Predicting climatic niche shifts and future range dynamics of Antarctic lecideoid lichens under climate change scenarios

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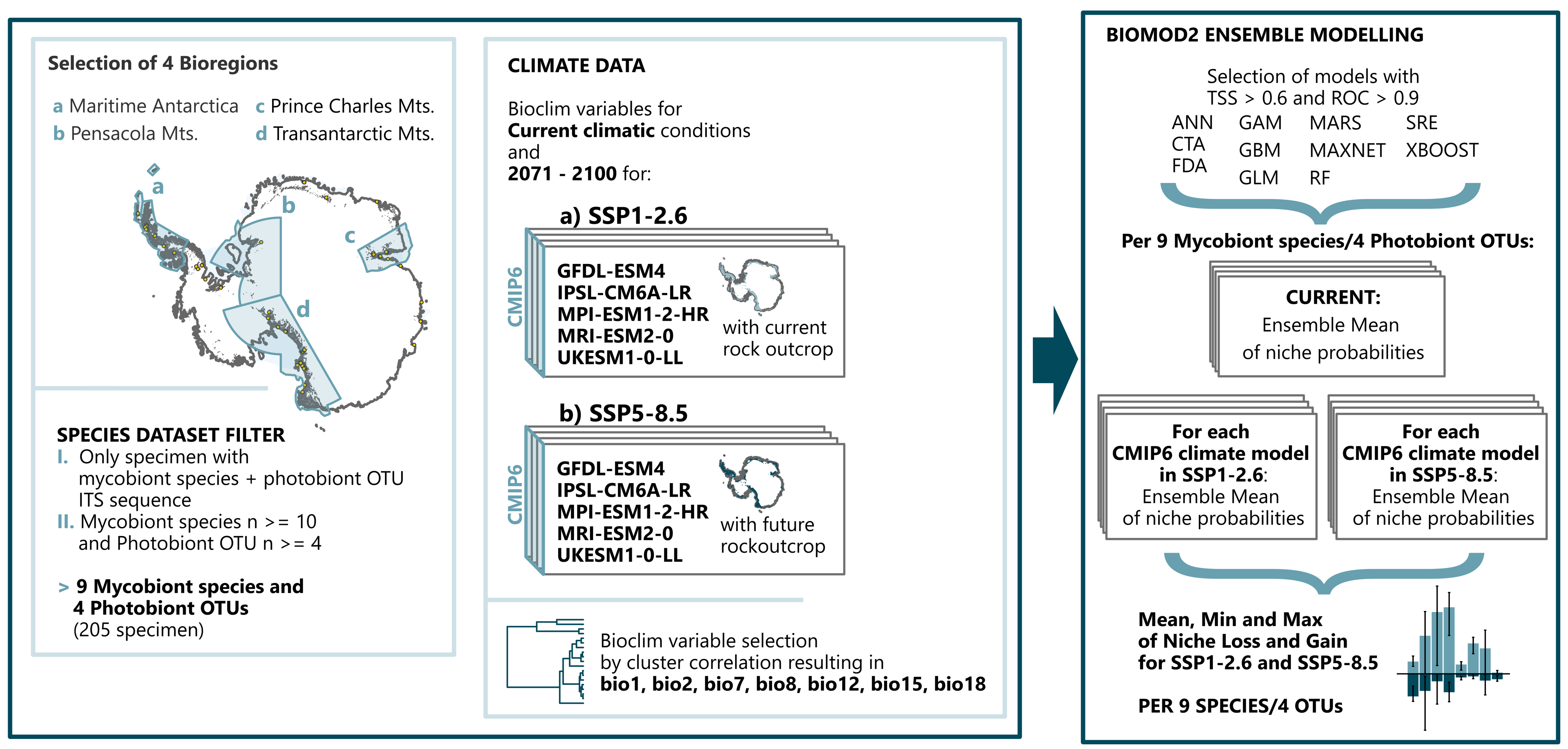
SUMMARY

Overview. Rock-dwelling lecideoid lichens are a diverse and major component of terrestrial vegetation in Antarctica, uniquely adapted to extreme environmental conditions. The study surveyed the lichen diversity and modelled the effects of two climate change scenarios on their distribution range shifts on the Antarctic continent.

Methods. The climatic niches of nine Antarctic lecideoid lichen species and four photobiont OTUs were projected using **biomod2** package in R. Based on this their potential distributional shifts were predicted for **current climatic conditions** and under two contrasting climate forcing scenarios, **SSP1 2.6** and **SSP5 8.5,** across four selected Antarctic bioregions: **maritime Antarctica, Pensacola Mountains, Prince Charles Mountains** and **Transantarctic Mountains.**

Results. For each species, the projected range expansion is expected to exceed the habitat loss associated with climate warming. However, high niche losses are expected in maritime Antarctica, while regions in continental Antarctica are projected to gain new species. This niche expansion is primarily driven by a shift towards inland areas as previously unsuitable areas become climatically suitable. In response to projected climatic shifts, lecideoid lichens may undergo an **overall range expansion**, particularly into previously **uncolonized inland** areas as microhabitats become increasingly suitable.

MATERIAL & METHODS



References

Lee JR, Raymond B, Bracegirdle TJ, Chadès I, Fuller RA, Shaw JD, Terauds A. 2017. Climate change drives expansion of Antarctic ice-free habitat. *Nature* **547**(7661): 49-54.
McGaughran A, Laver R, Fraser C. 2021. Evolutionary Responses to Warming. Trends Ecol Evol 36(7): 591-600.

RESULTS

CLIMATE - DRIVEN MAJOR NICHE EXPANSION OF ALL LECIDEOID LICHENS MYCOBIONT SPECIES AND PHOTOBIONT OTUs.

Niche expansion exceed niche reduction for all mycobiont species and photobiont OTUs in both scenarios. Highest niche expansion projected for Transantarctic Mts.

Lecidea atrobrunnea and associated photobiont *Tr*_I01 are predicted to exhibit a major niche expansion in maritime Antarctica for both scenarios.

New niches are projected to be established in Pensacola Mts. for *Lecidea andersonii*, *Lecidea polypycnidophora*, *Lecidella greenii*, *Lecidella siplei* and *Rhizoplaca macleanii* and *Tr*_S02.

Highest losses are expected for cold-adapted, Antarctic endemic photobiont *Tr*_S18.

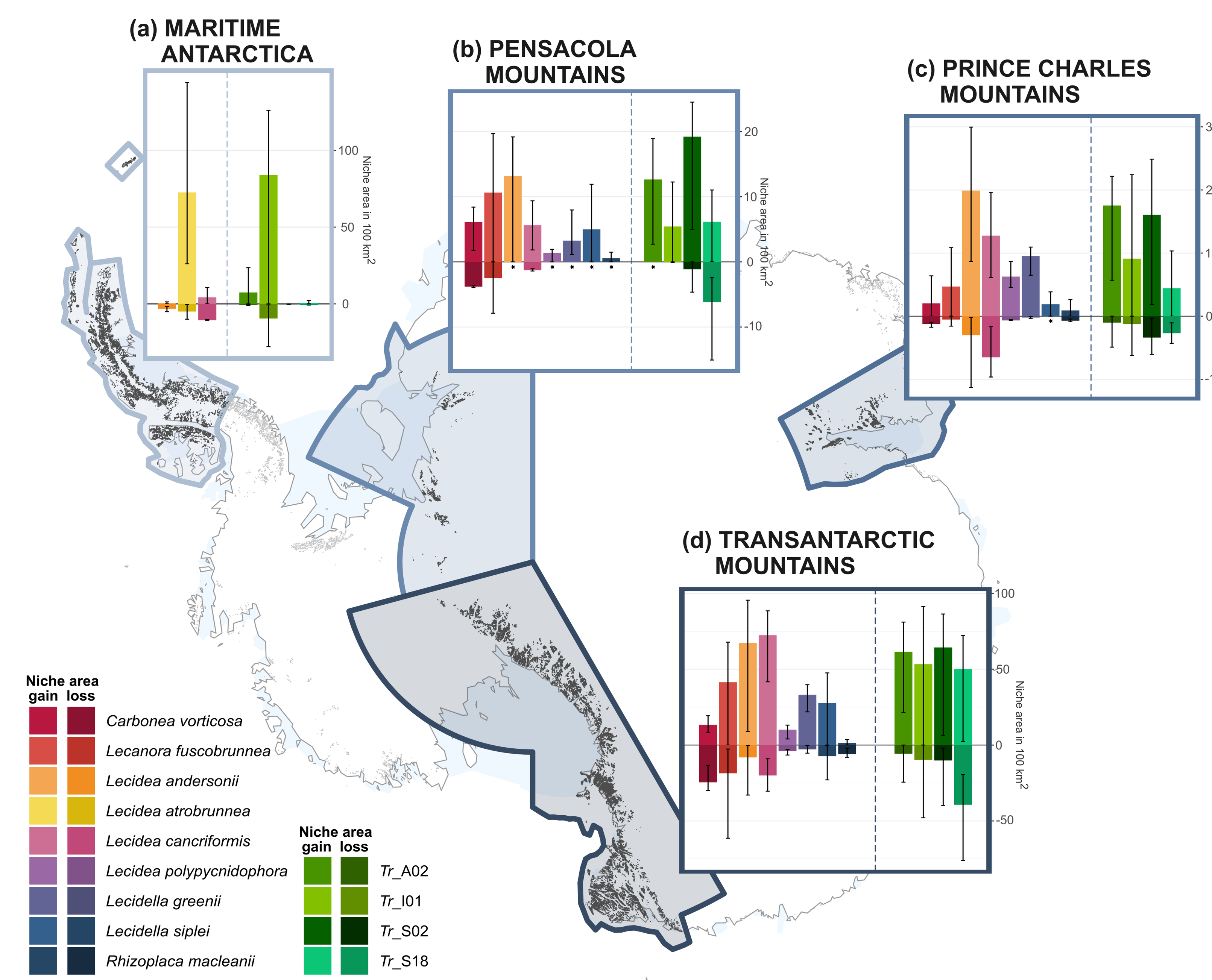


Fig. 1: Change of probable niche area (Mean of each model absolute area in 100km²) per mycobiont species/photobiont OTU for each selected region for SSP5 8.5: (a) Maritime Antarctica; (b) Pensacola Mountains; (c) Prince Charles Mountains and (d) Transantarctic Mountains. Bars above x - axis (0) show the absolute gain of probable niche area (niche expansion), and bars below the x -axis show the absolute loss of probable niche area (niche reduction). Mycobiont species and photobiont OTUs are colour coded according to the legend in the left lower corner. Error bars represent the minimum and the maximum value, resulting from different Climatic models used (see Methods: Climatic Data and Models). Bars with Asterisks present the mycobiont species/photobiont OTUs, which are predicted to establish an entirely new niche in this area. The respective analysis with SSP1 2.6 can be found in Fig. S4 and Table S5. Please note the different scales per region.

INLAND - DIRECTED SHIFTS OF HIGH OVERLAPPING SPECIES NICHES IN BOTH SCENARIOS.

Areas with higher species richness are predicted to shift inland, while a decline in species richness is to be expected in coastal regions.

Spatial trend most pronounced in SSP5-8.5.

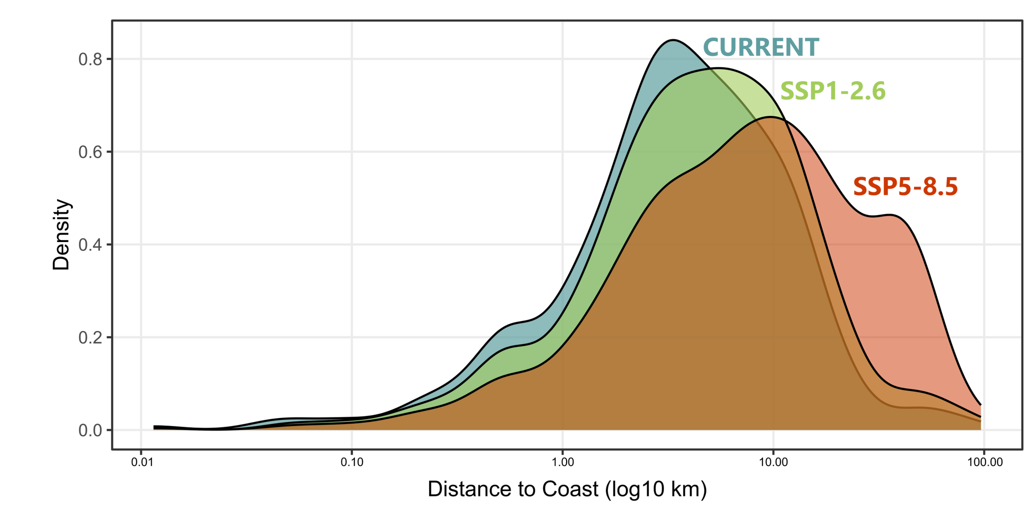


Fig. 2: Distance to Coast for all overlapping niches with species number n >= 4 for current conditions and the two contrasting climate forcing scenarios SSP1 2.6 and SSP5 8.5. X-Axis (Distance to coast) in log10 scale.

CONCLUSION

Conversely to mountain regions worldwide, **climate warming in Antarctica is expected to create additional space for colonization** due to two main processes:

1. Exposure of additional rock surface as snow and glaciers retreat (Lee et al., 2017)
2. Gradual transformation of currently uninhabitable areas into more climatically suitable environments.

Inland shifted areas as "climatic" refuges.

Coastal regions are more prone to climatic change in the future (McGaughran et al., 2021).

Macroclimate as baseline for niche predictions in Antarctica

+ **dispersal ability:** Effective dispersal to climatically suitable areas may be limited by highly fragmented rock outcrops in Antarctica.
+ **micro habitats:** Ab initio establishment of lichen species depends on suitable microhabitats with sheltered conditions (wind and sun protection, with moisture retained in weathered rock, from air and by melting snow).