History, Fire, Global CO_2 and the management of endangered grassy woodlands

Photo: Oliver Frank

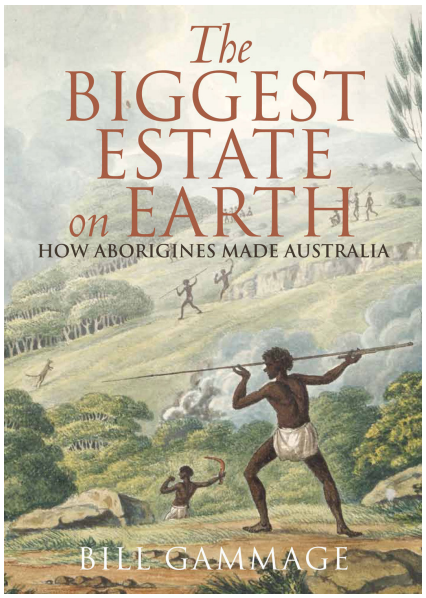
by Josh Dorrough,
Ecological research consultant
Visiting Scientist at CSIRO

We often focus on the temperature aspects of climate change but rising atmospheric CO_2 is with us here and now and is already changing vegetation and impacting on how we can manage it. Conditions are rapidly shifting in favour of trees over grasses and this has big implications for how we manage landscapes with fire.

There are two recent publications that have had a huge impact on how I view the Australian landscape. Bill Gammage's wonderfully rich book *The Biggest Estate on Earth* has challenged my ideas about current and historical land management and vegetation patterns. The second is a research paper by William Bond and Guy Midgley which details the impact of changes in our global atmosphere on vegetation, in particular the influence of atmospheric CO_2 levels on tree densities in grasslands and grassy woodland ecosystems (savannah).[1]

Despite the considerable differences in the two publications[2] there is a strong theme current to both. Both see fire as central to determining many vegetation patterns, something most ecologists and land managers would agree with. Gammage strongly argues that in 1788 vast (but specific) areas of Australia were open and grassy owing to intentional, planned fire undertaken by indigenous Australians. With the removal of planned fire following European settlement many of these areas rapidly thickened, promoting large destructive fires and requiring clearing of regrowth.

More recently, land retirement (or removal of livestock) in open grassy woodlands often leads to rapid regeneration, and loss of the open woodland characteristics, presenting a significant challenge for conservation management of



these ecosystems. Gammage would argue these landscapes lack the fire regimes necessary to keep country open. Previous work by Bond and Midgley has also demonstrated the role of fire in maintaining open grassy ecosystems across the globe.

The work of Bond and Midgley adds an additional element to the historical story told in *The Biggest Estate on Earth*. Their central argument is that while fires are crucial to determining the relative dominance of trees in higher rainfall savannah landscapes, atmospheric CO_2 concentrations influence how ***effective*** fire is.

Under current CO_2 levels, tree and shrub seedling growth rates are possibly **several times faster** than they were at the time of European arrival. This is important because the size of many tree and shrub seedlings is closely related to their ability to survive grass fires – the bigger the seedling, the more likely they can survive a fire and go on to become a large adult tree. In higher rainfall areas, some trees and shrubs that might have reached a size where they can survive fire in 3 to 4 years could do so in 12 to 18 months.

While increasing rates of tree and shrub growth due to increased CO_2 might be good in some respects, making it increasingly possible to restore tree cover

(Continued on page 4)

(Continued from page 3)
rapidly to agricultural landscapes with appropriate soils and management, it does have serious implications for how successfully we can use fire to keep country open and grassy, which is essential for maintaining much of the ground layer diversity of grasslands, grassy woodlands and grassy forests. While trees in woodlands are good for biodiversity, dense thickets may not be.

During the last glacial period (which peaked ~20,000 years ago) atmospheric CO_2 levels were less than half what they are today, approximately 180ppm (it is now 392 ppm and rising). In southern Australia not only was it much colder and drier, but lower CO_2 levels were strongly limiting for plant growth. Under these circumstances grasses dominated many landscapes, in particular drought tolerant C_4 summer active grasses, such as Kangaroo Grass (*Themeda triandra*). This is despite the colder summer temperatures as C_4 grasses compete more effectively against cool-season (C_3) grasses (such as native *Poa* tussocks), at low CO_2 concentrations. Tree and shrub seedling growth in contrast was much slower and relatively few fires were necessary to tip the balance in favour of open grassy ecosystems.

By the time of European arrival in Australia CO_2 levels had risen to about 280 ppm and the climate was warmer and wetter. Trees and shrubs would have been growing faster and fires would need to have been more frequent to keep country open. Since then CO_2 has risen dramatically and throughout the world tree densities in savannah woodlands have been found to be increasing, even where historic fire frequencies have been maintained.

It is almost certain that returning to pre-1788 fire regimes will not have the same effect that it did then or several thousand years before. There is little doubt that more frequent fires will be required to maintain open grassy woodlands. These more frequent fires would then need to be weighed up against the possible impacts on biodiversity and current land use. Other management strategies may need to be employed if we want to keep our woodlands and forests open and grassy, including physical removal, stem injection with herbicide and strategic use of livestock.

Regardless of the rate at which our climate is changing due to human actions, the effects of rising atmospheric CO_2 are already here. Navigating the interactions between CO_2, vegetation change and fire is a challenge for how we manage our land now and into the future.

Footnotes:

1 Bill Gammage 2011 *The Biggest Estate on Earth* Allen & Unwin

2 William Bond and Guy Midgley 2012 "Carbon dioxide and the uneasy interactions of trees and savannah grasses" *Philosophical Transactions of the Royal Society B* 367: 601-612

3 William Bond, Ian Woodward and Guy Midgley 2005 "The global distribution of ecosystems in a world without fire" *New Phytologist* 165: 525-538