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What's Happening in Antarctica? A Greening Story

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Abstract

Antarctica is the most extreme continent for life on Earth, and it is also one of the regions most threatened by climate change. Areas like maritime Antarctica and the Antarctic Peninsula have experienced significant temperature increases, with an average rise of 0.1 °C per decade over the past 50 years. Future predictions are equally concerning, with temperatures expected to rise by 0.5–1.5 °C over the next two decades (Steig et al. 2009; Turner et al. 2016;

Jones et al. 2019; Bozkurt et al. 2021; González-Herrero et al. 2022). These temperature increases could also significantly alter water and nutrient cycles in Antarctic soils, ultimately affecting nutrient availability for plants. Moreover, it is crucial to consider that in Antarctica, just as in the rest of the world, the atmospheric CO_2 (the essential carbon source for photosynthesis and a major greenhouse gas leading global warming), has risen dramatically since the Industrial Revolution, from 260 to 410 ppm today (Nunes 2023). Together, the changes in these abiotic factors are profoundly shaping the lives of terrestrial autotrophic organisms in Antarctica.

Interestingly, Antarctica holds another unique biological record: it is the continent with the lowest number of native vascular plant species—just two—in an environment primarily dominated by mosses and lichens (Ramírez et al. 2024; Colesie et al. 2023). However, recent studies have described the expansion of these angiosperms over the last few decades, especially the grass *Deschampsia antarctica* (Cannone et al. 2016, 2022). Rising temperatures and more frequent heat waves predict changes in the ecological balance, facilitating the proliferation of vascularized species that previously struggled to establish themselves under these conditions (Carrasco et al. 2021). This indicates that plant communities may undergo a significant transformation, influenced by global climate change (González-Herrero et al. 2022). Species expansion, and the concept of Antarctica "greening", is a complex process that integrates both abiotic factors and the species' ecological competence, and currently becoming an important scientific hotspot to technically assess accurately these changes at a regional scale (Roland et al. 2024; Walshaw et al. 2024, Colesie et al. 2025; Amaral et al. 2025). In any case, for autotrophic organisms in such a harsh and extreme environment as Antarctica, any expansion must be driven by increased net carbon gain throughout the year. In other words, favorable weather should enhance the physiological and photochemical drivers of photosynthesis, leading to higher carbon assimilation rates (Sáez et al. 2018a,b; Clemente-Moreno et al. 2020a,b; Gago et al. 2025; Lee et al. 2013).

However, these theoretically beneficial conditions do not mean the Antarctic region is close to becoming a paradise for plant life. Even with these favorable changes, the still harsh conditions imply that ecological success relies not only on improved growth and photo-synthetic rates, but also on enhanced stress tolerance mechanisms. These are crucial for plants to successfully cope with the challenging Antarctica growing season characterized by extremely variable temperature and light conditions, strong winds, freezing events and accompanied by reduced water and nutrient availability in the soil (Gago et al. 2023, 2025; Lee et al. 2013; Min et al. 2024, 2025; Ricco et al. 2025; Sanhueza et al. 2022; Sáez et al. 2024; Vallejos et al. 2025; Basile Dazzi et al. 2025). Therefore, could the improved carbon gains and nutrient acquisition also be key factors in the success of vascular species by enabling them to divert these increased resources toward stress tolerance, rather than solely toward growth?

Here, in this work we will review the main molecular ecophysiological factors that could be crucial for the expansion of vascular plants in Antarctica, specially focused on *Deschampsia antarctica*, as a model species, to promote the discussion about the future climatic change scenarios that the Antarctic continent is facing.

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