Species distribution models predict suitability but not growth of lodgepole pine reforestation stock under climate change

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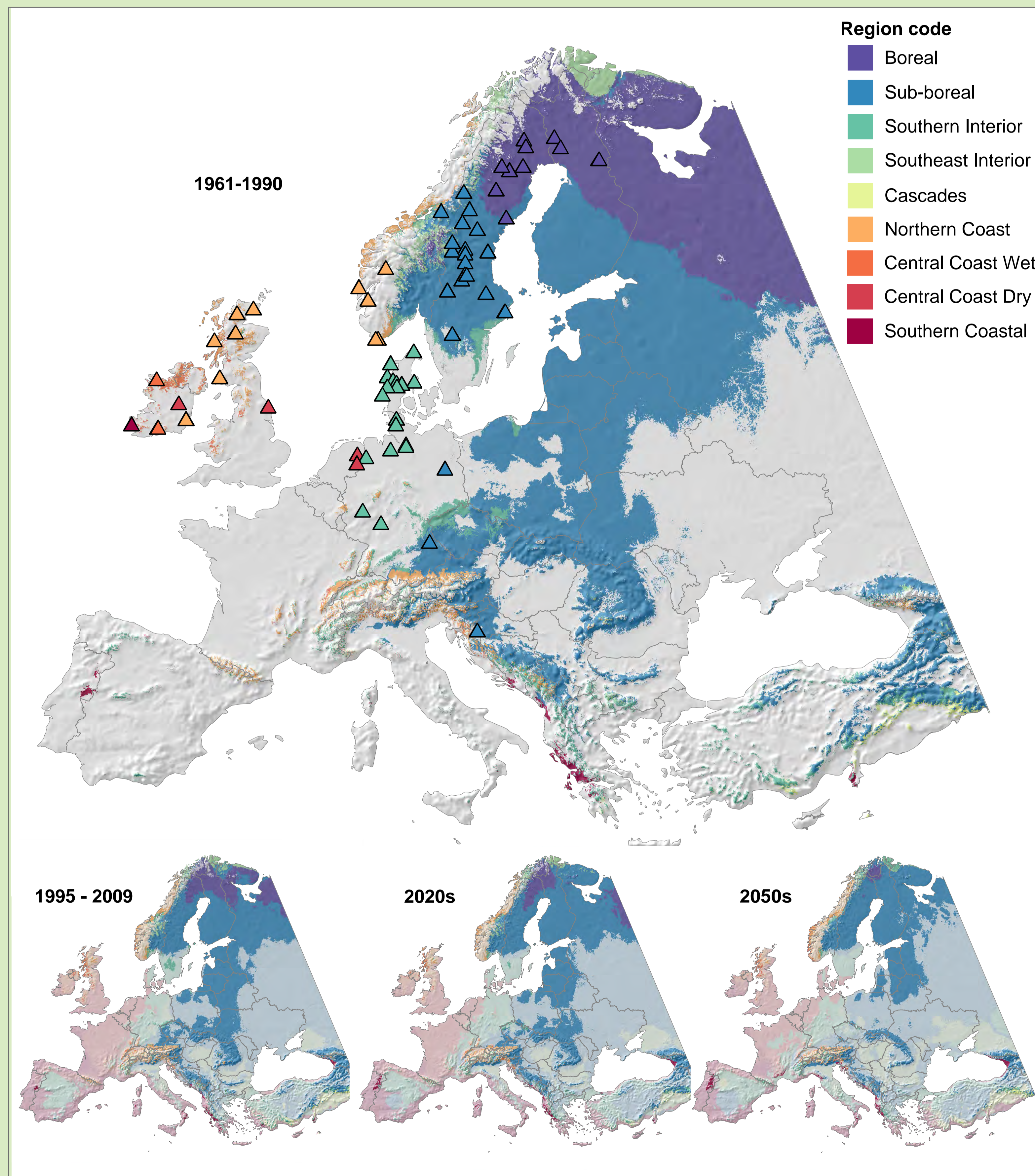
Introduction

Lodgepole pine (*Pinus contorta* Douglas ex Loud.) is native North American species that has been used widely in reforestation actions in Europe in previous decades because of its wide ecological tolerance and fast growth. Provenance trials with known seed origins planted in Europe can also be used to create species distribution models and evaluate how trees species react to being transferred to new climate conditions.
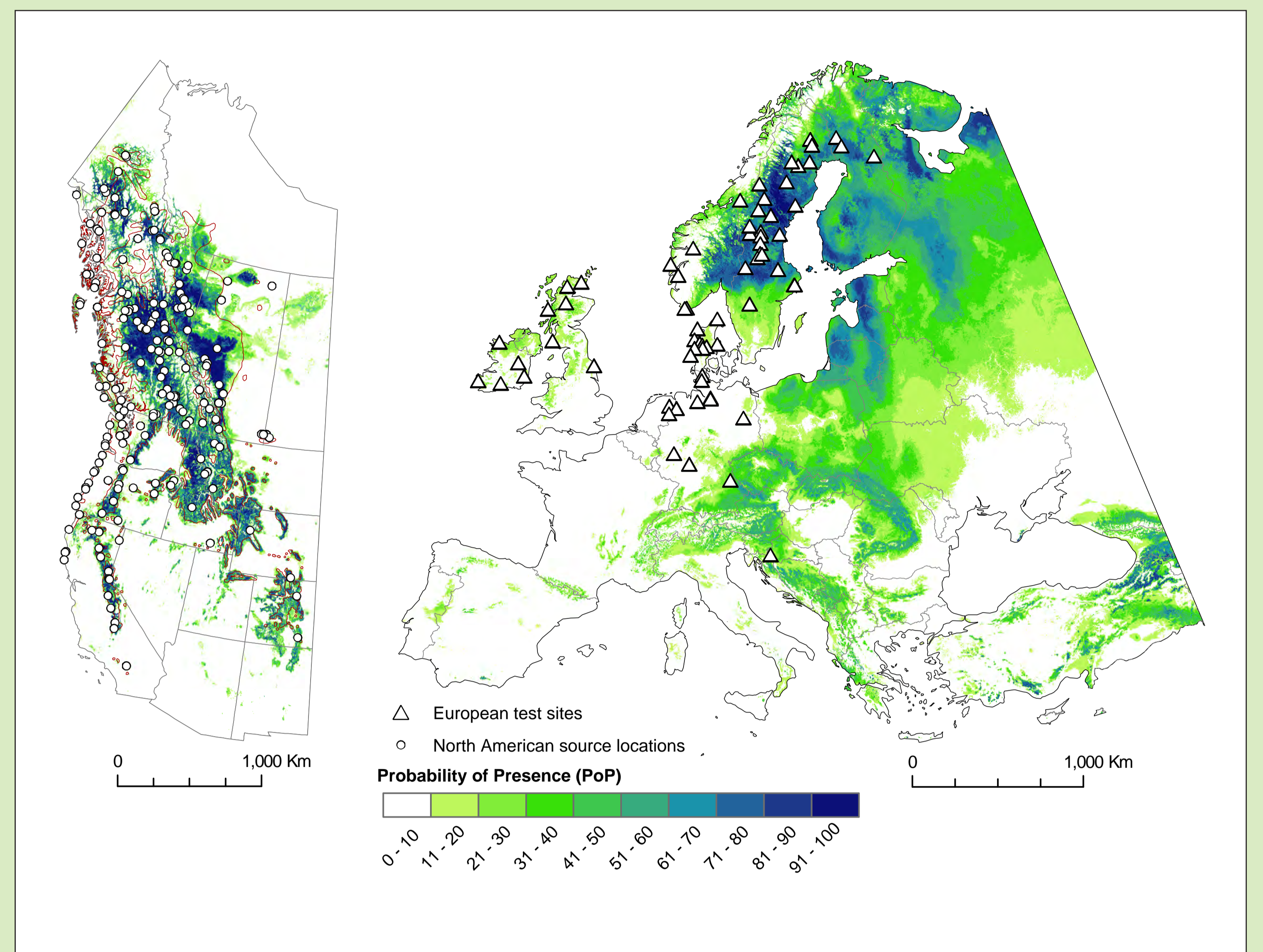
Objective

Here, we contribute a retrospective validation of the species distribution modeling approach by evaluating lodgepole pine seed source transfers from North America to European test sites (Fig 1). We quantify how tree populations respond when subjected to climate regime shifts, and we examine whether species distribution models developed for North America can retrospectively predict the success of these provenance transfers to Europe.

Methods

We evaluated more than 2000 transfers of lodgepole pine seed sources from North America to 73 European test sites (Fig 1). Model predictions of where the 9 North American regions find their best climate match in Europe under current and future climate were carried out with the RandomForest ensemble classifier, a widely used bioclimate envelope modeling approach.
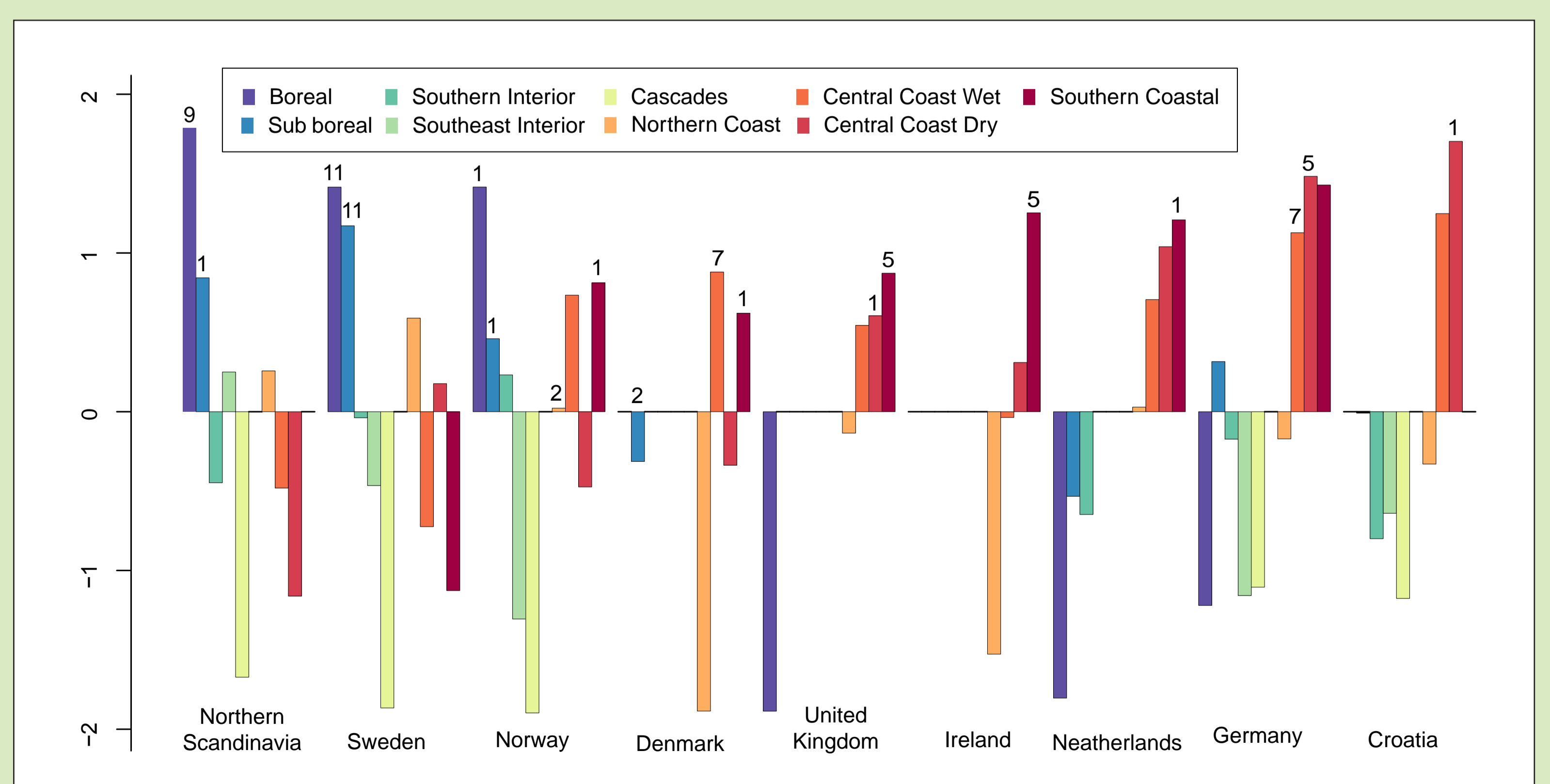

Fig 1. *Pinus contorta* known range, seed source locations, and species distribution model output (PoP) in North America and Europe, as well as provenance trial site locations in Europe.

Results and Discussion

We found that at the species level, the predicted suitable niche space of lodgepole pine in Europe was not a good predictor of growth performance. Excellent growth was observed in test sites outside the projected habitat in Denmark, Germany, England and Ireland, while growth was comparatively poor where habitat suitability was predicted to be highest. However, projections of high habitat suitability correspond to regions where lodgepole pine grows well relative to native species, and projections were accurate at the population level. With few exceptions, the provenances predicted as the best climate match were also among the top performers at provenance trials for all regions. (Fig 2 & 3)

Our research confirms a key criticism of the species distribution model approach to assess climate change impacts. Loss of habitat inferred from the realized niche space should not be interpreted as an imminent threat to species. However, we can nevertheless conclude that projections of the realized climate niche of species and their populations should be a useful approach to guide assisted migration under climate change, and to select well adapted planting stock for future reforestation.

Fig 2. Predictions of climatically best matching North American *P. contorta* populations as projected using a bioclimaticenvelope model for past climate (1961-1990), a recent 15-year climate average (1995-2009) and the 2020's and 2050's under an A2 scenario. (PoP>20%.)

Fig 3. Normalized observed mean performance of North American *P. contorta* populations in European regions. Numbers above bars represent the number of test sites where the population performed best in each region.

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