A big thanks to everyone involved in all the ANPC's activities for the year, your efforts are greatly appreciated. 2024 looks like being another busy year with our next ANPC conference in Queensland. I would just like to say I have enjoyed my 4 years as President and look forward to watching the ANPC continue to play an effective role in plant conservation in the years to come.

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Reconciling fire behaviour science and forest ecology

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As of 2020, changes to fire regimes, in particular increases in frequency, were a factor in the threatened status of more than 800 Australian species and 65 ecological communities (DAWE 2022). Although climate change is likely the dominant driver of these changes, human disturbance has amplified these effects. Here, I summarise a recent body of work demonstrating the ways that human disturbance-based management disrupts the 'ecological controls' on fire that enabled fire-sensitive species to thrive prior to British colonisation of Australia.

The legacy of poor science

Fire management in Australia is premised on the notion that the flammability of a woody ecosystem is determined by the fuel load, meaning the mass of fuel available to burn. Fuel is anything that burns in the fire. In some fires this is just the leaf litter on the ground, but in a crown fire it is all the fine material to the top of the tree canopy. Both types of fire could happen in the same place under different conditions, so there is no single, objective value that represents the actual fuel load. Consequently, the term 'biomass' is often used (Zylstra *et al*. 2022), but if biomass drives the bushfire hazard, then biomass is a threat to human welfare. Fuel reduction therefore implies biomass reduction; the reduction of terrestrial carbon storage. This provides the basis for an adversarial stance toward natural ecosystems, in which non-human life is classed as a hazard. The outcome is that fire management is seen as a 'balance' between the competing needs of the environment on one hand, and human welfare on the other.

The theory that bushfire risk can be reduced by fuel reduction has been supported by studies showing that some measure of risk is lowest immediately after fire, then increases to a dangerous level in following years. A recent review, however, found that studies which continue to examine risk after this period of initial increase have found that almost universally, risk later decreases (Lindenmayer and Zylstra 2023). This later decrease indicates that the period of increased fire risk was a *result* of burning, that disturbing forests and woodlands in this way drives a pulse of 'disturbance-stimulated flammability'. This occurs because nearly all forests exert 'ecological controls' on fire, in which natural processes of growth and succession cause older forests to be far less flammable than disturbed forests.

Ecological control theory

Ecological control theory (Zylstra *et al.* 2022, 2023; Lindenmayer and Zylstra 2023) operates through the four primary mechanisms of plant growth, self-pruning, leaf trait changes, and understorey self-thinning. Foliage higher up is less likely to ignite and instead will hinder fire by slowing windspeeds closer to the ground by acting as a buffer (overstorey shelter, Zylstra *et al.* 2016). As plants grow in height then, many eventually reach a height where they are too tall to ignite. The development of taller plants has flow-on effects that further decrease flammability.

As leaf area increases, many plants self-prune their lower, shaded branches so that the base of the canopy is further separated from lower plants. Larger plants can compete for light, water and nutrients more effectively via larger root systems and light exposure, so as the biomass of larger plants increases, either the biomass of smaller plants decreases, or succession alters the species composition of lower plants.

Lower plant biomass commonly increases at first as plants grow, but self-thinning of the understoreys causes them to become more open in older forests. There are numerous mechanisms that drive this, but self-thinning understoreys are well-documented across Australian forests (Lindenmayer and Zylstra 2023). Plant crowns also individually decrease in biomass, so that many species lose the leaves in the heart of their crowns (Pearcy *et al.* 2005), again reducing the amount of foliage available to burn. Leaf trait changes can occur within a species as leaves become thinner and sparser (Niinemets 2010) in the shade of taller plants, reducing the size and duration of flames from those plants. Alternatively, succession may cause transition toward more mesic species with much higher moisture content. This makes them harder to ignite, and less efficient to burn.

These changes are termed *ecological controls*, because they are ecological changes that limit the spread and severity of fire in the landscape. As a forest or woodland matures, the transition of biomass from low plants (close to the ground where they can feed the fire) into tall plants (that can slow the fire) means that flames become smaller and slower, large crown fire runs become rarer and the total burnt area from an ignition decreases. In wetter environments such as the east coast of Australia, the greater foliage biomass increases evapotranspiration, creating a cooler, moister microclimate that traps moisture in leaf litter and prevents fires from occurring more often.

Ecological Control Theory resolves a conceptual dilemma that arises from Fuel Load Theory. If, without human intervention, fuel loads accumulate to levels where catastrophic wildfires are likely under most conditions, how did fire sensitive species thrive in the millions of years prior to human arrival? Ecological control theory resolves this because the persistence of such species becomes far more likely if forest flammability is internally regulated.

Disturbance stimulated flammability

The corollary of this is that disturbance can disrupt ecological controls and stimulate an extended period of heightened flammability until the ecosystem recovers. Specht and Morgan (1981) summarised the trend as 'disturbance (gaps, microhabitats, fire, overgrazing, invasion of woody weeds etc.) may reduce the overstorey cover which will be compensated by an increase in understorey cover.' Disturbances such as logging and burning therefore remove tall, later-successional plants which act as overstorey shelter (calming the fire), and replace them with short, early successional plants which act as fuel (feeding the fire).

This is illustrated in Figs. 1 and 2. In January 2020, a lightning strike ignited 60-year-old regrowth in Illawarra Southern Escarpment Wet Forest. This could have been disastrous as it occurred at the peak of the unprecedented 2019-20 'Black Summer', but instead, the fire self-extinguished and remained unknown to fire agencies (Fig. 1). Examination of the burnt patch revealed that flames had been very low, but had still scorched taller midstorey plants acting as overstorey shelter. Three years later, the loss of this overstorey shelter coupled with the dense growth of *Croton verreauxii* and grass stimulated by the fire has resulted in a forest where a fire will now burn severely even in milder conditions (Fig. 2).

Cooperation with country

By reconciling fire behaviour science with forest ecology, ecological control theory provides an alternative paradigm where human safety is not at odds with biodiversity conservation and carbon storage. If forest and woodland ecosystems naturally limit wildfire in the landscape, then human interaction with forests should cooperate with these processes rather than disrupt them.

Figs. 1 and 2 exemplify this. NSW fire authorities now utilise Ignition Management Zones (IMZs) 'to minimise the propagation of ignitions and limit the rapid escalation of fires' (NSW Department of Planning and Environment 2022). A cooperative approach recognises that the undisturbed forest is far more effective at containing ignitions, so the best management for the area as an IMZ is to maintain the mature forest.

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Figure 1. Scorched forest (left-hand side) from a lightning strike in wet sclerophyll forest in January 2020, which self-extinguished, leaving the right hand side unburnt.

Figure 2. Three years after the fire, dense *Croton verreauxii* with a surface layer of grasses covered the entire burn area.