Natural fires & plant invaders *what is the link?*

Brian van Wilgen explains the link between invasive alien plants and ecosystems where fire is a natural feature.

Fires are a natural feature of many of South Africa's ecosystems, and they occur regularly in the dry season in fynbos shrublands, grasslands and savannas across the country. Plant species that occur naturally in fire-prone ecosystems are adapted to survive fires, either by re-sprouting after fire, or by germinating from seeds that survive the fire. Not only are plants adapted to survive fires, they also often require fires to complete their life cycles, or to remove competition from other plants. In other words, the vegetation is not only fire-adapted, it is often fire-dependent. Examples of fire-adapted species include proteas in fynbos that age and die without fire, and many other fynbos plant species whose seeds are stimulated to germinate by smoke from fires. In savannas, the balance between grasses and trees is maintained by fire, and it has been clearly demonstrated that exclusion of fires for long periods leads to the elimination of grass and dominance by trees and shrubs – so-called 'bush encroachment'. Managers of natural ecosystems and rangelands therefore recognise the vital role played by fires, and they use fire to maintain these ecosystems.

How fires start

For a fire to start, three conditions must occur together – there must be (i) sufficient fuel in a continuous fuel bed to allow fires to spread, (ii) warm, dry weather, and (iii) a source of ignition. In savannas, grasslands and fynbos, a mixture of dead and live plant material (fuel) that will support a spreading fire normally develops quite quickly. Such vegetation does not normally burn in the wet season (as plants are green and the vegetation is moist), but in the dry season all that is needed is a source of ignition, and big fires can occur. In the days before human populations reached their present high levels, fires were started by lightning. Nowadays, however, most fires are started by humans, either accidentally or deliberately. Fire managers have simultaneously to achieve two goals. First, they have to ensure the safety of people during veldfires, and to protect property and assets at risk from fires. Secondly, they need to ensure that fires continue to play their vital role in maintaining healthy and productive ecosystems, and trading off the needs of ecosystems with the imperative for safety is one of the biggest challenges to fire management.

Pine trees grow to a much larger size than the fynbos shrubs that they replace, increasing fuel loads and the intensity of fires, leading to damaging fires of unnaturally high intensity. Image: Brian van Wilgen

What is the influence of invasive alien plants?

Invasive alien plants obviously don't affect either the weather or the frequency and distribution of ignitions, but they often drastically change the structure of the vegetation, changing both the amount and the type of fuel available to support fires. As a result, they can introduce fires into areas where fires did not occur historically, and by increasing the mass of plant material in fire-prone ecosystems, they can make fires more intense. For example, the invasion of fynbos shrublands by alien pines (*Pinus* species) and hakeas (*Hakea* species) can substantially increase the above-ground plant mass, increasing the amount of fuel available to burn, and make fires more intense and more difficult to control.

The greater intensity of the fire also damages the soil. While soils are not negatively affected by fires in un-invaded fynbos, the higher fire intensity on invaded areas leads to the development of water-repellent layers in the soil. This in turn leads to severe erosion during the following rainy season, degrading catchment areas and leading to flood damage. Houses that are situated next to invaded fynbos are at higher risk of destruction during wildfires, because of the increases in fire intensity associated with higher fuel loads.

In the arid karoo shrublands, which hardly ever burn because there is too little fuel, invasion by an alien perennial grass could change the vegetation sufficiently to allow fires to burn. Experimental studies have shown that, should this happen, very few of the karoo shrubs would be able to survive, and this would ultimately affect the core natural resources that support the karoo economy.

Invasive alien plants and fire management

Invasive alien plants also complicate fire management because, like the plants in the ecosystems they invade, they too are often fire-adapted (see Box 1). Invasive alien plants also have a competitive advantage over native plant species, because they typically are not accompanied by the host of pathogens and insect enemies that help to keep them in check in their home ranges. This means that fires will simply result in the further spread of some invasive alien plants, if the invasive plants themselves are not felled prior to burning.

Invasion of many ecosystems by fire-adapted alien trees and shrubs is an enormous threat to the conservation of these ecosystems. An example is provided by invasive Australian wattles that produce an abundance of seeds that accumulate in the soil. These seeds are stimulated to germinate en masse by fires in fynbos, grassland and savannas, which means that burning can dramatically increase the number of plants. Felling followed by burning can be used to deplete soil-stored seed banks, but is not effective over large areas because repeated and intensive follow-up weeding of new seedlings is needed.

The introduction of alien grasses into fire-free karoo shrublands can result in fires which damage the fire-sensitive plants, ultimately reducing the livestock carrying capacity of these farmlands. Image: Brian van Wilgen

There may be some good news, however, as the introduction of biological control to reduce the seed output of Australian wattles may be changing this picture. The introduction of a suite of seed-feeding weevils and gall-forming flies and wasps (which prevent seed production by inducing the formation of galls instead of seed pods), has significantly reduced the seed output of many Australian wattle species. This in turn has increased the prospects for effective control by combining mechanical felling, fire and seed reduction.

Fires to manage invasive alien plants

Fires can also be used to assist the management of alien plants in some cases. For example, triffid weed (*Chromolaena odorata*) invades many of the savanna parks in northern KwaZulu-Natal, and it is a priority species for control. Clearing this species manually can be expensive, but high-intensity fires, if we are able to apply them safely, can clear these plants very effectively. The follow-up operations to remove regrowth are much less expensive, so large areas can be cleared effectively by combining fire and follow-up weeding. This has been demonstrated in the Phinda reserve near Mkhuze. In this area, fire scientists are conducting trials that involve aerial ignition of fires from helicopters. These trials have shown that spiral ignition patterns can produce relatively intense fires under safe burning conditions, and the practice holds much promise for improving effective control of triffid weed.

In conclusion

Fires are both inevitable and necessary in many of our ecosystems, but fires and invasive alien plants interact in many and complex ways that can substantially increase the difficulty of managing fires. Invasive alien plants make the fire control problem worse, and they aggravate the effects of what would otherwise be an ecologically beneficial process. Because invasive alien plants are spread by fires, fire also increases their impacts on water resources, rangeland productivity, and biodiversity in fire-prone fynbos, grasslands and savannas. It is thus important to increase attempts to remove invasive alien plants from fire-prone ecosystems, as well as to prevent their introduction and spread in areas that are currently not invaded. **Q**

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Aftermath of an intense fire in an area invaded by triffid weed in Phinda reserve, northern KwaZulu-Natal. The weeds have effectively been cleared, and the area has been opened up to a degree that will facilitate follow-up weeding. Image: Brian van Wilgen

Fire and invasive pines

Pine stands adjacent to fynbos seen after the recent fires in Noordhoek, Western Cape. Image: Bridget Farham

Mountain slopes near Stellenbosch, showing the effects of fire in an area that was invaded by alien pine trees. The imprints of burnt logs can be clearly seen, and will lead to soil damage and erosion in the rainy season. Image: Brian van Wilgen

The pine trees and hakea shrubs that invade fynbos shrublands are killed by fires and spread over considerable distances by means of winged seeds that germinate in the post-fire environment. Control is possible through pre-fire felling (after which seeds are released) and burning after 1 – 2 years (which kills any resultant seedlings before they can mature). The control is effective, but because of the difficulties in reaching invasions in remote and rugged terrain, progress with mechanical clearing of these trees and shrubs has been limited. In the case of hakeas, biological control in the form of a seed-feeding weevil and a seed-feeding moth has been in place for several decades, and this has led to some progress in their control. No biological control agents are currently available for pines, however, due to concerns about the impact they may have on the forest industry (potential seed-attacking insects may spread diseases such as pitch canker). Finding a sustainable solution to the fire-driven pine invasion problem is possibly the most important challenge facing managers of fynbos ecosystems.