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BUDA MENDES/GETTY

Smoke rises from a fire in Brazil's Pantanal, the world's largest tropical wetland, in September.

Rescue Brazil's burning Pantanal wetlands

Renata Libonati, Carlos C. DaCamara, Leonardo F. Peres, Lino A. Sander de Carvalho & Leticia C. Garcia

Climate extremes, poor management and lax laws are making this World Heritage Site prone to fierce fires. Researchers and governments must develop a plan to manage these risks together.

Brazil has changed. As well as the COVID-19 pandemic killing more than 170,000 of its citizens so far, 2020 has seen almost one-third of the Pantanal, the largest tropical wetland in the world, on fire. Four million hectares of forest, savannah and shrub-land (an area bigger than the US state of Maryland) have gone up in flames since January (see go.nature.com/2jtw6va). Almost all the Indigenous territories and conservation facilities were burnt, as was

much private land. Conservation areas such as Encontro das Águas State Park have been devastated – it contained one of the largest populations of jaguars in the world.

Fires' impacts have been felt nationwide. Smoke has spread thousands of kilometres, reducing air quality in São Paulo, Rio de Janeiro and Curitiba. Southern states have experienced showers of black rain. The fires are decimating Brazil's economy, curbing inward investment as well as sectors such as

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air travel and tourism that are already hit hard by the pandemic.

The public is worried. The fires have made the headlines for months. Thousands of Brazilians have volunteered to fight the flames, rescue wildlife or donate money. Yet, Brazil's government is doing little. It is ignoring the causes of the fires: a combination of inadequate fire management, climate extremes, human behaviour and weak environmental regulations. Worse, it has slashed funding for fire prevention and has been slow to contract firefighters. It has even cast doubts on the reliability of satellite fire detections.

On the scientific front, fire risks and impacts in the region are under-studied. Deeper research is needed on the weather conditions that fan fires, as well as the influences of ecology and management. Scientists need to know how the many factors behind large fires interact, including vegetation stress, extreme weather and human activities. And more studies are needed to inform fire management strategies in the region.

This year's fire season in the Pantanal is exceptional. But the conditions that led to these blazes are becoming increasingly common as the area warms. In response, political, socio-economic and scientific approaches need to change. Researchers and governments need to come together to develop a comprehensive strategy for preventing and managing fires. Otherwise this great tropical wilderness will not bounce back.

Devastating impacts

With more than 84% of its territory conserved, the Pantanal is the largest remaining wetland area of natural vegetation in the world. It's a UNESCO World Heritage Site. Indigenous, riverine and quilombo communities live there. Traditional farmers practice unique forms of sustainable agriculture, including grazing cattle on native pastures and moving animals to higher land when lowlands flood. Tourists flock to the region for its spectacular scenery, safaris and sport-fishing.

Each rainy season, from October to April, pulses of floods swell the Paraguay River to support ecosystems found nowhere else on Earth. Endangered jaguar, giant otter, marsh deer and hyacinth macaws roam wild. Thousands of birds pass through on their migrations¹. It's a haven for caimans, capybaras, monkeys, deer, coatis, tapirs, snakes and the jabiru stork (*Jabiru myxeria*) – the region's symbol.

The fires have affected all aspects of life. COVID-19 has made things worse. PREVFOGO, the national centre for forest fire prevention and fighting, has struggled to hire and train firefighters. Many fires broke out in remote regions, even underground, that were hard to reach. Local firefighters in the Kadiwéu territory, for example, struggled almost alone

to push back exceptionally fierce flames (see 'Pantanal fire crisis').

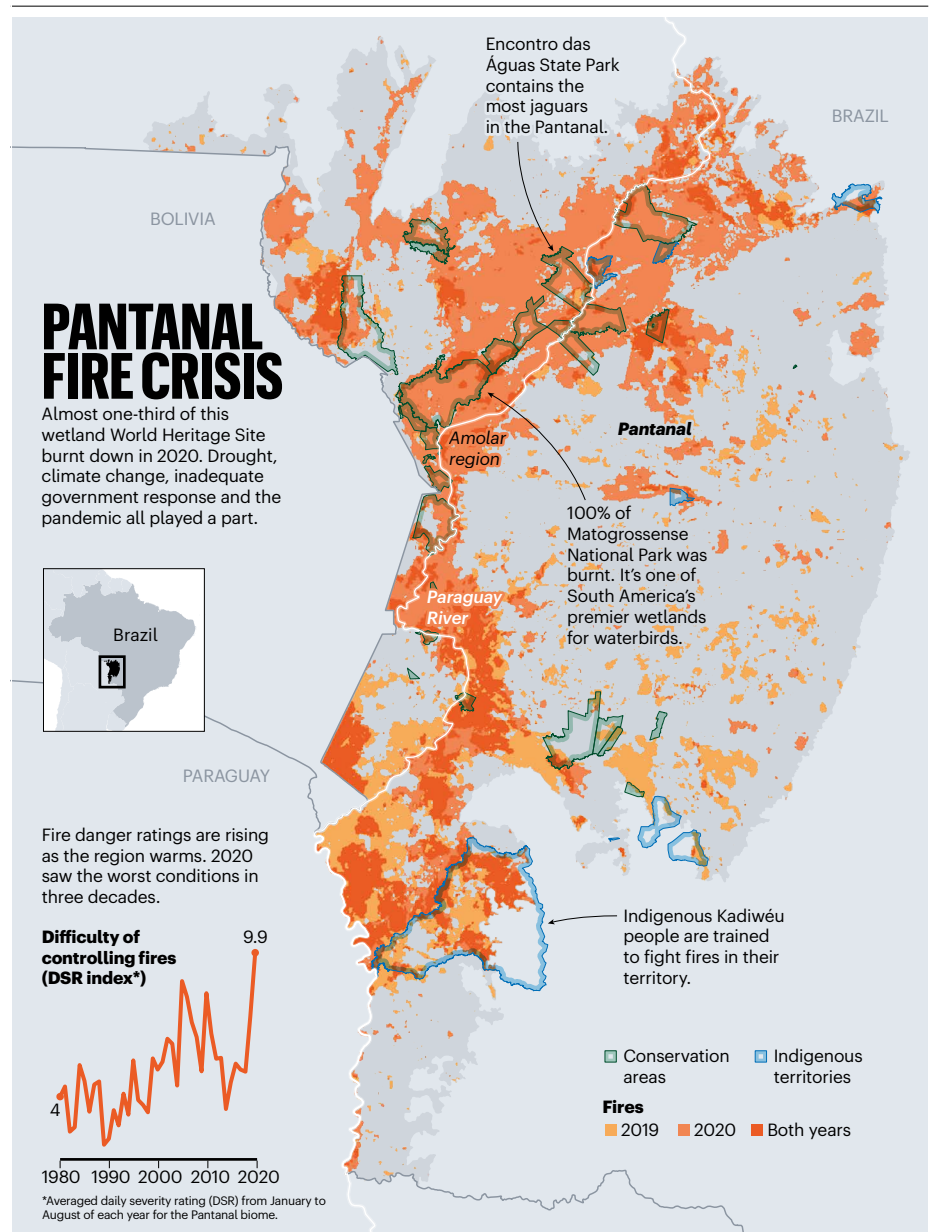
The total loss will take months to calculate. But the impacts are long lasting. Charcoal and ash contaminate rivers and promote harmful bacteria that poison drinking-water supplies and kill fish. Eroded soils are flushed downstream. Fire-sensitive plants struggle to produce seeds. Vast tracts of land will need to be assessed to understand whether they can be restored. Communities will have to be rebuilt.

Growing risk

What lies behind these fires? The Pantanal is no stranger to burning, even though it is a wetland². For half the year it is dry and prone to catching alight, especially during drought. Sometimes lightning causes the spark. More often it is human-related – flashes from electrical cables, burning garbage and wood from

cattle fences, use of fire to ward off bee attacks when collecting honey, and even car crashes and damaged agricultural machinery. Cattle-men burn the landscape to remove shrubs and stimulate the growth of native grasses, which are adapted to fire and sprout after pruning or scorching. Such fires regularly get out of control, especially in areas where there's no system for managing them³.

The frequency and severity of fire outbreaks are worsening, as the climate warms and human impacts increase. Since 1980, average temperatures there have risen by 2 °C and humidity has fallen by 25%, according to the European Centre for Medium-range Weather Forecasts (ECMWF). This year saw the worst drought recorded in the Pantanal in 60 years (see go.nature.com/2jpdubc), induced by unusually warm waters in the North Atlantic⁴. The wet season saw 57% less rain than normal. By June, the Paraguay River was at half its usual



level. This combination of hot, dry conditions pushed flammability thresholds to their highest since 1980. Such thresholds indicate the difficulty of controlling fires, a scale that is quantified using the averaged daily severity rating (DSR) index, which is derived from ECMWF data. Deforestation in Amazonia has also been linked to reduced rainfall in the Pantanal, although this is debated.

Environmental regulations are failing to keep up⁵. In July, Brazil's government issued a 120-day ban on the use of fire in the Amazon and the Pantanal. It seems to have been widely ignored. The government has denied responsibility, blaming Indigenous peoples and traditional communities for starting fires, and criticized campaigns by the media and non-governmental organizations highlighting the exceptionality of the fire season.

Resources for environmental protection and climate actions have been slashed, especially in the past two years. The Ministry of the Environment's US\$630-million budget was cut by around 20% in 2020 and looks set to fall by a further 35% in 2021. Brazil is also failing to meet its commitment to reduce greenhouse-gas emissions under the Paris climate agreement⁶. Licensing requirements for dams, roads and mines have been weakened (*Nature* 572, 161–162; 2019). Last year, to promote agricultural and biofuel production, the government revoked the law that has prohibited new sugar-cane plantations in the Amazon and the Pantanal that has been in place since 2009 (ref. 7). The decree was provisionally suspended by the Brazilian federal court in April, and is awaiting a final decision.

Researchers need to bolster evidence to back a new approach. Until now, most studies in the Pantanal have focused on a single discipline, plant ecology for example. Research on other topics, such as climate, isn't granular enough. There are few studies of human causes and responses to fires in the Pantanal, to inform fire-management strategies. A full understanding of cycles of burning and long-term trends is missing.

Fire science is multidisciplinary, spanning fields from climate to chemistry, ecology to economics, as well as risk analysis and computational modelling. A task force is needed to bring together researchers from all these areas, along with technicians working in the field.

Neglecting the connections between climate, land use and fire management will make it impossible to restore the Pantanal to its former state, let alone protect the region in the future. Any change to the natural pattern of burning disrupts ecosystems and food chains, sometimes completely. For instance, jaguars will struggle to find herbivores to eat, if the latter are killed by flames or are unable to find fruits and leaves in a scorched landscape. Generations of fire-sensitive trees could be lost, including *Genipa americana*³, fruits of which

are a staple for fauna and used by Indigenous people to make black ink for body painting.

The impacts cascade quickly. Repeated wildfires lower the resilience of communities and vegetation; forests are replaced by open landscapes with fewer resources.

Economic fallout

Brazil must act on deforestation and forest fires to protect its economy. After earlier fires in 2019, Norway and Germany froze their donations to the Brazilian government's Amazon Fund, after having contributed more than \$1.2 billion and \$68 million, respectively. Around 250 investors, including the California Public Employees' Retirement System (CalPERS), representing approximately \$17.7 trillion in assets, endorsed an open letter pointing out the financial impacts that deforestation may have on investee companies (see go.nature.com/36gzirt).

“Resources for environmental protection and climate actions have been slashed.”

In June, 7 European investment firms, managing \$2 trillion in assets (\$5 billion linked to Brazil), announced they might divest from beef producers, grain traders and government bonds in Brazil if there was no progress in stopping deforestation and fires. Soon after, 34 companies (including the Church of England and KPL, Norway's pension fund, managing around \$4 trillion) wrote to Brazilian embassies in their countries (including Norway, Sweden, France, Denmark, the Netherlands, the United States and the United Kingdom) expressing concerns over the dismantling of environmental policies in Brazil.

European countries (France, Austria and the Netherlands) threaten not to ratify the provisional trade deal between the European Union and the Mercosur bloc (comprising Brazil, Argentina, Uruguay and Paraguay), unless Brazil achieves its Paris climate commitments. The EU–Mercosur agreement was negotiated for 20 years and is considered the largest free-trade agreement in history. It accounts for \$20 trillion of global gross domestic product (GDP), about one-quarter of the world's economy, and the consumer market in the 32 countries reaches 780 million people. Currently, Brazilian companies export almost \$20 billion to the EU; the deal would lead to an increase of \$100 billion for Brazil's GDP by 2035.

Steps forward

Brazil's government must develop a long-term strategy to mitigate damage from wildfires in the Pantanal that takes all factors into

account, including effective fire management and environmental protection policies. Researchers need to shore up knowledge about the fire regime there to inform this strategy.

First, gather satellite and other data about the time, location and intensity of fires, burnt area and vegetation conditions before and after. This information can then be used to assess factors behind the onset and spreading of fires. Scientists should model the impacts of current and future land use and climate change on fire events, as well as feedbacks such as between biomass burning and global warming.

Second, model fire management and response strategies, including the impacts on biota, pasture, communities, economies, ecology, weather and fire risk. Fire managers need to decide which areas to protect and which activities to prohibit, taking into account scientific, Indigenous and local knowledge. Some areas could be kept fire free, or have carefully managed blazes outside the dry season to protect biodiversity. Other areas might accommodate agriculture, cattle or tourism, as long as fire-management principles, as well as state and federal legislation on environmental protection are followed (such as the 2012 Brazilian Forest Code). Near-real-time information about the location, intensity and spread of wildfires in the Pantanal should be disseminated, along with daily forecasts of fire danger.

Funding should be directed towards fire management and environmental protection, as well as to law enforcement and fine collecting by environmental inspectors. Education and information programmes in schools or by the media would make the population more aware of the consequences of irresponsible behaviour.

A warming and fast-changing world demands a new proactive approach to fighting wildfires.

The authors

Renata Libonati and **Lino A. Sander de Carvalho** are adjunct professors of

climatology and remote sensing, and

Leonardo F. Peres is an associate professor of atmospheric sciences and remote sensing at the Federal University of Rio de Janeiro, Brazil.

Carlos C. DaCamara is an associate professor of climate science at the University of Lisbon, Portugal. **Letícia C. Garcia** is an adjunct professor of restoration ecology at the Federal University of Mato Grosso do Sul, Brazil. e-mail: renata.libonati@igeo.ufrj.br

1. De Pinho, J. B., Aragona, M., Hakamada, K. Y. P. & Marini, M. *Â. Bird Conserv. Int.* **27**, 371–387 (2017).
2. Pivello, V. R. *Fire Ecol.* **7**, 24–39 (2011).
3. Pott, A. & Pott, V. J. *Wetl. Ecol. Manag.* **12**, 547–552 (2004).
4. Thielen, D. et al. *PLoS ONE* **15**, e0227437 (2020).
5. Abessa, D., Famá, A. & Buruaem, L. *Nature Ecol. Evol.* **3**, 510–511 (2019).
6. da Silva Junior, C. A. et al. *Sci. Rep.* **10**, 16246 (2020).
7. Ferrante, L. & Fearnside, P. M. *Science* **359**, 1476 (2018).