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The hard road back from overshoot

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As global temperatures move beyond 1.5 °C, overshoot now defines the landscape ahead, sharpening legal claims, exposing economic risks and revealing how far politics still trail the pace of change.

There is a point at which ambition becomes memory. The 1.5 °C world was once a promise to the future. It is a promise written into treaties, argued in court, affirmed in court rulings, folded into national policies and business plans, and repeated in classrooms around the world. Scientists now speak of overshoot, a term suggesting that the internationally set and agreed upon line will be crossed, and management of overshoot will try to find the way back, as if recovery were a kind of faith. Surpassing this temperature threshold and then returning to it, known as climate overshoot among the science community, describes a period when the planet warms beyond the agreed limit before cooling again. The Paris Agreement was designed to avoid it. But emissions have kept climbing, and even the most optimistic models now project that the global temperature will rise past 1.5 °C in just a few years, reach 2 °C in the next decade, and will remain above that for decades before coming back down, perhaps[1]. The new debate is no longer only about prevention but how to recover from what has already been set into motion.

Still, the goal endures. "Given the lack of emissions reductions, overshoot is becoming an ever more plausible path," said Carl-Friedrich Schleussner, referring to projections that global temperatures will surpass the Paris Agreement's 1.5 °C world. "It's [1.5 °C] a legal and ethical imperative. Overshoot doesn't erase that. It makes it more urgent."

Schleussner, a senior research scientist at the International Institute for Applied Systems Analysis, has spent a decade trying to quantify what overshoot means, not only for modelling global temperatures but for understanding systems people depend on and how to manage it[2]. Coral reefs bleach, ice sheets melt, 50% of species vanish and droughts lengthen. These things happen long before temperatures start to fall. "We can't just go above and then slide back," he said. "We carry the damage forward."

Overshoot will unfold unevenly and over generations, and the risks are great. "We are leaving the first best world behind," Schleussner said, a world where emissions had fallen fast enough to avoid overshoot altogether, "and are entering a second or third best world, where we must manage the consequences of our insufficient actions." Those consequences extend beyond physics. They include the social and legal weight of who bears the costs of recovery and who gains from delay.

Joeri Rogelj, a climate scientist at Imperial College London, agrees that the framing must shift. "It's not only about reaching 1.5," said Rogelj, speaking at the Royal Society in London in September 2025. "It's about how far we go beyond it, how long we stay there, and what we do on the way down."

Rogelj describes overshoot as less a future scenario than a management problem already underway. Global temperatures have risen by 1.1–1.4 °C. The first stage of overshoot, he explained, is happening now, with the expected failure to stay below the Paris Agreement's 1.5 °C limit. It's not an abstract line on paper, but a boundary fast approaching, within the next 3 years. "The more we learn the worse it looks," he said. "Risks we once thought belonged to 2 degrees [Celsius] may appear much sooner." Beyond 1.5 °C, risks climb sharply, strengthening moral and legal cases for limiting the magnitude and duration of overshoot. The next stage, he said, is a rapid shift to net-zero emissions, followed by an effort to reverse warming through negative emissions to bring global temperatures down.

Examining the trajectories of each stage is technical but rooted in a moral question: if nations exceed the Paris Agreement limit, how should they act to bring the world back?

The Paris Agreement already requires nations to bring their highest possible mitigation ambition to the table; it is a standard that leaves little room for delay. Rogelj's work shows how fast pathways narrow once warming slips past 1.5 °C. With warming signs emerging across the Amazon, the Atlantic, coral reefs and glaciers, the risks sharpen[3]. "Decision-makers need evidence today, and that evidence needs to be based on the

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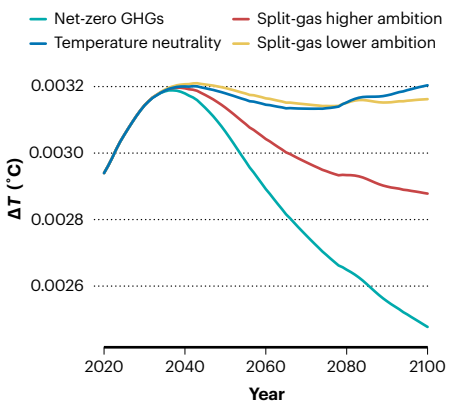

Fig. 1 | National temperature contributions for Ireland under alternative greenhouse gas mitigation scenarios evaluated under shared socioeconomic pathway SSP1–2.6 global emissions assumptions. Lines show outcomes of four scenarios that illustrate the relationship between greenhouse gas (GHG)-specific reductions and warming. The blue line marks the temperature neutrality scenario, the green line the most ambitious net-zero GHGs scenario. Comparison of the yellow and red lines highlights the impact of different levels of ambition for split-gas scenarios. ΔT, temperature change. Figure adapted from ref. 4, under a Creative Commons license CC BY 4.0.

best available science," Rogelj said, urging highest mitigation ambition from every country.

The question now is how nations use science to confront the hard arithmetic of emissions, land use and livelihoods to manage overshoot. Many places have already begun to examine it. Ireland, long known for its rich green landscape, is one of them. Lately, that colour may feel more like an obligation than a gift, as Ireland weighs the climate costs tied to the land that defines it.

Róisín Moriarty, a researcher at the University College Cork's Sustainability Institute, studies how national climate targets stack up against global temperature goals. Many still don't. She said, "We're trying to build a framework that keeps national actions consistent with 1.5 °C even in an era of overshoot."

Moriarty works at the uneasy intersection of science and policy, translating climate thresholds into national roadmaps. "What farmers need," she said, "is a very clear roadmap to a transition. If we don't have that, a lot of change will happen, and it won't be managed very well." Her point is less about agriculture than about governance. In the era of overshoot, recovery depends on having a plan.

That plan has taken on new urgency since the International Court of Justice ruled in 2025 that climate change constitutes an existential threat and that states are legally bound to prevent it. Moriarty and colleague Hannah Daly, also of the Sustainability Institute at University College Cork, were among those who briefed national leaders after the ruling, translating its language of "due diligence" and "ambition" into something actionable.

The International Court of Justice's opinion did more than restate moral imperatives; it clarified legal ones. Nations now carry binding obligations to protect the climate system, regulate private actors, end fossil fuel subsidies and halt new fossil fuel licenses. Weak or symbolic targets, the ruling said, are no longer enough. Countries must pursue "the highest possible ambition" to hold warming to 1.5 °C. For Moriarty, it marked a shift from aspiration to liability. She said, "The law has caught up to the science."

Moriarty's own work begins with methane and its outsized role in near-term warming[4] (Fig. 1). Ireland, like much of the developed world, built prosperity on emissions that now make it vulnerable. Cutting methane, Moriarty argues, buys time. "If we reduce methane substantially," she said, "we limit the amount of temperature overshoot, maybe both in peak and duration, because we're not letting it get out of control." Each tonne avoided now reduces the scale of carbon removal required later, narrowing what she calls "the impossible job of the future."

That idea, a managed descent rather than a chaotic fall, has begun to ripple outward. Moriarty talks about it as a "framework for recovery," a way of aligning national targets with the physics of repair. It's pragmatic. "The more we do now," she said, "the less we have to do later, or at least the less impossible that future job becomes." Hope, in her view, isn't found in breakthrough technologies or grand declarations but in the hard, disciplined work of making the transition legible. This means clear targets, clear timelines and clear responsibilities.

National commitments will need to bear the weight of the science. "Our goal is to show policymakers the trade-offs and co-benefits in these pathways," Moriarty said. "Overshoot isn't just about temperature. It's about development choices." The ruling by the International Court of Justice has already altered the ground beneath those commitments. As nations claim progress towards 'net zero', emissions tell a different story. Many plans postpone the hardest cuts, betting that future technologies will balance the carbon books. It is a fragile calculus and one that works only if carbon dioxide removal can draw down emissions, and if delay itself does not become the defining feature of climate policy.

Within the scientific machinery of the IPCC, overshoot has moved from a technical footnote to organizing principle. The Seventh Assessment Report, expected in 2029, now carries overshoot across every working group, from physical science to social, ethical and legal assessments.

In September 2025, there was a moment when the 160 attendees of the first international conference on overshoot were sitting in the opening session, and it became clear that overshoot was no longer a technical term but a kind of reckoning. Jim Skea, who is chair of the IPCC, had been talking for ten minutes when he tried, delicately, to separate the scientific from the human. The very word 'overshoot', he suggested, is already a complication. Scientists using it to mean different things, laypeople hearing only a breach in temperature with no return, and policymakers lost somewhere in between. He cautioned against unnecessary flourishes and multiplying meanings when consistency will be an anchor for public understanding.

"When a layperson hears the word overshoot, they may reasonably interpret that as exceeding a warming level without any notion of returning. They may imagine a brief excess. But what matters is what happens in between, and who bears the cost," Skea said, noting that future IPCC assessments will need to confront those ethical dimensions more directly. "Overshoot is not just a scientific question," he said. "It's a societal one. The decisions we make now will shape conditions for decades."

Managing overshoot, really managing it, means implementing large-scale carbon dioxide removal systems that exist somewhere between near-term actions and last resort. These systems include natural approaches from enhanced soil carbon storage to engineered solutions such as direct air capture and carbon capture and storage. Each approach carries a ledger of costs and technological uncertainties, harm to ecosystems, and effects on communities. Some will benefit. Others will bear a burden.

Putting carbon dioxide removal into practice is only part of the challenge. Schleussner is trying to contextualize this moment in the longer arc of time. "We need to understand the opportunities and limits on the enhanced action up to net zero and beyond. And we need to establish an urgency to act, but also

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an obligation for enhanced removal and the remedial measures needed to return," he said.

The analysis is becoming clearer. Sustained net-negative emissions will mean major actions across sectors. Choices being made now will determine whether overshoot is a brief interval of a few decades or a lasting, sustained period requiring both ambitious and technological responses towards negative emissions to bend the curve.

Ewan White has watched legal frameworks strain under new realities. The narrative around net zero is already shifting to include negative emissions, explained White, a PhD candidate in international environmental law at the University of Oxford. "Scientists have been remarkably successful in mainstreaming the idea of net zero," he said. "But it's not enough. Developed countries now face a legal and ethical necessity to go net negative, and to remove more than they currently emit."

The next step will force hard choices in agriculture, in aviation, in meat production. "We have an opportunity," White said. "The world we would make on that path would be better [with] cleaner air and fewer extremes, but we have to name the task, net negative, for what it is."

For Mirey Atallah, chief of the Adaptation and Resilience Branch at the United Nations Environment Programme, that is far from an abstract concept. It's a new operating condition.

"For us, overshoot means everything, everywhere, all at once," Atallah said, describing a world in which mitigation, adaptation and loss-and-damage responses must all intensify simultaneously. Atallah frames the challenge as both practical and human-centred.

While science can map risks, the real test lies in translating those insights into specific steps that policymakers, practitioners and communities can implement without freezing in place. Her team's recent overshoot report connects the dots between emissions trajectories, climate risks and the concrete actions that can keep nations on track while navigating the growing complexity of climate impacts[5].

Atallah also emphasized the importance of timescales and relatability. Climate risks are framed in decades or centuries. She argues that scientists need to make the long-term consequences of overshoot tangible now, linking them to decisions about infrastructure, water systems and public services that matter today.

"We need to unpack in very concrete terms what it means," Atallah said. "We need science that is objective, that can serve policy, and that leads to action." In practice, that means integrating overshoot into national climate strategies, adaptation plans and finance frameworks. It also means managing expectations. Recovery from overshoot, if possible, will not happen quickly. The inertia of both the climate system and global economy ensure that the path back will test not only technology, but also political will and notions of fairness.

Models sketch overshoot as a curve back towards safety. Nature offers no such arc[6]. Overshoot barely registers in biodiversity science, even as the systems humans rely on, such as pollinators, forests and food webs, show no inclination to return once they fall apart. Christopher Trisos, who has made a career out of studying those edges, put it bluntly. "If you go above a temperature threshold and a species goes extinct or ecosystem collapses, it just doesn't reappear when the world cools again. That's an irreversible loss," said Trisos, a senior research officer at the African Climate and Development Initiative at the University of Cape Town and director of the Climate Risk Lab at the African Synthesis Centre for Climate Change, Environment and Development.

Returning to 1.5 °C does not return the world we knew. Species gone will remain gone. Migration routes will be severed. Forests may have turned to cropland, or asphalt, or memory. "The path up and the path down are not mirror images," Trisos said. Cooling does not retrace the route.

Ironically, the very methods imagined to cool the planet risk deepening biodiversity loss. Large-scale land-based carbon removal such as bioenergy crops and vast new forests requires space. And that kind of space tends to overlap with biodiversity hotspots and Indigenous territories. "You end up with species at compound risk," Trisos said. "First from changing climate, and then from losing habitat to the solutions we use to fix it." The social costs follow the same pattern. "Whose land will be used for carbon removal? Who will benefit and who will lose access to land, water or livelihoods it provides?" Trisos asked.

These are questions with a long lineage. Thelma Arko, a Utrecht University-based researcher, describes carbon markets as an extension of extractive logics, built on new language. A US$2 billion carbon offset market, projected to expand 100-fold by mid-century, promises solutions while appropriating forests and farmland. "Carbon markets are fuelling a new scramble for African land," Arko explained in *ROAPE*, warning that reducing ecosystems to carbon storage risks commodifying biodiversity and land, perpetuating colonial patterns[7]. Carbon accounting's complexity excludes local stakeholders, while Indigenous ecological knowledge that has sustained forests for generations is dismissed in favour of carbon markets, Arko explained. Economists may frame overshoot as risk and opportunity; Arko's work shows the imbalance built into that framing.

Others offer variations of the same warning. In Canada, First Nations peoples have argued that carbon capture schemes allow

fossil fuel expansion while they absorb the fallout. In the USA, the Great Plains Action Society opposes carbon pipelines that threaten waterways and cultural sites. Across Asia, civil society groups have condemned Japan's plan to export captured carbon dioxide to other countries, calling it waste colonialism, a shifting of burdens.

The debate over what to do with carbon points to a divide. And then economic considerations enter, and the pointer turns towards damages, adaptation costs and the policies that balance them. Overshoot arrives in economics as a series of losses to be measured. Tamma Carleton, an environmental and resource economist at the University of California, Berkeley, tracks how climate damage expresses itself in humans, crops and labour markets. Overshoot is a new concept in her field. She describes it as "the damages are now happening."

The field of economics has spent decades modelling emissions curves and is now waking up to the adaptation challenge, Carleton explained. That challenge includes who can adapt on their own, who cannot, and what public institutions must step in to do. "The lion's share of economics of climate change research has been done on mitigation," she said. Economics is now being pulled in to understand impacts and adaptation; failing crop yields, heat stress, disease shifts and labour hours lost from heat.

It is here, at the point where models meet lived consequences, that the financial picture sharpens. Adaptation already will need US$200–US$300 billion each year by 2030, while current financing flows are a fraction of that. Overshoot stretches the distance between what must be financed and what the world is willing to fund. And yet, the investments needed to confront overshoot, from decarbonizing energy to rebuilding infrastructure and restoring landscapes, could strengthen economies even as they reduce risks.

Overshoot, long treated as a speculative scenario, is now inscribed in the Conference of the Parties (COP) text as the condition the world is entering. That acknowledgement does more than signal a temperature threshold. It establishes a reference point against which impacts can be measured and responsibility assigned. Legal scholars have already noted how this shifts the ground, giving courts and litigators clearer footing to compare harms and hold actors liable, a trend accelerated by the International Court of Justice ruling that risks steepen sharply beyond 1.5 °C. As Schleussner observes, while the legal frontier is moving quickly, politics remain "far too slow" and still two or three steps behind what is happening in the rapidly changing scientific reality. Overshoot, in that light, will test whether governments can adjust to the pace the moment demands, or whether the gap between warming and response continues to widen.

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References

1. Schleussner, C.-F. et al. *Nature* **634**, 366–373 (2024).
2. Schleussner, C.-F. et al. *Nat. Clim. Change* **15**, 1136–1140 (2025).
3. Lenton, T. M. et al. (eds) *Global Tipping Points Report 2025* (Univ. of Exeter, 2025).
4. Duffy, C. et al. *Environ. Res. Lett.* **20**, 094019 (2025).
5. *Adaptation Gap Report 2025: Running on Empty* (United Nations Environment Programme, 2025).
6. Meyer, A. L. S. & Trisos, C. H. *One Earth* **6**, 1614–1617 (2023).
7. Arko, T. Carbon markets and the new scramble for African land. *ROAPE* https://go.nature.com/3ZAzQYS (30 October 2024).

Competing interests

The author declares no competing interests.