Does elevated CO_2 impact future bamboo distribution under climate change?

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Introduction

Bamboo, thriving in tropical and subtropical regions between 46°N and 47°S, is a versatile non-timber forest resource. It aids in poverty alleviation and climate change mitigation through economic contributions, carbon fixation, and degraded land restoration. Assessing the future of bamboo stands is essential for management and conservation strategies, and understanding climate change impacts on ecosystem services. Bamboo's distribution is sensitive to climate change, influenced by increasing atmospheric CO_2 concentrations due to its C3 photosynthetic pathway. However, the effect of CO_2 on climate impact assessments and potential changes in bamboo distribution has been largely overlooked.

Methods

- We utilized ten niche modeling algorithms, incorporating field campaign data and regionally downscaled climatic variables, to understand bamboo distribution.
- Analysis showed that potential evapotranspiration (PET) is a key determining factor for the distribution of bamboo, and one that is directly affected by the elevated CO_2 due to reduced stomatal conductance.
- To incorporate atmospheric CO_2 concentration impacts in species distribution modeling, we proposed a straightforward, quantitative method. This involved applying two PET projections to our model: one accounting for CO_2 effects and the other excluding them.
- Furthermore, we devised a correction factor to adjust PET within our developed distribution models.

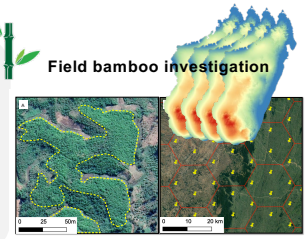
- **Quantifying the CO_2 effect**

$$E_{P_0} = \frac{0.408sR^* + \gamma \frac{900}{T+273}\mu D}{s + \gamma(1 + 0.34\mu)}$$

$$E_{P_m} = \frac{0.408sR^* + \gamma \frac{900}{T+273}\mu D}{s + \gamma\,[1+\mu(0.34 + 2.4 \times 10^{-4} \times \Delta CO_2)]}$$

$$\text{C-factor} = \frac{E_{P_m}}{E_{P_0}} = \frac{s + \gamma(1+0.34\mu)}{s + \gamma\left[1 + \mu\left(0.34 + 2.4 \times 10^{-4} \times \Delta CO_2\right)\right]}$$

Field bamboo investigation

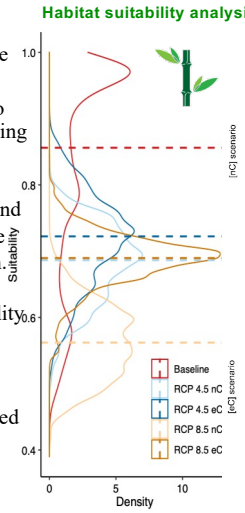


Results

- Our results found that future climatic changes negatively impact potential bamboo distribution in Madagascar, leading to a decline of 34.8% of climatic suitability and a decline of 63.6 ± 3.2% in suitable areas towards 2100 under RCP 8.5.
- However, increasing atmosphere CO_2 offsets the climate impact for bamboo, and led to a smaller reduction of 19.8% in suitability and a potential distribution expansion of +111.6 ± 9.8% in newly suitable areas.
- **Driver analysis:**

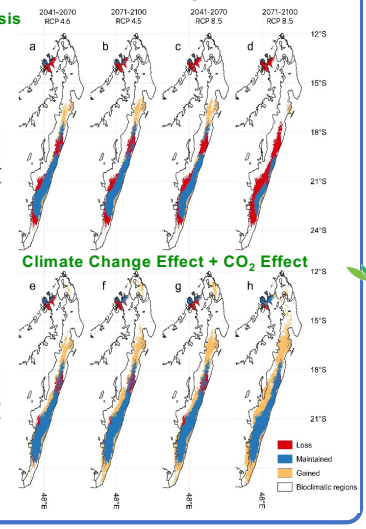
We also found that the decline in climatic suitability for bamboo was related to increasing monthly potential evapotranspiration of the warmest quarter and minimum temperature of the warmest month. Conversely, the decreasing isothermality and increasing precipitation of the warmest quarter contributed to projected increase in bamboo-suitable areas.

Habitat suitability analysis



Climate Change Effect

Climate Change Effect + CO_2 Effect



Conclusions

- Future climatic changes negatively impact bamboo potential distribution, leading to declines in suitability and suitable areas towards 2100.
- However, increasing atmosphere CO_2 partly offsets the climate impact for bamboo, and leads to a smaller reduction in suitability and a potential distribution expansion in suitable areas.
- Our results highlight the importance of accounting for the CO_2 effect on future plant species distributions.

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For more details:
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