News & views

Figure 1 | Testing the effects of fire in Kruger National Park, South Africa.

Ecology

Savannahs store carbon despite frequent fires

Niall P. Hanan & Anthony M. Swemmer

An analysis of carbon stored in the plants and soil of an African savannah suggests that atmospheric carbon dioxide concentrations – and thus global warming – might be less affected by frequent fires than we thought. **See p.445**

Savannahs burn more frequently than any other biome, and tropical savannahs alone account for 62% of the carbon dioxide emitted from fires globally[1]. Strategies involving fire suppression[2] or the planting of trees[3] in savannahs have therefore been proposed as a means of reducing CO_2 emissions and increasing carbon sequestration, thus potentially contributing to the mitigation of global climate change. But it remains unclear whether these measures would make a substantial difference to the accumulation of CO_2 in the atmosphere. On page 445, Zhou *et al.*[4] analyse a long-term fire experiment in Kruger National Park, South Africa, and reveal that the total amount of carbon stored in the ecosystem increases more slowly than expected in the absence of fire – challenging our assumptions about how fire affects carbon storage in savannahs.

In contrast to the intense fires that spread through the canopy of temperate and boreal forests, savannah fires usually burn herbaceous plants, which are close to the ground. These surface fires typically release less CO_2 into the atmosphere, per unit of burnt area, than do forest fires. Furthermore, the carbon that is released would otherwise be emitted through decomposition or herbivore respiration within a few months[5]. Thus, although savannah fires contribute to seasonal variability in atmospheric CO_2, their net long-term contribution to atmospheric CO_2 concentrations is small. Instead, their potential impacts on carbon storage occur indirectly and more slowly, through damage or loss of tree seedlings and saplings, which reduces the number of adult trees over time[6].

Zhou and colleagues used data from a large experiment that has been running for the past 68 years, and that has influenced our understanding of how fire frequency and timing interact with rainfall to control the structure of woody vegetation, such as that found in savannahs[7] (Fig. 1). The experiment tests 12 distinct fire treatments that have been implemented in plots of around 7 hectares, which are separated by fire breaks and are located in areas with different climates and soil types throughout Kruger National Park (Fig. 2).

For logistical reasons, the authors focused on a subset of treatments in the part of the park that receives the most rainfall: a group of four plots subjected to annual fires in August (the dry season), plots burnt every third August, and a final group that remained unburnt. The triennial fires replicate the natural fire frequency for the Kruger area, whereas

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Figure 2 | A long-term fire experiment in Kruger National Park, South Africa. Zhou *et al.*[4] analysed data from a large experiment that has been running since 1954. The experiment tests 12 distinct fire treatments that have been implemented in plots of around 7 hectares, which are separated by fire breaks. The treatments include annual, biennial and triennial fires; the control plots have been protected from fire for almost 70 years. This photograph provides an aerial view of a set of fire treatments near Pretoriuskop in the southwestern corner of the Park (25° 12′ S, 31° 17′ E).

those that burn annually simulate a very high fire frequency and those left unburnt, fire suppression.

Zhou *et al.* estimated the amount of carbon stored above and below ground in each of these plots. To infer the above-ground biomass of all the trees in each plot, the team measured tree sizes with a lidar (light detection and ranging) sensor mounted on a drone. They then used ground-penetrating radar and diverse sampling approaches to estimate below-ground root biomass and organic matter in the soil.

The authors found that annual burning substantially reduced the biomass and amount of carbon in vegetation above ground, but a similar decrease was not found in root and soil carbon pools. In particular, the concentration of carbon in the soil was almost as high in burnt plots as it was in unburnt ones. Zhou *et al.* estimated that fire suppression in the savannah ecosystem they studied would result in a yearly increase in sequestration of only around 0.35 tonnes of carbon per hectare from the associated increase in woody biomass. This is substantially less than the 9.4 tonnes per hectare proposed as an annual estimate by those advocating fire suppression[3] — which calls into question the idea that fire suppression would contribute meaningfully to climate-change mitigation.

Zhou and colleagues' results enhance our understanding of carbon dynamics in savannahs. However, their conclusions are limited to a few plots in the wettest corner of Kruger National Park. Many savannahs are drier than the authors' study site, particularly those in Africa. These drier areas burn less frequently and are unlikely to be greatly affected by fire suppression. Other savannahs, including many in South America and Australia, have higher rainfall than Kruger National Park, but different soils, or are dominated by plants with different evolutionary lineages. Similar studies in other regions are needed to further explore the role of fire suppression and tree planting in fire-prone savannahs.

Programmes designed for carbon sequestration and climate-change mitigation also need to consider the social and economic implications for communities that rely on savannah landscapes for grazing livestock and harvesting wood, fruits and other resources. More is not always better when it comes to trees, particularly in savannahs. Indeed, many savannah ecologists have criticized proposals for tree planting and fire suppression, arguing that increasing the cover of woody vegetation through either means reduces biodiversity[8]. Tree-planting programmes in drylands can also fail, because seed germination and seedling survival rates are low[9], particularly in larger projects in which individual plants cannot be tended individually. Similarly, fire suppression can lead to fuel accumulation and higher-intensity fires later on[10]. Ultimately, it is important to balance the costs and feasibility of fire suppression or tree planting with the potentially small carbon-storage benefits estimated by Zhou and co-workers.

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Biochemistry

Methane might be made by all living organisms

Chang Liu & Jingyao Zhang

It is textbook knowledge that some bacteria can generate methane enzymatically. A study now provides evidence that an alternative, non-enzymatic mode of methane production could occur in all metabolically active cells. **See p.482**

Methane is mainly produced enzymatically by microorganisms called methanogenic archaea, in strictly oxygen-free (anoxic) conditions. In the past decade, it has become apparent that some oxygen-dependent species, including certain plants and fungi, can also produce methane[1]. However, the mechanisms that underlie this alternative mode of methane generation have been unclear. On page 482, Ernst *et al.*[2] reveal a process of methane production, driven by reactive oxygen species (ROS), that could occur in all living organisms, regardless of whether or not they exist in an anoxic environment. This