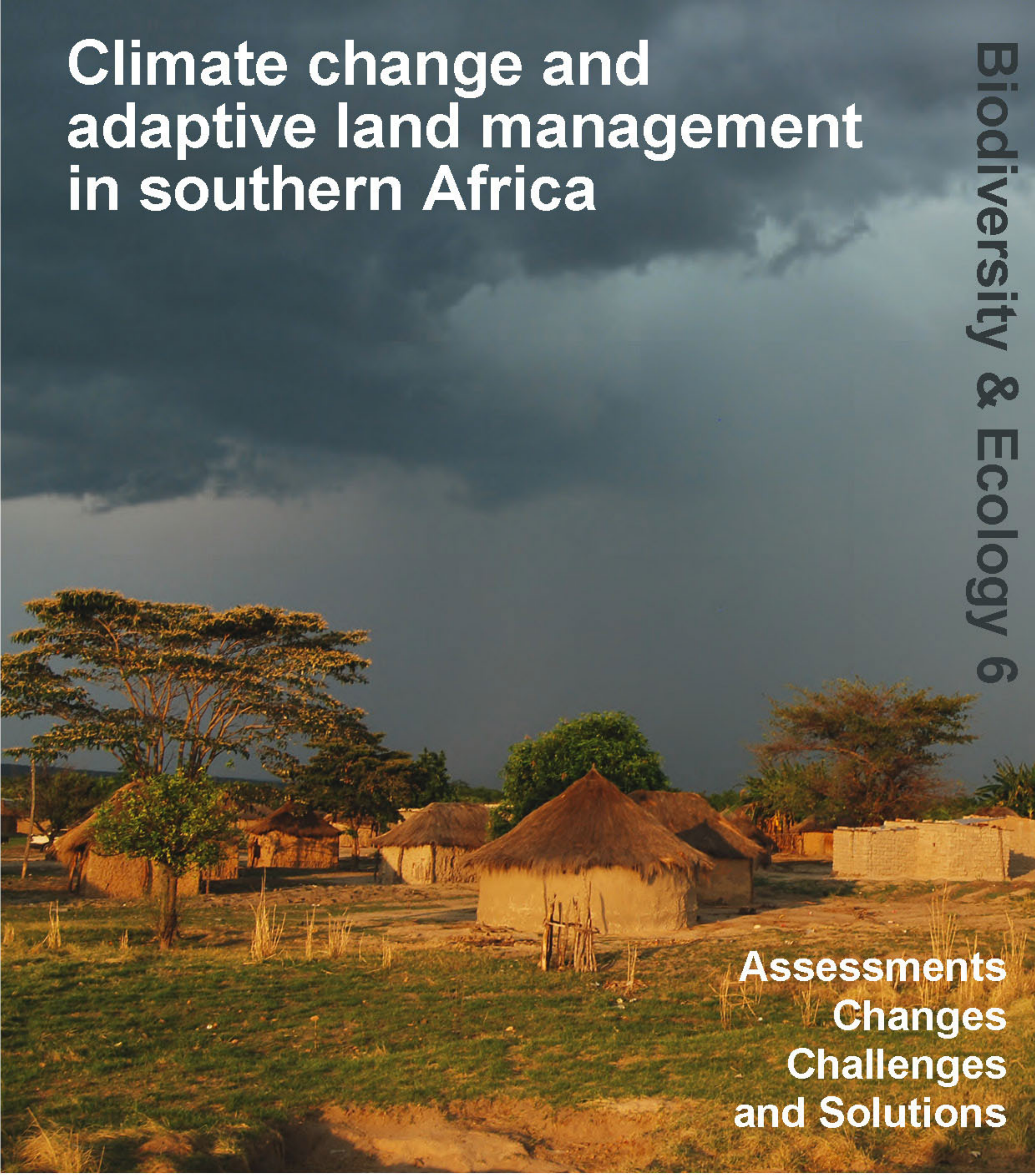
Climate change and adaptive land management in southern Africa

Biodiversity & Ecology 6



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Changes
Challenges
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Assessments, changes, challenges, and solutions

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Impact of fire on the *Baikiaea* woodlands

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The tropical woodlands and savannas of southern Africa have amongst the highest fire frequencies in the world (Aldersley et al., 2011; Pausas & Ribeiro, 2013). Although fire has been a major driver of these ecosystems for millions of years (Bond & Zaloumis, 2016), most fires in the *Baikiaea* woodlands have an anthropogenic origin as the fire season is in the late dry season, when hardly any natural ignitions take place (Archibald et al., 2008; Gambiza et al., 2005; Stellmes et al., 2013). With northern Namibia and southern Angola projected to become warmer and drier, fire frequency is expected to increase (De Cauwer et al., 2016; Enright et al., 2015; Pausas & Ribeiro, 2013), as detected by some studies (Pricope & Binford, 2012; Schelstraete, 2016). The current fire regimes cause forest degradation, especially through the decrease of woody biomass and carbon sequestration (Chidumayo, 2013). Forest degradation is difficult to quantify as it requires comparison with an undegraded condition and often entails repeated measurements over time. Long-term studies in the *Baikiaea* woodlands have been very limited. One study of an annual burning experiment over 16 years in northern Namibia illustrated how fire negatively affected woody regeneration, especially of species such as *Baikiaea plurijuga* and *Commiphora* spp. (Geldenhuys, 1977). The SASSCAL task 038 assessed the impact of fire on the tree layer of the open *Baikiaea* woodlands at the border between Namibia and Angola, especially for trees with a minimum diameter at breast height (DBH) of 5 cm. A forest inventory was repeated after a period of one year to assess the impact of a single fire. Additionally, single forest inventory data were used to assess the impact of multiple fires on basal area and on tree damage.

Impact of a single fire on forest structure and tree damage

A comparison of forest structure and tree damage before and after a late dry season fire in northern Namibia was performed (Schelstraete, 2016). Forest structure was determined through stem density, basal area, and DBH derived from 33 forest inventory plots situated in Hamoye State Forest and 33 plots in Ncaute Community Forest. Tree damage was assessed through five subjective damage classes (0–4), from no damage to fatal damage (Fig. 1). Comparison of the forest inventory datasets, collected within a one-year interval, showed that there was no significant change in stem density, basal area, or DBH distribution of trees. The effect of the fire on forest composition was limited to a small increase in fire damage class for all tree diameters.

Figure 1: *Pterocarpus angolensis* with serious fire damage (fire damage class 3) at base of stem

Impact of multiple fires on basal area

The study of Schelstraete (2016) also assessed the fire frequency during the period 2001–2015 in the 66 inventory plots with MODIS (Stellmes et al., 2013) and Landsat images. Mean fire frequency was 2.2 fires in a plot over 15 years, or 15% for Hamoye and 17% for Ncaute. There was no significant relationship between fire frequency over a period of 15 years and basal area of three DBH classes in the plots. The basal area of *Burkea africana* and *Pterocarpus angolensis* did increase significantly with fire frequency in the more open community forest; this may be explained by the lower fire frequencies and higher harvesting intensities found closer to villages.

Impact of multiple fires on tree damage

Tree damage data were extracted from recent forest inventories in 217 sample plots in southern Angola and northern Namibia. Only 28% of the 3,779 stems recorded showed no damage, while 11% were fatally damaged or dead. Fire was the main cause of damage, with 45% of all stems showing fire damage. Fire damage increased slightly but significantly with DBH class (Fig. 2). Some woody species showed relatively more moderate to fatal fire damage (> 60% of stems), especially *Diplorhynchus condylocarpon*, *Dialium englerianum,* and *Strychnos pungens*. Species that appeared most resistant to fire, with less than 30% of the stems having moderate to fatal damage, were *Combretum psioides* and *Terminalia sericea*. The most fire-resistant timber species appeared to be *Pterocarpus angolensis* (Fig. 1), and the least resistant was *Guibourtia coleosperma,* with 28% and 53% of stems having moderate to fatal fire damage, respectively.

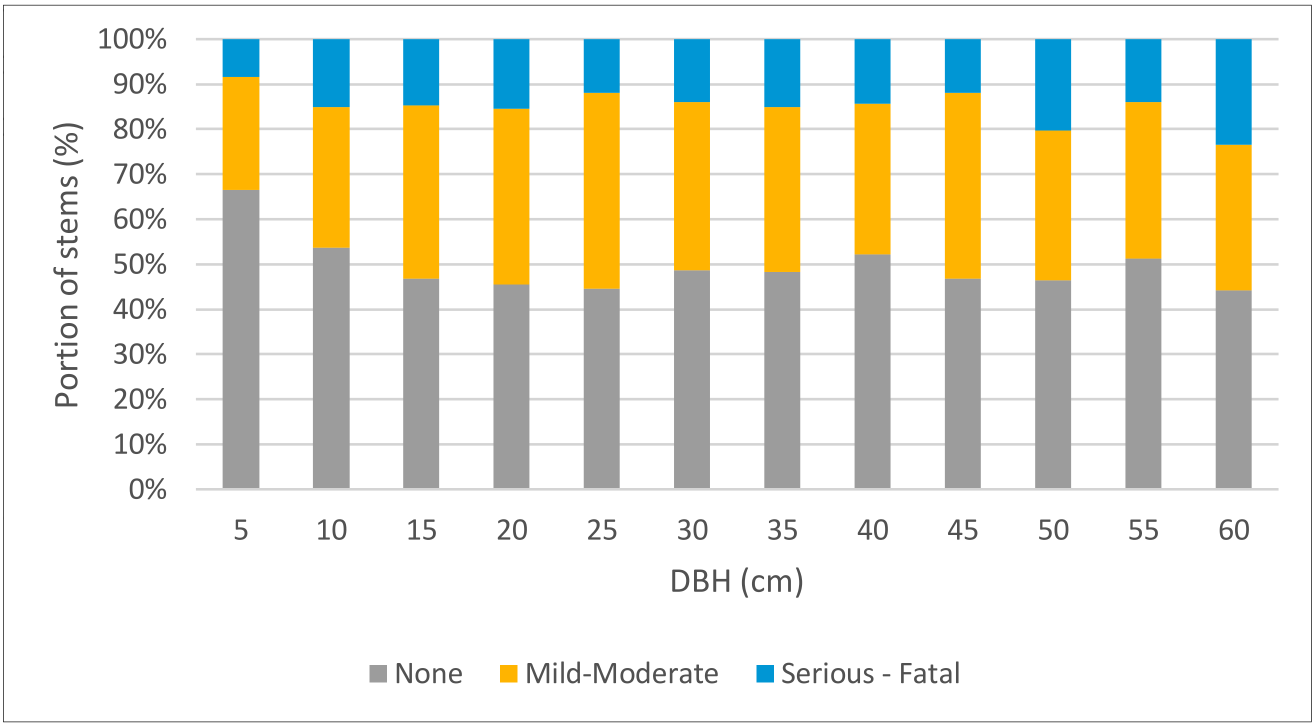

Figure 2: Fire damage per diameter at breast height (DBH) class for 3,648 stems collected in 217 inventory plots with a nested circular design up to 2,827 m² (data with DBH > 60 cm were excluded).

Conclusions

Although a single fire does not have an effect on tree layer composition, the accumulation of damage caused by recurring fires in the late dry season can result in early tree mortality and thus a decrease in wood biomass. Geldenhuys (1977) found that mid- to late dry season fires result in a significantly higher stem mortality compared to early burning or no burning. Studies with fire frequency measured over longer periods than 15 years should, however, be performed to learn more about the impact of fire on biomass and tree population dynamics in the *Baikiaea* woodlands. The effects of fire on tree damage and mortality vary with species, as is also the case for tree regeneration (Geldenhuys, 1977), thereby altering tree composition. A limitation of fire frequency and intensity is needed to protect certain socio-economically important species such as *Dialium englerianum* and *Guibourtia coleosperma*. Preventive management such as the reduction of the fuel load through grazing in the late growing season and early burning can reduce fire intensity and hence tree damage (Gambiza et al., 2008).

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References

Aldersley, A., Murray, S.J. & Cornell, S.E. (2011) Global and regional analysis of climate and human drivers of wildfire. *Science of the Total Environment*, **409**, 3472–3481.

Archibald, S., Roy, D.P., Wilgen, V., Brian, W. & Scholes, R.J. (2008) What limits fire? An examination of drivers of burnt area in Southern Africa. *Global Change Biology*, **15**, 613–630.

Bond, W. & Zaloumis, N.P. (2016) The deforestation story: testing for anthropogenic origins of Africa's flammable grassy biomes. *Philosophical Transactions of The Royal Society B Biological Sciences*, **371**, 20150170.

Chidumayo, E.N. (2013) Forest degradation and recovery in a miombo woodland landscape in Zambia: 22 years of observations on permanent sample plots. *Forest Ecology and Management*, **291**, 154–161.

De Cauwer, V., Geldenhuys, C.J., Aerts, R., Kabajani, M. & Muys, B. (2016) Patterns of forest composition and their long term environmental drivers in the tropical dry forest transition zone of southern Africa. *Forest Ecosystems*, **3**, 23.

Enright, N.J., Fontaine, J.B., Bowman, D.M., Bradstock, R.A. & Williams, R.J. (2015) Interval squeeze: altered fire regimes and demographic responses interact to threaten woody species persistence as climate changes. *Frontiers in Ecology and the Environment*, **13**, 265–272.

Gambiza, J., Campbell, B.M., Moe, S.R. & Frost, P.G. (2005) Fire behaviour in a semi-arid *Baikiaea plurijuga* savanna woodland on Kalahari sands in western Zimbabwe: research letter. *South African Journal of Science*, **101**, 239–244.

Gambiza, J., Campbell, B.M., Moe, S. & Mapaure, I. (2008) Season of grazing and stocking rate interactively affect fuel loads in Baikiaea plurijuga Harms woodland in northwestern Zimbabwe. *African Journal of Ecology*, **46**, 637–645.

Geldenhuys, C.J. (1977) The effect of different regimes of annual burning on two woodland communities in Kavango. *South African Forestry Journal*, 32–42.

Pausas, J.G. & Ribeiro, E. (2013) The global fire–productivity relationship. *Global Ecology and Biogeography*, **22**, 728–736.

Pricope, N.G. & Binford, M.W. (2012) A spatio-temporal analysis of fire recurrence and extent for semi-arid savanna ecosystems in southern Africa using moderate-resolution satellite imagery. *Journal of Environmental Management*, **100**, 72–85.

Schelstraete, M. (2016) Assessment of fire damage on the forest population near Hamoye, Kavango, Namibia.

Stellmes, M., Frantz, D., Finckh, M. & Revermann, R. (2013) Fire frequency, fire seasonality and fire intensity within the Okavango region derived from MODIS fire products. *Biodiversity and Ecology*, **5**, 351.

References [CrossRef]

Aldersley, A., Murray, S.J. & Cornell, S.E. (2011) Global and regional analysis of climate and human drivers of wildfire. *Science of the Total Environment*, **409**, 3472–3481. CrossRef

Archibald, S., Roy, D.P., Wilgen, V., Brian, W. & Scholes, R.J. (2008) What limits fire? An examination of drivers of burnt area in Southern Africa. *Global Change Biology*, **15**, 613–630. CrossRef

Bond, W. & Zaloumis, N.P. (2016) The deforestation story: testing for anthropogenic origins of Africa's flammable grassy biomes. *Philosophical Transactions of The Royal Society B Biological Sciences*, **371**, 20150170. CrossRef

Chidumayo, E.N. (2013) Forest degradation and recovery in a miombo woodland landscape in Zambia: 22 years of observations on permanent sample plots. *Forest Ecology and Management*, **291**, 154–161. CrossRef

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Gambiza, J., Campbell, B.M., Moe, S.R. & Frost, P.G. (2005) Fire behaviour in a semi-arid *Baikiaea plurijuga* savanna woodland on Kalahari sands in western Zimbabwe: research letter. *South African Journal of Science*, **101**, 239–244.

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