LIFE AFTER DEATH IN FYNBOS

The story of fire and seeds.

by ***Penny Mustart***

Since the fire on Table Mountain this summer, the topic of 'devastation to the fynbos' is frequently brought up. What happens to fynbos after fire? Other regions with Mediterranean climates - rain in winter and hot, dry summers - are also prone to fires when the vegetation is tinder-box dry. California, Western Australia and the Mediterranean basin all have recurrent, vicious fires in their summer months. In the Western Cape area fires have occurred since the inception of the Mediterranean climate five million years ago, with an increase in frequency over the last one million years. They are started by lightning, rock falls, and of course by humans. There is evidence of human hearths 10 000 to 100 000 years ago, and it is likely that hunter/gatherers burnt small areas of veld to attract small game to the new flush of growth. Undoubtedly man has led to a dramatic increase in the frequency of fire - we are all too familiar with the results of careless fire-making today.

Fynbos has evolved as a distinct vegetation type over the last five million years. It evolved in response to several environmental factors such as summer drought, nutrient poverty of the soil and in particular to fire: there was strong natural selection for plants that had successful fire-survival strategies. Plants that could not survive recurrent fires quickly became extinct. Thus today we have our valued and unique fynbos: rich with species that have an intriguing variety of fire survival strategies. What are these?

First, there is the '**sprouting**' strategy whereby plants have insulating mechanisms that enable them to survive fire. Many fynbos species have sturdy, fire-resistant rootstocks. In this group are Proteaceae species such as *Leucadendron salignum* (common sunshine cone bush) and *Protea cynaroides* (king protea), many Restionaceae (reeds) and Cyperaceae (sedges) as well as a host of plants in several other fynbos families. A slightly different strategy is found in *Protea nitida* (wagon tree) which has thick bark that insulates buds in the stem from fire damage. Sprouting plants soon grow fresh shoots from their undamaged roots or stems, thus giving the veld its greenness in the early months after fire. Plants with underground bulbs or tubers also survive fires. These geophytes (earth plants) flower profusely after fire, often providing wonderful displays. Flowers of bulbous plants are not so evident in later years.

However, many fynbos plants do not survive fire – the adult plants die. Such fynbos species rely on their seeds - the next generation - to continue the line. Plants with this '**seeding**' strategy form a fascinating group, comprising a variety of schemes that have evolved to ensure that seeds are not consumed in the fire, and also to link their germination to the wet winter season after fire. There are several ways in which seeding fynbos species accumulate seeds between fires. One strategy is to store the seeds in sturdy, fire-resistant cones or cone-like structures. Each year's crop of cones (and their seed) is retained on the plant, resulting in a plant 'banking' up several years of successive seed crops. Such stores of seed can be quite large. A mature *Leucadendron coniferum* (dune conebush) accumulates up to 20 000 seeds! This strategy is called 'serotiny' and is found in all *Protea* species, many *Leucadendron* species, and a few *Erica* and Bruniaceae species. In addition to fire-protection, the nutrient-packed seeds are out of reach of foraging mice. During a fire these serotinous plants die. The cones dry out, open up

Erica daphniflora **in the Cederberg, two years after fire. New stems have sprouted from fire-resistant rootstock.**

and their seeds fall onto a bed of ash-enriched soil. These seeds germinate when temperatures at night drop below 10 °C - perfectly cued to the wet winter season. However, a drawback of this strategy is that seeds lie exposed on the barren, post-fire landscape, presenting a nutritious meal for small, hungry mammals. Clearly the shorter the period of exposure before the winter germination period, the more seeds survive. Hence a fire in the late summer to early autumn period leads to greater numbers of surviving seedlings than a fire in spring. In the latter case seeds will have to endure the long, hot summer months before germination during the next winter.

Many seeding fynbos species do not accumulate seed banks in cones; instead ripe seeds are released each year during autumn. This category includes a wide diversity of fynbos species that have developed an extraordinary collaboration with ants. This strategy is found in Proteaceae (for example, all *Leucospermum* or pincushions) and many Cyperaceae, Restionaceae and Rutaceae (buchu) species. Seeds of these 'myrmecochorous' species have a fleshy appendage or an oily covering (an elaiosome) which attracts ants that drag the seeds down to their underground nests. Here they eat the elaiosome and leave the seeds buried, safely cached away from granivores and insulated from the fire's heat - waiting for the conditions that will stimulate germination. It is not surprising to find that these seeds are cued to germinate only after fire. The fire's heat begins the process by cracking the thick seed coat thus allowing water to enter. Actual germination occurs in winter when the altered temperatures of the fire-cleared soil provide the cue. In effect, the soil surface now lacks the insulating and shading effect that the vegetation cover had provided, and at night it becomes colder and during the day it gets hotter than before the fire. These enhanced temperature oscillations are the cue for germination. It has been further observed that the scale of germination of myrmecochorous species is influenced by the intensity of fire. For example a hot, intensely burning fire in summer favours the germination of these seeds.

On the other hand, seeding species that are not myrmecochorous do not fare so well during hot fires. In particular this applies to species of Asteraceae that produce small seeds. After release from the parent plant, these seeds are gradually covered by a shallow layer of litter and soil. Clearly these seeds are not well insulated from hot fire and are easily killed. However, they survive cooler, less intense fires, such as those occurring in winter. Such seeds are cued to germinate by a variety of fire-linked factors: by heat, by smoke or by altered day-night temperatures in the soil, as described above.

Yet another strategy is used by legumes (for example *Aspalathus* species). These rapidly growing plants die off a few years after fire, leaving behind tough, nut-like seeds stored in the soil. Requiring a future fire's heat to germinate, they often wait for many years before emerging as seedlings.

In summary, germination of seeds of many fynbos species is linked directly (heat, smoke) and indirectly (soil effects created through vegetation clearing) to fire. In this way a new generation of plants is established in soil that has been enriched with plant ash, and in an environment that is free of competing adult plants.

The reliance of so many fynbos species on their seeds to survive brings up an important issue. On average, fynbos areas burn at intervals of about twelve to fifteen years. This interval is long enough for most species to reach reproductive maturity in order to establish adequate seed stores before the next fire. However if fires are too frequent,

***Watsonia vanderspuyiae*, a Cederberg geophyte with underground corms that survive fire. Flowering is stimulated by fire.**

Understanding the behaviour of fynbos plants and their seeds helps us to understand how fynbos will recover after fire. No two fires are alike. They differ in size, intensity, time since previous fire, and season of burn. Thus the abundance and mix of species after each fire will vary accordingly. Fire has played a major role in creating the astounding number of species in fynbos. Appropriate fire management is important in maintaining this diversity. But that is another story.

Top. **A crowd of newly emerged *Protea susannae* seedlings in winter, three months after fire.**
Above. **Cone of fire-killed *Protea susannae* on the Agulhas Plain. Only a few seeds remain – most fell to the ground, awaiting winter rains.**

occurring at shorter intervals than above, then plants may not accumulate enough seeds between fires. Further, if fires have burnt large areas, there is small chance of seeds from neighbouring, unburned regions helping out, since most fynbos seeds are not dispersed long-range. Consequently there will be few seedlings to replace the fire-killed adult plants. In this manner slow-maturing species become locally extinct. An extreme example of this is *Widdringtonia cedarbergensis* (Clanwilliam cedar), one of the few tree species growing in fynbos. Requiring about twenty years before producing enough seeds, it is under threat of extinction due to the high frequency of fire that currently prevails. The large fire on Table Mountain this summer occurred in areas that had previously burnt only one to three years ago. This poses a threat to many seeding species.

At the other end of the scale, if fire intervals are too long, many fynbos species senesce and decrease their reproductive output. This is especially relevant in high rainfall areas where the vegetation forms dense stands and plants compete for limited nutrients in the soil. Thus fire is needed to 'rejuvenate' the fynbos: nutrients locked up in ageing plants are released back to the environment and a new generation of seedlings begins another cycle.

About the author
Penny Mustart is an ecologist who did her Ph.D. on seed ecology of Agulhas Proteaceae. She is currently involved in a programme to restore the threatened Cederberg endemic cedar, *Widdringtonia cedarbergensis*, by planting out nursery-grown seedlings into its native habitat. Penny is also a member of the *Veld & Flora* editorial committee.