

Comment



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As the ice retreats, Antarctic species are struggling to reproduce, feed and compete with invasive species.

Protect Antarctica – or risk accelerating planetary meltdown

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To keep Earth habitable, humanity must recognize the value of Antarctica and seek to save it from irreversible damage.

Far from being a remote, isolated continent, Antarctica is integral to Earth's climate and life-support systems. Its vast ice sheet stores more than 90% of the planet's surface fresh water and influences sea levels, circulation of the atmosphere and how much sunlight the planet reflects. Around Antarctica, the Southern Ocean acts as the lungs of the deep sea, accounting for roughly 40% of the global ocean's uptake of carbon dioxide emissions generated by human activities, shaping how seawater mixes and distributes nutrients to support marine life around the globe¹.

Yet, many of these stabilizing features are showing signs of degradation. The West Antarctic Ice Sheet is retreating, with

widespread thinning of glaciers and ice shelves. Changes there are accelerating, as damage in one area exacerbates melting and stresses in others. And now, parts of the more stable East Antarctic Ice Sheet seem to be thinning, too². Pooling melt water on its surface would eat away at the ice further³, possibly triggering the break-up of more ice shelves⁴. Meanwhile, Antarctic waters seem to have entered a new regime, with record-low sea ice, greater salinity and less stratification of upper ocean layers^{5,6} (see 'Antarctica under threat').

Runaway melting in the Antarctic will be grave for the world. Loss of ice could contribute more than 60 centimetres to sea-level rise by the end of this century and will disrupt the Southern Ocean's freshwater balance,

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circulation and mixing⁷ – signs of which are already evident in some areas⁸. Less general ocean mixing means that less oxygen and fewer nutrients are transferred to the deep ocean, making it harder for marine organisms there to survive and reproduce, as well as lowering the ability of the seas to take up carbon.

Before this crucial reservoir of ice is lost, transforming the planet forever, it is essential that policymakers and others recognize Antarctica's extraordinary economic value and seek to protect it. Environmental services, fisheries and tourism in Antarctica contribute more than US\$180 billion to the global economy each year⁹. Yet, governments and businesses continue to undervalue these services, prioritizing political aims and short-term financial objectives (such as maximizing profit or gross domestic product) over sustaining the stability of the planet, which supports people's lives and underpins all economies.

Strategies are needed to broaden society's goals beyond financial gains and to account for long-term risks and benefits. Here, we set out what's at stake and propose economic goals and governance changes to guide policy responses towards long-term planetary stability.

Continent under threat

As the ice melts and oceans change, ecological stresses are intensifying across the Antarctic. Populations of krill – key prey for penguins, whales and seals – are declining as oceans acidify¹⁰, affecting the whole region's food web. Shrinking sea ice exacerbates these threats¹¹. For example, if seals and penguins find it harder to obtain krill, especially at crucial times such as breeding periods, populations will be more vulnerable to more frequent and extreme disturbances, such as heatwaves or algal blooms.

On the Antarctic Peninsula and sub-Antarctic islands, warming is driving changes in vegetation and species distributions. For example, fast-spreading grasses are crowding out native vegetation, disrupting nesting habitats for seabirds and altering nutrient cycles. Thawing permafrost releases greenhouse gases and might awaken dormant microorganisms, with unpredictable consequences¹².

Human activities compound these pressures. Invasive species, including grasses, insects and microbes, transported by visitors and cargo, are beginning to colonize ice-free areas¹³. Pollution, too, is on the rise: persistent organic pollutants, hydrocarbons and microplastics have been detected across the region, including in seabirds and marine sediments¹⁴. These substances accumulate in food webs and impair reproductive and immune systems in native fauna.

All of these changes are linked and interact in ways that are often non-linear and self-reinforcing. For example, ice-sheet retreat

adds fresh water to the seas, which weakens ocean circulation and accelerates warming and acidification, destabilizing marine ecosystems. Humans can increasingly reach regions that were once isolated, spreading pollution and invasive species and disturbing habitats. These cascading dynamics raise the possibility of 'runaway' change, in which the breach of one threshold makes others more likely, eventually overwhelming the capacity for intervention.

Lack of oversight

Meanwhile, monitoring systems in the Antarctic remain inadequate. Environmental assessments often focus on linear trends and single variables, underestimating how multiple pressures converge and reinforce each other. This limits scientists' abilities to detect early warning signs and precludes coordinated preventive actions.

“Antarctic governance must evolve to be fit for the Anthropocene.”

Fragile governance is also increasingly a problem. The Antarctic Treaty System (ATS) has maintained peace and scientific cooperation in the region for more than six decades. It includes the 1959 treaty and subsequent agreements on wildlife, marine conservation and environmental protection. However, its consensus-based structure and slow pace of reform are struggling under the pressures of the twenty-first century.

Diplomatic stalemates about issues such as new marine protected areas and the approval of further consultative parties to the treaty

are straining the system. Expanding national scientific programmes and rising commercial activities, including fishing and tourism, test the system's resilience.

Should the ATS lose legitimacy or fail to enforce protections, it could open the door to unregulated exploitation and even geopolitical conflict. Weakening of Antarctic governance could further erode environmental stewardship and fracture international collaboration on climate and biodiversity¹⁵.

Solutions for a stable future

Preventing irreversible change in the Antarctic and Southern Ocean requires urgent, system-wide transformation – across governance, science, economics and public engagement – as well as the rapid reduction of global emissions to curb climate change.

Antarctic governance must evolve to be fit for the Anthropocene – the age of significant and lasting human impacts on the planet. The ATS requires stronger enforcement mechanisms, faster institutional responsiveness and more-efficient ratification processes. Reforms could include capping tourist numbers and re-evaluating the 'use' principle, which allows any tourism activity that national authorities approve, except those that are explicitly prohibited.

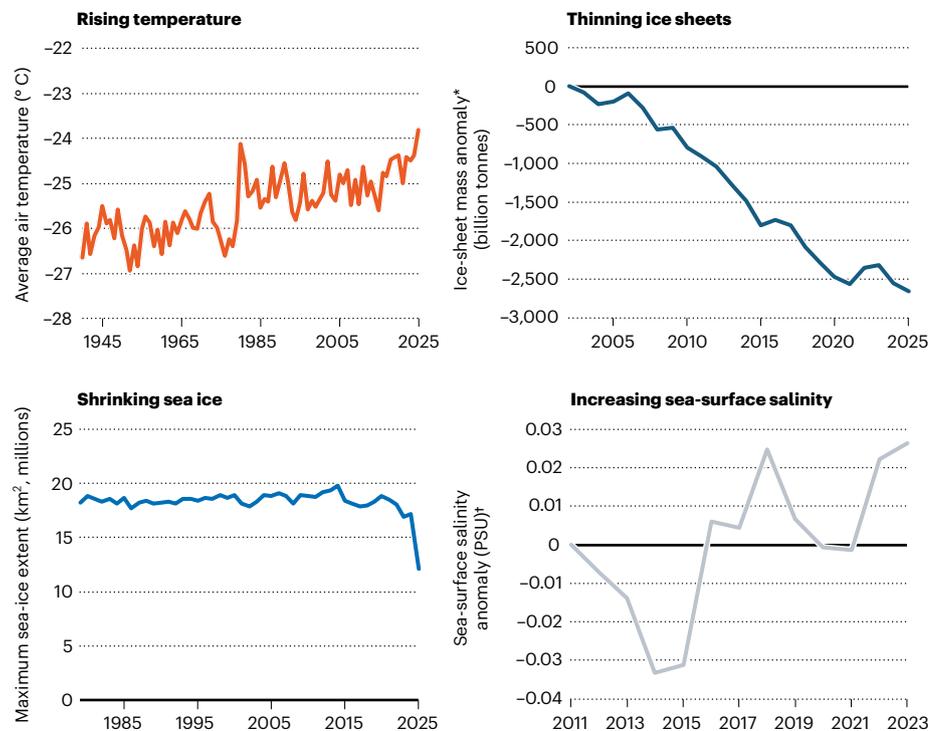
It is also essential to expand marine protected areas to safeguard biodiversity, and to embed scientific knowledge on socio-environmental thresholds and 'tipping points' in decision-making processes. For example, adding early warning thresholds into regulatory frameworks and requiring mandatory action when those thresholds are crossed would strengthen resilience. Environmental thresholds should be codified so



Rising numbers of human visitors risk disrupting nesting sites for seabirds.

ANTARCTICA UNDER THREAT

Warmer conditions in Antarctica are accelerating the melting of glaciers and sea ice, as well as the saltiness of surrounding seas.



*Anomaly for Antarctic ice sheet using ice-mass measurement data from NASA GRACE satellites, calculated against the first data point (March 2002). †Salinity anomaly of Southern Ocean using soil-moisture and ocean-salinity satellite data, calculated against the February 2011 value. PSU, practical salinity unit.

that, for instance, certain fishing operations are suspended automatically when they are breached – just as fire bans activate during hot and dry weather.

Territorial claims in Antarctica, such as those held by the United Kingdom, Argentina, Chile and Australia, cannot be acted on while the Antarctic Treaty is in place. Signatories need to reinforce their commitment to this indefinite freezing of such claims so that environmental initiatives, such as extra protections for specific areas or species, are not seen as proxies for expansion of sovereignty. Such perceptions, whether justified or not, undermine cooperation and trust. More voices from Indigenous-knowledge holders and civil-society groups should also be incorporated into ATS negotiations and decision-making processes.

Free-market economic systems also need to take into account the true value of ecosystem services, ecological stability and the cost of exceeding tipping points. Reforming these systems requires shifting social norms, regulations and incentive structures to promote and reward environmental stewardship and penalize activities that cause degradation.

Such mechanisms include increasing recognition and support for long-term philanthropic conservation, utilizing social-marketing tools to influence public behaviour, and implementing economic incentives such as green bonds and biodiversity credits to secure sustained funding for conservation. These reforms must

be underpinned by binding international agreements that limit extractive activities, apply economic tools and establish equitable frameworks for benefit-sharing.

Although Antarctica is not formally governed as a global commons, the ATS embodies key elements of commons governance, such as by prohibiting the enforcement of territorial claims. Building on this foundation, the signatories to the treaty could draw on economist Elinor Ostrom's Nobel-prizewinning work¹⁶ outlining core principles for managing shared resources sustainably, to guide future institutional reform within the ATS¹⁷. Real-world examples include the UK National Trust, a conservation charity headquartered in Swindon, which has protected landscapes through collective ownership since 1895 (ref. 18). Similar trust-based approaches have been proposed to manage global atmospheric and oceanic commons¹⁹.

Robust and sustained monitoring is also crucial. Investing in satellite observation and advanced *in situ* monitoring technologies would vastly improve scientists' ability to detect early warning signals. Just as weather forecasting revolutionized disaster preparedness, real-time tipping-point monitoring could enable early interventions and prevent some irreversible outcomes.

To make these tools effective, open data platforms and international coordination will be essential. For instance, improving

understanding of ecosystem dynamics, such as spatial distributions of krill, requires predictive ecosystem models supported by comprehensive, high-quality data.

Finally, public engagement and education must have a central role. Antarctica's remoteness has led to political neglect, with decisions devolved to technocrats rather than being debated publicly. More-ambitious public campaigns and media coverage could build a global constituency for Antarctic protection. Greater transparency of Antarctic Treaty meetings could help to ignite public interest.

What happens in Antarctica sends ripples – through every ocean current, weather system and ecological network – around the globe. The future of the Earth system depends on the choices that are made now, for the ice, for the oceans and for the generations yet to come.

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