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On the importance of constraining tree demography parameterisation with species distributions

Niche theory has been applied to project tree species distribution in response to environmental factors. Often the niche, and therefore the associated species distribution, is projected using the correlation between current distribution and abiotic variables only. However, the niche is commonly defined as the set of environmental conditions that allows a species to maintain a positive intrinsic growth rate, r. This growth rate represents the performance of a population in function of the demography of its individuals: an increase in radial growth and fecundity should also increase r, while an increase in mortality should decrease r. However, measuring r is not straightforward, particularly for size-structured populations such as trees. A second problem is that individual growth (mortality) does not necessarily decrease (increase) towards range margins, making tree range limits difficult to predict from demographic rates. Finally, tree demographic rates are complicated to estimate at large scale due to high variability in environmental conditions and coarse time resolution of the National Forest Inventories data.

Our goal is to develop a dynamic range model. First, we estimate yearly tree demography (radial growth and mortality) with a Bayesian state-space model. This allows us to use annual climate data, even though forest census are conducted at uneven time intervals. The regeneration is inversely calibrated. Then, the demographic rates are used as priors into a population dynamics model from which we can deduce the population growth rate r for each plot in the National Forest Inventories data. We then compare r to presence and absence data. Because we expect a high probability of presence when r is positive, we can constrain the likelihood of the demographic rates and reevaluate them in the light of the mismatch between predicted population growth rates and presence/absence data.