmin	°C	0.90	0.00244





- Spearman correlations between growth (Diameter x Height) of the seedlings and the two most significant climatic variables: Mmin = Mean minimum temperature in the coldest month (centigrade degrees) and Smrsprpb = Summer/Spring precipitation balance: (jul+aug)/(apr+may); P. martinezii: AF= Agua Fria, AL= Agua Alardin, EB= El Butano and LE= La Encantada, P. mexicana: EM= El Mohinora, LM= La Marta y EC= El Coahuilon and P.chihuahuana: QD= Quebrada de los Duran.

Conclusions

- Our results suggest that there are significant quantitative genetic differences (QGD) among the analyzed *Picea* species and that these QGD are correlated with two climate variables (the mean minimum temperature in the coldest month and the Summer/Spring precipitation balance), supporting the hypothesis that local adaption capability is different among species.
- Our findings may have important practical implications for *ex-situ* conservation programs. Also, reforestation programs should be more successful if the seedlings from a provenance are planted in very similar climate conditions to the ones of its provenance, given the strong provenance-climate association.