

Biodiversity and Climate Change

The Challenge of Sustaining Life Connections in the Amazon

Key Messages

- The Amazon's biodiversity is the result of long-term ecological and evolutionary processes, and its resilience depends on the region's integrity.
- Pressures such as deforestation, fires, overexploitation of resources, and climate change threaten this vast and complex web of life.
- Strengthening protected areas and enhancing ecosystem connectivity, including the restoration of ecological corridors, is crucial to ensuring ecosystem health and the conservation of Amazonian biodiversity.
- Promoting integrated biodiversity knowledge and monitoring, while respecting and incorporating traditional knowledge, is essential to harmonize indicators, guide strategic decision-making, and ensure biodiversity resilience and conservation.
- Climate and biodiversity strategies must be aligned under a shared Amazonian agenda that translates commitments into coherent, cooperative, and measurable territorial actions.
- Amazon regional cooperation, with ACTO playing a key role, is decisive to prevent irreversible losses and safeguard the future of the Amazon.



Amazon Under Pressure: Threats to Biodiversity

The Amazon is the result of complex evolutionary and ecological processes that have taken place over millions of years. It harbors about 10% of all known species, including 40,000 plant species, more than 2,400 freshwater fish, 1,300 birds, 425 mammals, 427 amphibians, and 371 reptiles—many of them endemic and threatened with extinction. The maintenance of this diversity depends on the integrity of key ecological processes such as forest connectivity, migration, gene flow, pollination, and seed dispersal.

However, this natural wealth is under increasing threat. Approximately 18% of the Amazon has already been deforested, and an additional 17% is degraded, occurring at rates that far exceed species' natural regeneration capacity, driven by human pressures hundreds to thousands of times greater than natural processes.¹ The main drivers of these high rates include the conversion of native vegetation to livestock and agriculture, the construction of roads and other infrastructure without adequate government oversight, which facilitates illegal occupation, illegal logging, mining, and fires caused by illegal burning practices.²

Overexploitation of fauna and flora further aggravates this scenario. For instance, overfishing and unregulated practices reduce the recovery capacity of fish stocks, resulting in a shift toward smaller, less productive species.³ In addition, climate change acts as an accelerator of these pressures: rising temperatures, prolonged dry seasons, and increased aridity intensify stress on forests and aquatic ecosystems, creating a feedback cycle that approaches a tipping point.^{5,6}

Impacts of Climate Change: Ongoing Transformations in the Amazon

Climate change is reshaping the physical and biological conditions of the Amazon, acting as a multiplier of other human pressures. Regional warming, altered rainfall patterns, and the increasing frequency of extreme events (such as severe droughts, atypical floods, and heat waves) not only increase mortality and immediate biodiversity loss but also reduce the capacity of ecosystems to recover.⁶

CHANGES IN THE HYDROLOGICAL CYCLE AND EXTREME EVENTS

Climate change can substantially prolong the dry season in the Amazon. In combined simulations of warming scenarios and forest loss, the dry season would increase, on average, by 69% in the Amazon basin (which corresponds to up to 60 additional days without rainfall in many areas). This extension reduces soil moisture and essential refugia for plants and animals, transforming a seasonal variation into a new persistent environmental condition.⁶

With less accumulated moisture throughout the year, the forest becomes structurally drier. This causes water stress, tree mortality, reduced growth, and alterations in flowering and fruiting cycles, reducing landscape resilience. At the same time, vulnerability to fire increases, especially in fragmented areas, where forest edges and small fragments lose moisture more rapidly, becoming ignition points. Studies show that fires increased especially in open forests and transition zones, and that their recurrence causes biomass loss, soil degradation, and tree mortality,⁷ effects that are difficult to reverse.

These changes interact with the hydrological cycle of várzeas, igarapés, and floodplains, which function as nurseries for Amazonian fish. Many of these animals synchronize their reproduction with the flood pulse (river rising and falling cycles), which provides reproductive habitats, food, and protection for juvenile fish. When the flood season shortens, the favorable period for spawning and juvenile growth shrinks. Studies show that dry years reduce the proportion of females in spawning condition and the size of mature females. Signs of lower reproductive success and recruitment, critical effects when combined with intensive fishing.⁸ The socioeconomic implications are immediate. Riparian communities, whose food and income depend on fishing, face reduced stocks, smaller fish, and greater food insecurity in consecutive drought years.

Glossary

OTHER EFFECTIVE AREA-BASED CONSERVATION MEASURES (OECMs)

Geographically defined areas that do not have conservation as their primary objective but are governed and managed in ways that deliver positive and long-term outcomes for the *in situ* conservation of biodiversity, such as Indigenous Territories and areas managed by local communities.

NATIONALLY DETERMINED CONTRIBUTIONS (NDCs)

Commitments made by each country under the Paris Agreement, defining goals and actions to reduce greenhouse gas emissions and adapt to climate change.

NATIONAL BIODIVERSITY STRATEGIES AND ACTION PLANS (NBSAPs)

Strategic documents developed by each country to guide their biodiversity protection efforts and ensure its sustainable use, in compliance with the obligations of the Convention on Biological Diversity (CBD) and aligned with global targets such as the Kunming-Montreal Global Biodiversity Framework.

ACTO THEMATIC AMAZONIAN NETWORKS (RAFO, RADA, and RAMIF)

Technical cooperation bodies coordinated by ACTO that bring together authorities and experts from Amazonian countries in strategic areas for the sustainable management of natural resources, to share experiences and harmonize public policies. They include: i) the Amazon Forest Authorities Network (RAFO); ii) the Amazon Water Authorities Network (RADA); and iii) the Amazon Integrated Fire Management Network (RAMIF).

CHANGES IN VEGETATION AND ECOSYSTEMS

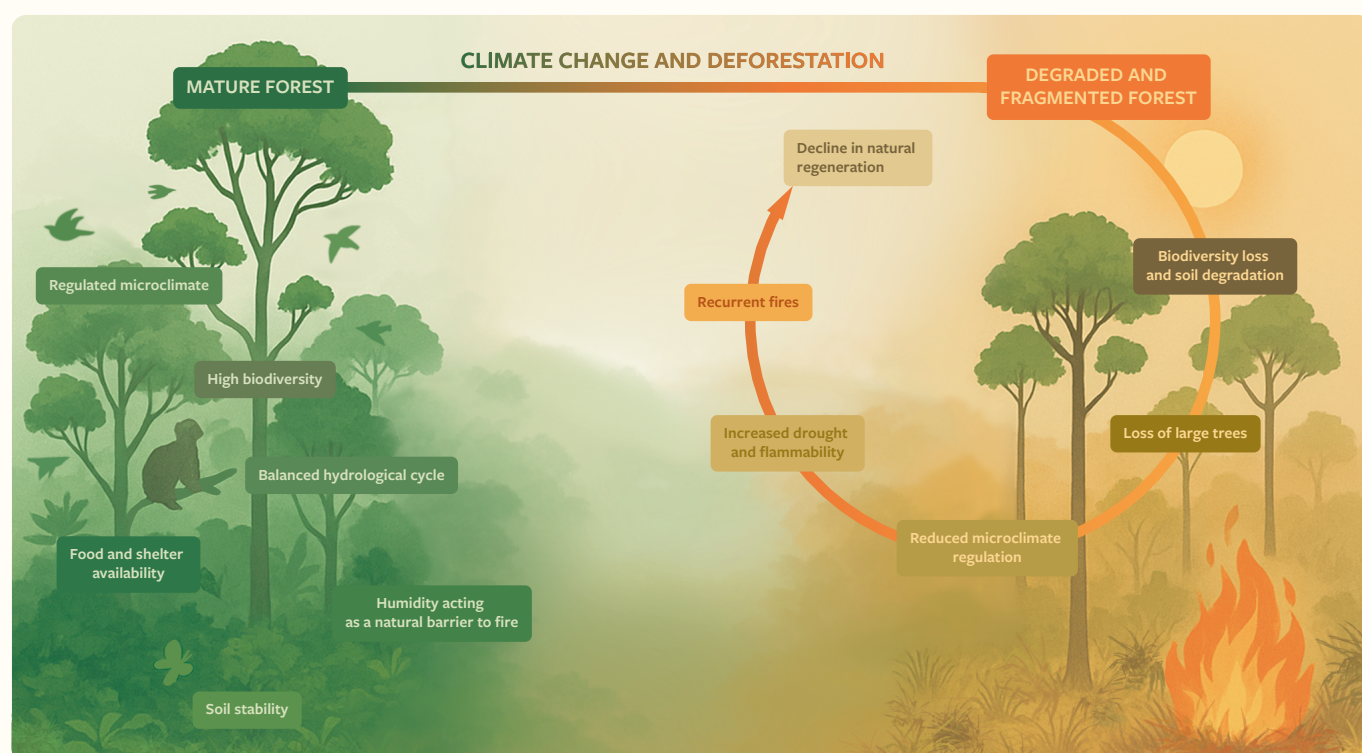
The Amazon forest does not respond uniformly to climate change: different areas, species, and ecological interactions show distinct vulnerabilities. Models indicate that the combined effects of deforestation and warming can reduce rainfall, extend the dry season, and intensify temperature extremes. These conditions favor the replacement of parts of the forest by more open vegetation, in a process of “savannization” projected to occur particularly along already degraded and fragmented forest edges. In some regions, this transition could become consolidated within a few decades if current pressures persist.⁶

Signs of this transformation are already detectable in long-term forest inventories and botanical collections. Research spanning 30 to 60 years reveals consistent structural changes in forest

composition: tree species more tolerant to drought are increasing, while moisture-dependent species are declining. Alterations in traits such as leaf size and shape indicate adaptation to drier and warmer environments, which, however, does not offset the loss of diversity, leading to forests that are less varied and less resilient.⁹

Taken together, these processes indicate that the Amazon is undergoing a structural transformation that threatens its biodiversity and ecosystem services. The shift toward more open ecosystems implies carbon loss, reduced regional rainfall, and the depletion of natural resource bases that sustain millions of people. Unlike the natural cycles of flooding and drought that characterize the Amazon, these are now deep and persistent changes, heightening the risk of crossing ecological tipping points.

Figure. Contrast between mature and degraded forest: on the left, attributes and ecosystem services of undisturbed remnants that sustain ecological balance; on the right, the feedback loop driven by deforestation and climate change, which accelerates forest degradation and fragmentation.



IMPACTS ON WILDLIFE AND FOOD WEBS

Climate change profoundly alters species interactions by modifying their behavior, life cycles, abundance, and geographic distribution, a critical issue for extractive and forest-dependent communities. These shifts can cause spatial and temporal mismatches (for example, plants flowering outside the period of pollinator activity), reconfigure food webs, and even amplify or invert indirect effects, with consequences greater than the direct impacts of climate change on individual species.^{10,11}

Case studies in the Amazon illustrate the impacts of the combined effects of climate change, habitat loss, and forest fragmentation. Modeling studies with primates indicate a growing mismatch between these animals and the tree species that rely on them for seed dispersal, leading to the collapse of this ecological service, reduced tree recruitment, and an overall decline in diversity, especially of species with high ecological value.¹²

In small forest fragments (<100 ha), analyses of food webs show that predator-prey networks become simplified, and species lose essential interactions. This can trigger prey overpopulation, predator

disappearance, and changes in vegetation regeneration.¹³ Defaunation (the decline in abundance and presence of large vertebrates) further intensifies these effects. The loss of large mammals and birds compromises seed dispersal, nutrient cycling, and herbivore control. Without these “ecosystem engineers” and dispersers, regeneration favors fast-growing, low-biomass plant species, resulting in lower carbon stocks and reduced availability of fruits and seeds.¹⁴

The decline of pollinators and seed dispersers also generates cascading effects. Reduced seed dispersal limits forest regeneration to smaller areas, causing a drop in structural diversity (fewer canopy layers and large tree species). This, in turn, decreases fruit and seed availability for frugivores and leads to a decline in predator populations, altering their abundance, behavior, and the configuration of the food web. Combined, these changes can push the ecosystem toward a tipping point, resulting in an alternative, less diverse state that provides fewer essential ecosystem services. Studies in the Amazon indicate that such transitions can occur rapidly and be difficult to reverse, underscoring that prevention is far more effective and less costly than attempting to restore the system after collapse.⁵



The Brazil Nut Tree

The Brazil nut tree (*Bertholletia excelsa*) is an emblematic species of the Amazon. It is a long-lived tree that sustains extractive production chains, generates household income, and preserves the cultural values of traditional communities. Its reproduction and nut production depend on specific ecological interactions: pollinators (large-bodied bumblebees, such as the *Eulaema* species) and seed dispersers (mainly agoutis), making it sensitive not only to logging but also to the disruption of this intricate network of species.

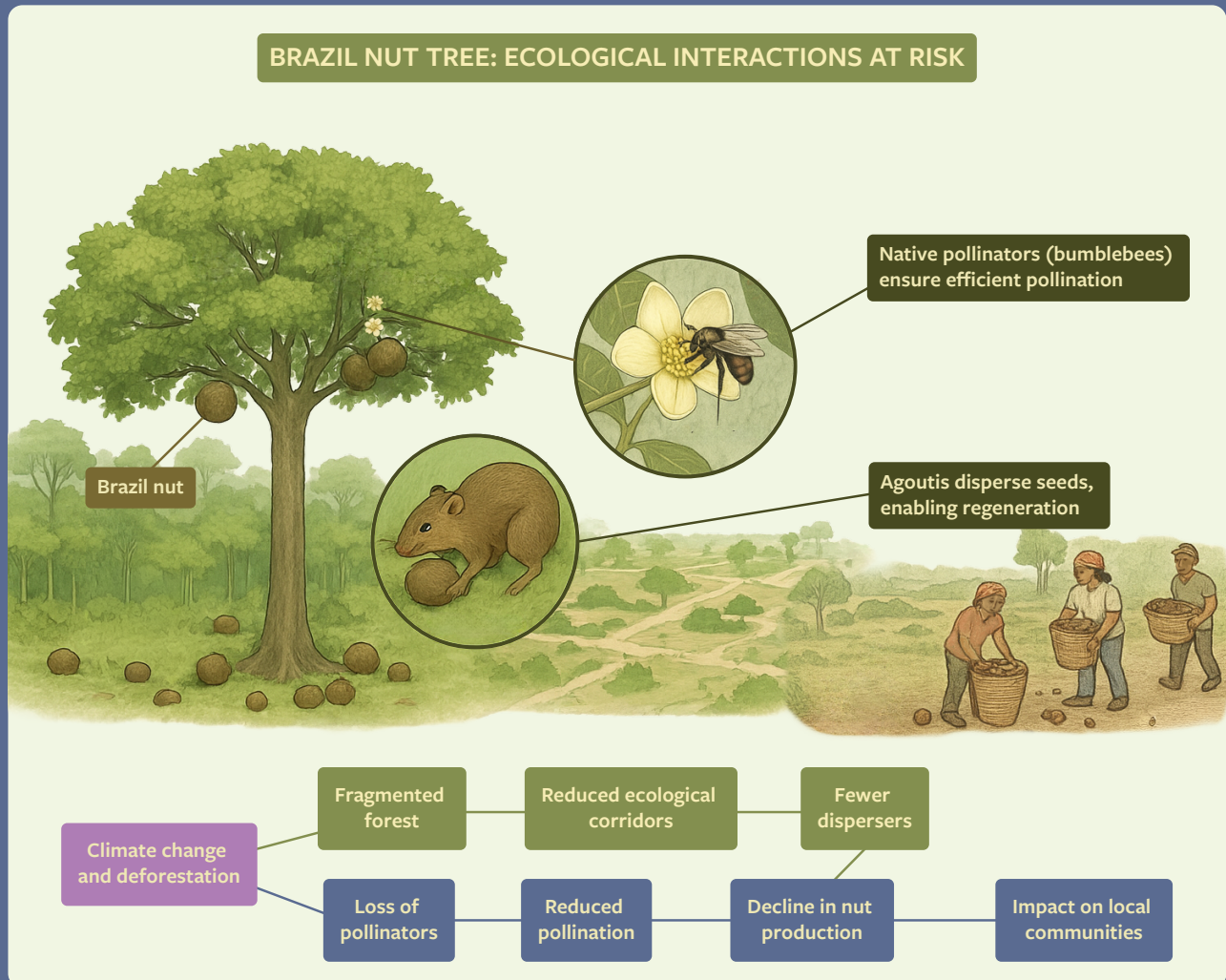
A study¹⁵ combining climate models, forest loss simulations, and dispersal limitations presents a concerning outlook for the interaction between the Brazil nut tree and its animal partners. While the area with suitable climatic conditions for the tree itself may remain stable or even slightly expand by 2090, pollinators face much greater habitat losses: for some species, spatial overlap with the Brazil nut tree could decrease by up to 80%, and local pollinator richness may decline by around 20%—leaving many trees without effective pollinators

in large parts of their range. Some key bumblebee species may completely lose access to analogous climatic conditions, paving the way for local extinctions.

Seed dispersers show more variable responses: while some species maintain or expand their potential range, others retreat. As a result, the average overlap between the Brazil nut tree and its seed dispersers is less affected than that with pollinators. These patterns indicate that, even if the trees persist, the breakdown of interactions with their pollinators and dispersers could severely compromise both reproduction and the sustainable harvesting of Brazil nuts.

The findings highlight that protecting the trees alone is not enough to secure nut production. It is essential to preserve continuous forests and ecological corridors, aligned with anti-deforestation policies and climate adaptation strategies. Without such an integrated approach, the sustainable production of Brazil nuts is at risk.

Figure. From flower to basket: how the loss of pollination and seed dispersal, driven by climate change and deforestation, disrupts the Brazil nut's production cycle, reduces nut supply, and threatens the livelihoods of local communities.





Recommendations

FOSTER REGIONAL COOPERATION TO ADDRESS SHARED AMAZONIAN CHALLENGES

The implementation of ACTO's Biological Diversity Program contributes to this effort, serving as a long-term guiding framework for the development and execution of strategic actions. The Regional Assessment on Biological Diversity and Ecosystem Services of the Amazon (2023), coordinated by ACTO, provides a foundation for informed and integrated decision-making, strengthening the interface between science, policy, and society.

INTEGRATE BIODIVERSITY AND CLIMATE AGENDAS

Conservation strategies should seek synergies between the goals of the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC), ensuring that Nationally Determined Contributions (NDCs) and National Biodiversity Strategies and Action Plans (NBSAPs) are aligned toward a joint Amazonian agenda for climate mitigation and biodiversity conservation.

STRENGTHEN BIODIVERSITY KNOWLEDGE AND MONITORING

Enhance the monitoring of species and ecosystems across the region through the compilation and systematization of national data from Amazonian countries. The Amazon Regional Observatory (ORA) serves as a strategic platform to identify knowledge gaps, harmonize indicators and datasets, and track progress toward national and international biodiversity and climate targets. Cooperation among ACTO's Thematic Networks, such as the Amazon Networks of (i) Forest Authorities (RAFO), (ii) Water Authorities (RADA), and (iii) Integrated Fire Management (RAMIF), further strengthens countries' capacities and regional synergy.

PROTECT AND VALUE TRADITIONAL KNOWLEDGE

Biodiversity governance must include the strengthening of traditional knowledge management and protection, ensuring prior informed consent and the fair and equitable sharing of benefits, in accordance with national legislation and the rights of Indigenous Peoples and local and traditional communities.

PROMOTE THE SUSTAINABLE USE OF BIODIVERSITY

Policies should reinforce the sustainable use of biodiversity, emphasizing fair and equitable benefit-sharing to ensure the persistence of biodiversity and the well-being of extractive communities. ACTO has developed the Guide for Sustainable Investment and International Cooperation in Amazonian Biodiversity and Ecosystems (2024) as a tool to prioritize projects implemented in partnership with Indigenous Peoples and local communities.

STRENGTHEN PROTECTED AREAS AND ECOSYSTEM CONNECTIVITY

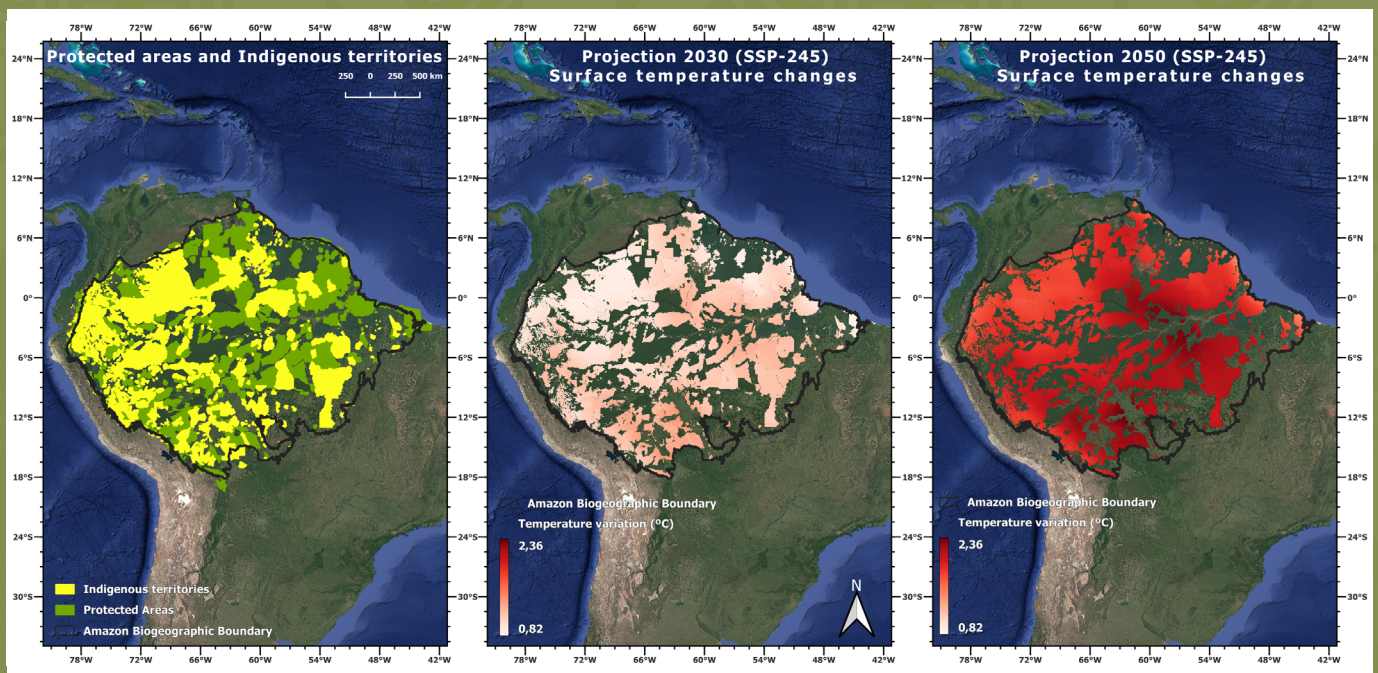
Improve the effectiveness of existing protected areas and other effective area-based conservation measures (OECMs) by strengthening management and their strategic articulation with public policies. Promote ecological corridors and the restoration of native vegetation to reduce vulnerability to climate change and enhance ecosystem resilience.

Amazonian Trajectories: Scenarios for 2030 and 2050

The figures below are based on the average of CMIP6 climate models, which project temperature change for 2030 and 2050 under a scenario of continued current greenhouse gas emissions (SSP-245). These projections are overlaid with the network of protected areas in the Amazon,¹⁶ including Indigenous Territories (ITs).¹⁷ The maps indicate where the average temperature increase is expected to be greatest in each year and identify which protected areas may exceed critical thresholds established by the Paris Agreement, namely +1.5°C and +2°C. The IPCC warns that risks to biodiversity rise sharply once warming surpasses these levels, increasing both local and global extinction rates.

Protected areas are the world's primary strategy for conserving biodiversity, delivering positive outcomes across the planet, and they currently cover nearly half of the Amazon. Indigenous Territories are also included because they are key to the conservation of native vegetation and ecosystems, playing a crucial role in maintaining Amazonian biodiversity in harmony with the people who inhabit them. However, even with extensive territorial protection across Amazonian countries, the biodiversity within these areas will be affected if global warming is not contained.

Figure. Distribution of Protected Areas and Indigenous Territories in the Amazon (left); Temperature projected change in 2030 (center) and 2050 (right) under the SSP-245 scenario according to CMIP6 climate models.



WHAT THE MAPS REVEAL

According to the climate models, warming is projected across the entire Amazon, though it is expected to be most intense in the central-northern, central-eastern, and southern regions. By 2030, additional heat is anticipated in thousands of protected areas, with some exceeding +1.4°C. While local increases may remain below the 1.5°C threshold, such thermal shifts could already alter species' life cycles and behaviors. By 2050, vulnerability to extreme temperature increases is expected to intensify, with several areas projected to surpass 1.5°C—and even reach 2°C. This means that regions critical to biodiversity conservation may experience climates very different from those to which their species are adapted.

Once warming exceeds 1.5–2°C, protected areas may lose their suitable climatic conditions, ceasing to provide refuge for many species. In other words, legal protection no longer equates to ecological protection when the climate itself changes. Some groups, such as amphibians, reptiles, fish, and pollinators respond early and sharply to warming. The decline of these indicator species can signal broader ecosystem degradation, underscoring the urgent need for climate mitigation and adaptation actions before critical impacts occur across multiple species. Conservation, therefore, must go beyond the designation of protected areas, integrating connectivity, adaptive management, ecosystem restoration, and above all, efforts to limit global temperature rise.

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RAÍSA VIEIRA

raisa.vieira@otca.org

Biologist, with a Master's and PhD in Ecology and Evolution from the Federal University of Goiás, including a research period at James Cook University (Australia). Specialist in systematic conservation planning, working with public policies and strategies for biodiversity restoration and conservation.

ARO SCIENTIFIC COORDINATION

Arnaldo Carneiro
arnaldo.carneiro@otca.org

ARO EDITORIAL COORDINATION

Paula Drummond

ARO CARTOGRAPHIC PRODUCTION AND MODELING

Lis Vale, Maycon Castro, Maria Fernanda Ribeiro, Mathias Alvarez e Rafaela Cipriano

DESIGN, LAYOUT AND ILLUSTRATIONS

Patrícia Sardá | Estúdio Abanico

PHOTOGRAPHY

Ubirajara Oliveira, Miguel, Jarno Verdonk, Banco OTCA

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AMAZON REGIONAL OBSERVATORY (ARO)

ARO is ACTO's reference center that integrates data, tests innovations, and disseminates information to support member countries in cooperation and decision-making.

AMAZON COOPERATION TREATY ORGANIZATION (ACTO)

ACTO is an intergovernmental organization formed by eight Amazon countries: Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, and Venezuela, which signed the Amazon Cooperation Treaty, making it the only socio-environmental bloc in Latin America.

ACTO / ARO

SEPN 510, Bloco A, 3º andar – Asa Norte | Brasília (DF), Brazil, CEP: 70.750-52
ora@otca.org | <https://www.oraotca.org/>

