GEF FYNBOSFIRE PROJECT

INFORMATION MANAGEMENT, FIRE RESEARCH & MODELLING AND FIRE RISK ASSESSMENT COMPONENT

Cost-effectiveness of different fuel management measures in the Wildland-urban Interface

May 2016

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CONTENTS

TABLES

FIGURES

1 BRIEF

Work under this output is focused on evaluating the effectiveness of a range of fuel treatments in facilitating more effective fire suppression in the wildland-urban interface (WUI) in the Fynbos Biome. Fuel management measures to be assessed in this output may include: firebreak preparation and maintenance; removal of standing biomass following clearing of invasive alien plants; removal of flammable materials around properties; and prescribed burning. The potential ecological, social and economic impact of these measures will be assessed, and the mechanisms to mitigate these impacts to ensure that the benefits outweigh the potential risks will be described. On the basis of the assessment of the approaches, costs and impacts of different fuel treatments, a review of good practices and knowledge on fuel management in the wildland-urban interface will be prepared, and disseminated to wildland fire managers.

Deliverables:

- Review current best practices in wildland-urban interface (WUI) fuel management measures in the Fynbos Biome, and collate current information on the approaches, costs and impacts of these measures.
- Recommend operating plans and procedures, taking into account environmental parameters, for fuel reduction in the WUI for inclusion in final project report.

2 INTRODUCTION

2.1 Rationale

Three shrubland vegetation types predominantly make up the vegetation in the Fynbos region (biome): fynbos, renosterveld and strandveld (Esler, Pierce & de Villiers 2014) . Fire is an essential process for maintaining the health and diversity of fynbos and renosterveld also needs fires to regenerate it (Esler *et al.* 2014). While strandveld is unlikely to burn except under exceptionally hot , dry and windy conditions (Rebelo *et al.* 2006), it is able to recover after fires as the dominant shrubs resprout and many of its herbaceous species recover from seeds.

The seasonal occurrence of hot, dry and windy conditions, especially in the western part of the Fynbos Biome, makes wildfires in fynbos inevitable (Van Wilgen & Burgan 1985). However, fynbos plants are well adapted to survive fires through a number of mechanisms, including resprouting after fires, serotiny and fire avoidance (Esler *et al.* 2014). Provided the interval between successive fires is within fynbos' ecologically desirable fire regime (12 to 16 years) fires are beneficial rather than damaging to the ecology (Van Wilgen *et al.* 2010; Kraaij & Wilgen 2014; Le Maitre, Kruger & Forsyth 2014b). Although fires are necessary to rejuvenate fynbos, they pose significant threats to human assets, livelihoods and lives and some fires have done considerable damage. For example, the Cape Peninsula and Simonsberg fires in January 2000 resulted in damaged and destroyed houses to the value of about R10.4 million (insurance claims of R40 million), forest plantation and vineyard and wine production losses of at least R 2.0 million (Kruger *et al.* 2000; Van Wilgen & Scott 2001). The losses caused by this fire led to the establishment of a public-private partnership, funded by private donations and government contributions, known as the Ukuvuka Fire Stop campaign. Its aim was to raise fire-awareness and preparedness, especially in informal settlements, but also in the WUI (Van Wilgen & Scott 2001; Combrink *et al.* 2003; Anonymous 2004). A similar level of losses is expected following the January-February 2016 fires across the Western Cape, and it is clear that something needs to be done to reduce the likelihood of such losses in future.

All landowners, including individual property owners, situated along the WUI need to take steps to protect their assets from wildfires and the National Veld and Forest Fire Act (101 of 1998) places a legal responsibility on them to prevent wildland fires spreading from their properties to adjoining neighbouring properties. The wording and intent of the Act are clear: actions aimed at protecting the WUI have to involve collaboration and planning to ensure that everyone's land and assets are duly protected. This report is aimed at assessing the measures that are currently being undertaken to identify ways of making them more effective. Local experience, and the findings of the numerous studies cited above, demonstrates that the effectiveness of firebreaks lies primarily in their design: how they are oriented relative to the prevailing wind during wildfires and the slope and position in the terrain. The unit costs (e.g. per km) are primarily those of preparation and maintenance, which depend on the method used (e.g. burning, brush-cutting), the width, and the terrain. It is only when the method contributes significantly to whether or not the fire can cross the firebreak, that cost and effectiveness are directly associated, otherwise they are not. However, a proper valuation of their cost effectiveness should also take into consideration the value of the assets that are protected and their vulnerability to ignition, both directly and indirectly via embers (Stockmann *et al.* 2010; Calkin *et al.* 2013). The values typically vary extensively between locations, which necessitates a case-study based approach but this was beyond the scope of this study. Instead we have focused on describing on fires in the WUI and their effects, and recognised best practice in mitigating fire risks (both hazard and consequences) in the WUI.

2.2 Fires and the WUI

Human activities are continually and more widely encroaching along the edge of wildlands where there is enough plant litter, dead branches, and fine plant material to sustain a fire. Fuel accumulation increases the likelihood that fires will become uncharacteristically large and intense (Syphard *et al.* 2009; Stockmann *et al.* 2010). This area where development borders on, and intermingles with, flammable wildlands is known as the wildland-urban interface (WUI) (Theobald & Romme 2007). It is the location where homes and structures are built among forests, shrubs or grasslands (Radeloff *et al.* 2005) (Figure 1), and descriptions of a WUI typically define it in terms of the presence of humans in the proximity of flammable vegetation (Herrero-Corral *et al.* 2012).

It is along this edge where people and their assets are particularly exposed to death or injury and damage from wildland fires. Gill *et al.* (2013) define assets as something we value and they can be social, economic and environmental in nature. Social assets include human lives, houses, schools and power lines, while environmental assets could include wetlands or biodiversity. The WUI is where most human fatalities, home losses and fire-suppression expenditure occur (Moritz *et al.* 2014). Wildfires are increasingly affecting humans and their assets worldwide. As the WUI expands so does the need for increased hazard reduction, but, although people often know there are fire hazards where they live, this does not necessarily mean that they will take actions to increase their safety (Stockmann *et al.* 2010; Calkin *et al.* 2013; Moritz *et al.* 2014).

The Fynbos Biome is no exception, and its WUI is continually expanding as more development, both formal and informal, takes place on the urban fringes of towns and cities. Over many years, wildfires in and around the City of Cape Town have highlighted the problems created by human communities living and making their livelihood on the interface between urban development and natural vegetation (Forsyth & Van Wilgen 2008).

Figure 1: Community exposed to wildland fire risk on the Wildland-urban Interface at Wittedrift near Plettenberg Bay (Greg Forsyth, CSIR)

2.3 International experience in protecting the WUI

Preventing wildfires reaching urban and peri-urban areas is an important goal for fire managers but it is impossible to stop all wildfires in all circumstances. In Mediterranean type ecosystems, fynbos being one of them, there is a belief that managing landscape fuels (e.g. prescribed burning) together with aggressive fire suppression will prevent fires from having impacts on urban areas (Stockmann *et al.* 2010; Keeley *et al.* 2011; Calkin *et al.* 2013). However, this is not the case and wildfires often reach the WUI despite prescribed burning. Managers cannot choose when wildfires come or where they start, they come when high or extreme fire weather conditions prevail and are often accompanied by strong winds. The only way to deal with the inevitable wildfire is to be thoroughly prepared, including reducing fuel loads and the vulnerability of assets in the WUI to such wildfires (Bradstock & Gill 2001; Stockmann *et al.* 2010; Keeley *et al.* 2011).

Many fires that penetrate the WUI do so by means of embers landing on flammable structures and igniting them. Homes and gardens need to be prepared in advance of a fire occurring. An effective response to protecting life and property on the WUI is to increase fuel reduction treatments (Stockmann *et al.* 2010; Gibbons *et al.* 2012). Communities have to develop their own adaptive solutions to living in fire prone landscapes and think strategically about positioning fuel treatments to best advantage (Keeley *et al.* 2011). Urban design and planning systems that take account of the occurrence of fires, and using insurance premiums to influence behaviour also need to be included in any WUI fire management plan (Syphard *et al.* 2013). Land use planning from a wildfire perspective represents an approach that extends beyond preparing communities for an inevitable fire, to preventing new residential buildings from being exposed to fire in the first place.

Fire management decisions are frequently based on achieving a single objective (e.g. protecting houses or timber plantations) and do not take into account the full social, environmental and economic consequences of fire management (Driscoll *et al.* 2015). Management strategies to reduce the risks to human life and property from wildfires often involve burning natural vegetation (Driscoll *et al.* 2015). Gibbons *et al.* (2012) found that prescribed burning was most effective when undertaken close to houses and at least every 5 years while Keeley *et al.* (2011) note that many fire-prone ecosystems have high biodiversity and co-exist alongside dense human settlements. Conflicts can occur between too frequently burning an area to reduce fire risk and long term biodiversity conservation goals. As more encroachment into fire prone ecosystems occurs, especially along the WUI, conflict between fire management objectives is likely to increase.

Decision makers must be satisfied by a management strategy that improves outcomes provided it does not lead to worse outcomes from other objectives (Stockmann *et al.* 2010; Driscoll *et al.* 2015). Cost effectiveness should be assessed not only in terms of preparation costs but also in terms of the human lives and assets that are protected (Ohlson *et al.* 2006; Driscoll *et al.* 2010). However, this is a much more complex decision than it appears as the costs of prevention can exceed the value of the assets protected (Penman *et al.* 2011; Penman, Bradstock & Price 2014). Many of these complexities are due to the fact that the costs and benefits are highly context specific, depending on factors ranging from the defensibility of the human lives and assets, to the building design and materials (Stephens *et al.* 2009; Penman *et al.* 2011; Gibbons *et al.* 2012) and the landscape setting relative to wind and topographic effects on the pattern of wildfire spread.

An Australian study examined a range of fuel reduction scenarios and found that reducing trees and shrubs from 90% to 5% cover within 40 metres of houses had the potential to reduce house losses by an average of 43%, making this the single most effective fuel treatment (Gibbons *et al.* 2012). The authors argue that modifying key fuels could substantially reduce house loss and save lives of people sheltering in houses during wildfires. This is realised through the creation of defensible spaces where the chance of successful fire suppression is increased.

In most weather conditions firebreaks (fuel breaks) are not effective as barriers on their own (Cheney 1996 in Keeley *et al.* 2011). Nevertheless they have value for facilitating access to areas of defensible space that can be utilised for fire suppression activities including back burning. Creating a mosaic of different aged vegetation is often cited as a way of limiting the extent of wildfires and protecting the WUI, but Keeley *et al.* (2011) noted that in chaparral landscapes the mosaic model fails where areas are prone to severe fire weather conditions, and where fires can spread through young stands of reduced fuels or spot long distances from the fire front.

Experience from California, Australia and elsewhere indicates that achieving a mosaic of differing age vegetation through the application of a prescribed burning programme is extremely difficult (Van Wilgen *et al.* 2010; van Wilgen 2013). Even if it could be done in practice, the protection offered to the WUI would be limited. Combining strategically positioned, well-maintained firebreaks with fuel reduction measures in the vicinity of houses to create defensible spaces, will be more effective in reducing the vulnerability of assets to wildfires on the WUI (Stockmann *et al.* 2010; Gibbons *et al.* 2012).

2.4 What do we mean by effectiveness?

We need to ensure that the measures taken to reduce the wildfire risk result in a situation where it is easier or possible to suppress a wildfire, and where the risk of damaging the veld ecologically or losing property, livelihoods and human life is substantially reduced (Van Wilgen & Scott 2001). However, we need to be practical about this and therefore our mitigation measures need to be cost effective. There should be a relationship between the cost of fire prevention and the value of the assets being protected (Stockmann *et al.* 2010; Penman *et al.* 2011). In the case of the Cape Peninsula the cost of maintaining the circum-Peninsula firebreak network is insignificant compared to the value of the assets being protected on the WUI (Philip Prins pers. comm. 2016). However, the value of these assets generally is not reflected in the budgets allocated for their protection, a disjunction that needs to be addressed.

Two measures commonly applied in the Fynbos Biome and aimed at reducing fuel loads and thereby wildfire risks are the preparation of firebreaks and the application of prescribed or block burning (van Wilgen, Bond & Richardson 1992; Van Wilgen & Scott 2001). However, prescribed burns are not only applied to reduce fuel loads but also to rejuvenate moribund vegetation and as part of invasive alien plant control operations. When applied strategically, they can be effective in reducing fuel loads but will never eliminate the risk of a wildfire entirely (Bradstock & Gill 2001; Keeley *et al.* 2011). They are also expensive and risky so they can only be safely applied to relatively small areas and their use needs to be carefully optimised, taking both the hazard and the vegetation ecology into account (Bradstock *et al.* 1998; Bradstock 2008; Keeley *et al.* 2011)

In considering effectiveness we need to ask the question whether these measures indeed achieve what they are designed to do. For example the main function of a firebreak is to provide an area where the fuel load is lower than the surrounding veld. This assists fire suppression in that it provides access for fire fighters, enabling them to get into position to fight a fire either through direct attack or indirectly through the practise of setting counter fires. But, to be effective, firebreaks need to be correctly positioned in the landscape, their width needs to be adequate (the width needs to take into consideration the height of adjacent vegetation) and they need to be well maintained (not overgrown), especially before and during a fire season.

Even if all these preparations are done, experience shows that under adverse windy, dry and hot weather conditions even wide firebreaks of 300 metre will not guarantee that fire will not burn or "spot" across it. Similarly in the case of prescribed burns recovering fynbos vegetation as young as 6 years can sustain a wildfire under adverse weather conditions (e.g. Jonkershoek, March 2015 fire)

3 APPROACH

3.1 Information gathering

Fire Protection Associations (FPAs) as described in Chapter 2 of the National Veld and Forest Fire Act (No. 101 of 1998) have an important role to play in managing wildland fire in South Africa. However, FPAs have limited resources and are not meant to replace municipal fire brigades which have specific mandates for dealing with fires in urban areas and around built infrastructure. Co-operation and collaboration between FPAs and municipal fire brigades is needed for effective fire risk management in the WUI.

Members of FPAs collectively have the knowledge and practical experience of managing wildland fires in the areas where they operate. In the Fynbos Biome the Cape Peninsula, Greater Cederberg, Greater Overberg, Southern Cape and Winelands Fire Protection Associations are well established and collectively cover a large proportion of the Fynbos Biome.

We held unstructured interviews with staff and members from a selection of these FPAs to understand what fuel reduction activities their FPAs are applying. We also obtained any documented information the FPAs had on fuel reduction related activities or measures (Table 1).

Table 1: Types and sources of information obtained and examined.

Type	Source	Notes
EASTFORD Fire Management Unit -STRATEGIC FIRE MANAGEMENT PLAN 2015/2016	Southern Cape Fire Protection Association	
Firebreak Guidelines	Southern Cape Fire Protection Association	
'Firescaping your garden' pamphlet	www.firewisesa.org.za	
GUIDELINES FOR FYNBOS AND STACK BURNING	Cape Peninsula FPA	
Things to take into consideration when planning and executing a prescribed burn	City of Cape Town – Biodiversity Management Branch	Edited by Dalton Gibbs
PRESCRIBE AND CONTROL BURNING STANDARD OPERATION PROCEDURES FOR THE GCFPA	Greater Cederberg FPA – May 2013	Jurie van Zyl, André De Witt, Charl Du Plessis, David Cleophas, and Wimpie van der Merwe
Firebreak inventory Report: Section North (2015-16 Fire Season)	Table Mountain National Park – October 2015	

Type	Source	Notes
Firebreak inventory Report: Section Central (2015-16 Fire Season)	Table Mountain National Park – October 2015	
Firebreak inventory Report: Section South (2015-16 Fire Season)	Table Mountain National Park – October 2015	
Firebreak inventory Report: City of Cape Town (2015-16 Fire Season)	Table Mountain National Park – October 2015	
Firebreak inventory Report: Private Firebreaks (2015-16 Fire Season)	Table Mountain National Park – October 2015	

We found that information on what fire managers perceive or understand the cost effectiveness of such measures to be, and how to measure the cost effectiveness, was lacking. There was some information on costs of preparation and maintenance but the issue of cost-effectiveness in terms of the value of the assets protected requires further research.

4 FUEL REDUCTION MEASURES UNDERTAKEN BY FIRE PROTECTION ASSOCIATIONS

The main fuel reduction measures undertaken by Fire Protection Associations (FPAs) can broadly be classified into the following activities:

1) Preparing and maintaining firebreaks;
2) Stack burning to remove felled biomass from the clearing of invasive alien trees;
3) Prescribed burning , often referred to as block burning, for reducing fuel loads in the proximity of for example timber plantations and, more importantly from a biodiversity perspective, to rejuvenate moribund veld;
4) Managing vegetation on vacant land along the WUI; and
5) Encouraging, and possibly providing incentives to, property owners along the WUI to firescape their gardens.

4.1 Firebreaks

Historical legislation relating to fires and their management in South Africa used the term firebelt (e.g. Forest Act, No 72 of 1968; Mountain catchment Areas Act, No 63 of 1970) where a firebelt is defined as a strip of land from which most of the flammable material has been removed before a fire occurs (Teie 2009). However, the more recent legislation, notably the National Veld and Forest Fires Act (NVFF Act), No 101 of 1998, uses the term firebreak. Although the Act does not provide a definition of the term firebreak, it is clear from the usage that the term refers to a constructed or artificial firebreak, which can be used as a line of defence or attack against wildfires, and facilitates the movement of firefighters and equipment.

There are also many natural or man-made features which can serve as firebreaks without being constructed for that purpose as they contain little or no fuel. These include vleis, rivers, cliffs, indigenous forests, roads or cultivated lands. These features are already available in the landscape and can be used at no cost or can be improved at little extra cost. For example, a road verge can be mowed to create a wider more effective fuel break. Unfortunately this can result in unwanted usage (e.g. unauthorised parking).

In this study we have followed the NVFF Act and refer to firebreaks. Unless indicated otherwise, we use the term firebreaks for those constructed and maintained deliberately to reduce fuel loads and act as a defence against fires approaching the WUI or other assets that require protection (Figure 2). We assume that fire managers will also use other natural or man-made features to augment or replace man-made firebreaks where they can serve this purpose.

Figure 2: Firebreak adjacent to Camps Bay (Pierre Gallagher, CPFPA)

○ Why do we need firebreaks?

The purpose of a firebreak will determine what type of construction the firebreak should conform to. The rationale for preparing firebreaks is to:

- Prevent the spread of prescribed or wild fires into or from a specific area and thereby prevent a fire from spreading from potential ignition sources (e.g. road verges);
- Break up continuous, similar-aged, fuel beds into smaller units thereby containing extensive spread;
- Provide access to a fire for firefighters and equipment; and
- Provide a line from where fire may be extinguished either through direct attack or having a relatively safe area to set a back burn (counter fire).

For these reasons firebreaks are often prepared where fynbos is found in the proximity of assets including timber plantations, vineyards and orchards or structures such as sheds and houses (Figure 3). These areas frequently correspond with the WUI. Firebreaks also need to be prepared on the perimeter of any area selected for prescribed burning prior to such areas been burnt. They are also often positioned under powerlines to reduce the heat and smoke generated by the fire and minimise the risks of an electrical shorts and power failures (Figure 4).

Figure 3: Wide firebreak at Kruisfontein plantation near Knysna to reduce fuel load on the Wildland-urban Interface (Braam du Preez, MTO-Cape)

Figure 4: Mowed firebreak running under powerlines in undulating terrain and sandy soils near Gansbaai (Greg Forsyth, CSIR)

○ Legislative requirement

Chapter 4 of the National Veld and Forest Fire Act, 101 of 1968 (NVFF Act) places a duty on landowners to prepare and maintain firebreaks and sets out the conditions for doing so out in Section 12 of the NVFF Act (Appendix 11.1). If the preparation and maintenance of any firebreaks involves burning then Sections 12 (2) to (10) apply. These conditions need to be complied with except if realignment agreements exist or where, for a valid reason, an exemption in terms of Section 15 of the NVFF Act has been granted (Appendix 11.1). Section 16 specifies actions to be taken to minimise negative environmental impacts when constructing and maintaining firebreaks (Appendix 11.1).

○ Firebreak preparation methods

A number of methods are commonly used for preparing firebreaks in South Africa including:

- Ploughing
- Grading
- Herbicide application

- Burning
- Hoeing
- Brush cutting or mowing

Preparing firebreaks by ploughing, grading and the use of herbicides can have negative impacts on the environment. Ploughing and grading disturb the soil while the application of herbicides can lead to the local elimination of indigenous vegetation. In the Fynbos Biome burning, hoeing using hand tools, brush cutting and mowing are considered to be more environmental friendly methods for preparing firebreaks.

The clearing of vegetation to construct a firebreak could therefore in certain instances constitute a listed activity in terms of the National Environmental Management (NEMA) Act, 1998 (Act No. 107 of 1998) Environmental Impact Assessment regulations of 2014. If so this would require written environmental authorisation in terms of NEMA from the relevant competent authority prior to commencement of such an activity. In the Western Cape Province this would be from the provincial Department of Environment Affairs and Development Planning. It is therefore advisable for FPA's, on behalf of their members, to consult with the relevant competent authority, to ensure that all legal requirements are understood and adhered to, before commencing with their firebreak construction and maintenance management plans.

Ploughing and grading would typically be used in flat locations with sandy soils and ploughing and grading can be especially cost effective as one operator can prepare many kilometres of firebreak rapidly. The cost of fuel needs to be covered, but normally the landowner has or can hire the equipment required, such as tractors or graders, so the only additional cost is for fuel. However, there are limited opportunities for this in the Fynbos Biome with its predominantly stony soils on steep slopes.

Herbicide application is expensive and is normally used for tracer belt preparation for the burning of firebreaks in grasslands. This method apparently is not used in the Fynbos Biome other than on alien invasive species growing within the firebreak but could be considered in areas where invasive grasses are dominant so the effects on plant biodiversity would be minimal.

Burning of firebreaks can be cost effective, but using burning to prepare firebreaks, especially in the proximity of residential areas, carries the risk of causing accidental fires. Burning of firebreaks in the Fynbos Biome was more wide spread in the past and it is still used on the borders of timber plantations, but an increasing number of FPAs in the Fynbos Biome are using brush cutting as their preferred method of preparing firebreaks on the WUI. However, it is not cost effective to do this for very wide firebreaks and typically this preparation method is confined to firebreaks of <20 m in width. Another consideration is that there are only a limited number of safe (suitable) days per year for burning (van Wilgen & Richardson 1985; Juhnke & Fuggle 1987; van Wilgen *et al.* 1992). Burnt firebreaks take up much more land than brush cut firebreaks because burnt firebreaks are prepared in parallel strips so that rotational burning is facilitated. Fynbos typically will not burn annually, unlike grasslands, so parallel firebreaks need to be maintained on a two to four year rotation to ensure that one is young enough to limit fire spread. Burning generally requires more labour but for a shorter period, and always carries the risk of igniting or initiating an accidental fire which could prove costly.

Preparing firebreaks by brush cutting or mowing does have the advantage that they can be cleared of vegetation annually before the fire season. They can be prepared in weather conditions that would be unsuitable for burning, and can be cleared of vegetation annually. The treated "sacrificial" area, where the objective is fuel load reduction rather than biodiversity, is also much smaller when a narrow brush cut firebreak is prepared than is the case of a burnt firebreak. In the proximity of the WUI, firebreaks should preferably not be burnt as this carries with it the risk of an accidental fire. However, on hot dry days sparks from brush cutter or chainsaw blades striking rocks can ignite fires. Clearing firebreaks using this machinery should not be allowed when the South Africa Weather Services Fire Danger Index (FDI) forecast for the day is in the orange or red category.

Narrower firebreaks will not easily stop a fire, so early detection and rapid response to contain fires in their initial stages is critical. However when a fire is running out of control on windy days it can easily spot (ember attack) across a 25 metre wide tar road as was the case on the Helshoogte Road six years ago (March 2009). During the wildfire at Muizenberg in March 2015, spotting was noted at approximately 800 metres from the fire front (Pierre Gallagher pers. comm. 2016). Similarly recently in the fynbos there have been instances of 1000s of hectares of six year old veld burning under (not particularly) severe weather conditions as was experienced at Jonkershoek near Stellenbosch during a wildfire in March 2015.

○ Firebreak specifications

The requirements for firebreaks are listed in Chapter 4 Section 13 of the NVFF Act. They are listed in general terms and states that an owner who is obliged to prepare and maintain a firebreak must ensure that, with due regard to the weather, climate, terrain and vegetation of the area —

(a) it is wide enough and long enough to have a reasonable chance of preventing a veldfire from spreading to or from neighbouring land;
(b) it does not cause soil erosion; and
(c) it is reasonably free of inflammable material capable of carrying a veldfire across it.

○ Firebreak construction and alignment

When deciding on the construction and alignment of firebreaks in the landscape a number of factors need be taken into account to ensure that they are effective.

- **Topography**

  Placing of firebreaks on ridges or spurs can be effective as air moving over the ridge reduces the danger of sparks being carried across it, while counter air-flow can facilitate suppression (Teie 2009). Vegetation is generally shorter on ridges, and ridge crests can often be relatively flat in comparison with the flanking slopes. In certain instances rare and endangered species are found along ridges and, where this is the case, the local alignment of the firebreak needs to accommodate this.

- **Slope and aspect**

  Firebreaks should not be constructed on very steep slopes as they could lead to soil erosion and it is difficult for fire fighters to work on very steep slopes. Badly positioned firebreaks could also promote uncontrolled access to areas by people who in turn could be potential sources of ignition. It is best to construct firebreaks along the contour and avoid slopes >20% to avoid soil erosion (Esler *et al.* 2014). Where steep slopes are unavoidable, specific erosion control measures must be implemented and maintained as part of the firebreak management.

- **Vegetation type**

The main differences between vegetation types are in the flammability, particularly the proportions of fine dead or live fuels and the height. For example, renosterveld typically has a relatively high cover of flammable shrubs and grasses but is relatively short, which makes it different from granite fynbos which has a high sedge cover and tall Proteaceae or sandstone fynbos with a high restio cover and tall Proteaceae (Esler *et al.* 2014; Kraaij & Wilgen 2014). Different kinds of fynbos also accumulate fuels at different rates with wetlands or south-facing slopes typically having rapid regrowth and dry north-facing slopes slow regrowth (Kruger 1977; Forsyth, Le Maitre & van Wilgen 2015).

- **Weather patterns**

Firebreaks should be positioned parallel or at an acute angle to the wind direction prevailing during the fire season (Scott, Prinsloo & Le Maitre 2000). Firebreaks located at right angles to the prevailing wind need to be as wide as possible to be effective as burning embers are often carried forward by the wind for some distance ahead of the main fire front, and these can cause spot fires. Typical weather patterns during wildfires and the topography also interact, resulting in fire pathways (characteristic patterns of spread) which must be taken into account in planning wildfire management measures (Geldenhuys 1994, 2011).

- **Environmental considerations**

Care must also be taken in constructing firebreaks so that negative environmental impacts are minimised. These are addressed in Chapter 4, Section 16 of the NVFF Act (Exemption from prohibitions on damaging plants) where it states that, "The right or duty to prepare and maintain a firebreak in terms of this Chapter prevails over any prohibition in any other law on the cutting, disturbance, damage, destruction or removal of any plant or tree, except that the owner must: (a) where possible, transplant any plant which is protected in terms of any law; or (b) where it is safe and feasible, position the firebreak so as to avoid such plant or tree. The Environmental Impact Assessment regulations of 2014 contained in the NEMA Act 107 of 1998 must also be adhered to in this regard. Therefore avoid disturbing or removing rare and endangered species when constructing firebreaks in sensitive habitats such as wetlands but, in doing so, care must be taken that such realignment does not render the firebreak ineffective. A recent problem noted on the Cape Peninsula is that some homeowners living along the WUI are planting shrubs and other plants within firebreaks. In some instances these plant species are flammable and may compromise the integrity of the firebreak. Some of these homeowners have become upset when these plants are removed by contractors or officials during annual maintenance operations (Pierre Gallagher pers. comm., 2016). A list of endemic "firewise" plants suitable for planting in firebreaks should therefore be compiled by the Cape Peninsula FPA (e.g. sour fig *Carpobrotus edulis*).

- **Utilise existing features in the landscape**

  To be cost effective firebreaks should, as far as possible, be integrated with natural features that are less fire prone and form barriers to fire such as indigenous forests, water bodies (e.g. dams and vleis), cultivated land that is unplanted in the fire season, rivers (with a wide stretch of open water) and roads (Figure 5). Roads are often used as firebreaks because they allow easy access for fire fighters and their equipment. Incorporating roads into an existing firebreak network can reduce costs significantly as vegetation in the road verges can be brush cut and removed at little extra cost to create wider more effective firebreaks.

Figure 5: Firebreak adjacent to Hout Bay utilising a road to augment the effectivity. Note the firebreak along the WUI on the opposite side of the bay. (Pierre Gallagher, CPFPA)

- **Avoid visual impacts**

  Firebreaks can also have significant visual impacts on the landscape, especially where they are perpendicular to steep slopes. Such firebreaks could also become sources of unsightly erosion which could be compounded if hikers make use of such firebreaks as footpaths.

- **Increases unwanted access**

  Firebreaks can often facilitate unwanted access that can lead to the development of footpaths in unsuitable situations and threats to security.

- **Failure of firebreaks to address fire hazards**

  Some common reasons for firebreaks being less effective than anticipated include:

  - Too narrow so that fires easily spot or burn across them (Figure 6);
  - Constructed on very steep slopes that hinder fire fighters;
  - Placement at right angles to the wind prevailing during the fire season wind and especially if such firebreaks run up steep slopes;
  - Flammable material is not removed before the start of each fire season;
  - Firebreaks are not regularly inspected to ensure they remain safe throughout the fire season;
  - Do not start and end at safe areas that have none or low fuel loads; and
  - Dumping of garden litter in firebreak by resident on urban edge.

Figure 6: Firebreak failure due to a combination of a flammable plantation downwind of it and its orientation almost at 90^{o} to the wind prevailing during the fire season (Greg Forsyth, CSIR).

In practice the specifications used for firebreaks by different FPAs are based on what over time has been demonstrated to be effective within that specific area. Individual circumstances will determine what type and width of firebreak will be best suited to local conditions. These specifications are typically then written into the FPA prescriptions. For example FPAs situated in the Fynbos Biome commonly construct brush-cut firebreaks of between 10 m and 20 m width along the WUI (Table 2; Appendices 11.2 to 11.4) and these are proving adequate. Esler *et al.* (2014) recommend that firebreaks should be a minimum width of 2.5 times the height of adjacent vegetation. They also advise that when preparing brush cut firebreaks the cut vegetation should be raked and dispersed into the surrounding veld so as not to create an additional fire hazard (high fuel load) and that resprouting plants should not be removed because their roots bind the soil and prevent soil erosion. The distance over which cut material should be dispersed depends on the width of the firebreak; for example, if the firebreak is 20m wide, then cut material must be dispersed into the veld at least 20m above the firebreak.

Firebreaks become more flammable over time (due to an increase in the abundance of restios, sedges and grasses) (Van Wilgen 1981, 1982), making them less effective and shortening the rotation required to maintain low fuel loads. Although you can brush cut a firebreak every year in fynbos you cannot burn them annually because there is insufficient fuel. It is thus critical for FPAs to budget annually for the maintenance of their firebreak networks.

○ Example of a firebreak maintenance plan

The City of Cape Town together with SANParks annually makes provision for the maintenance of the firebreaks forming the circum-peninsula firebreak network (Appendix 11.2) (Figure 7). The Cape Peninsula FPA currently manages this firebreak network on behalf of the City of Cape Town and private landowners. For example the brush cutting of firebreaks located in the Glencairn Noordhoek Cluster was scheduled from 16 November to 15 December 2015. The work involved:

- Brush cutting
- Initial clearing
- Tree trimming
- Alien vegetation treatment and herbicide
- Fuel load reduction

Figure 7: Contractors brush cutting a firebreak in Hout Bay (Pierre Gallagher, CPFPA)

An extract from the City of Cape Town firebreak specifications, prepared by the Cape Peninsula FPA, for the firebreaks in the area between Glencairn and Noordehoek is given in Table 2 (see Figure 8). Another current example of a firebreak maintenance schedule is the Eastford Fire Management Unit of the Southern Cape FPA (see Appendix 11.3).

Table 2: Glencairn / Noordehoek cluster firebreak specifications

Firebreak Name And Number	Description	Length	Width	Method	Special Requirements Or Comments
CoCT S7 Cairnside Map 32	Stretches from Dido Valley Road along Penguin Road along the urban edge to Whyte's Way.	1440m	15 – 20 m	Brush-cut & Initial Clear	None

Firebreak Name And Number	Description	Length	Width	Method	Special Requirements Or Comments
CoCT S8 Glen Road and Glencairn Urban Edge Map 33	From the end of De Villiers Way along the urban edge to Glen Road.	1520m	20m	Brush-cut	None
P S5 Glencairn Urban Edge Map 44	Stretches from Whytes's Way along the urban edge to De Villiers Way.	870m	15m	Brush-cut	None
CoCT C6 Lake Michelle South Map 19	The Southern boundary between Lake Michelle and the Wetlands.	1730m	5 - 10m	Brush-cut & Initial Clear	None
P S6 A Old Game Camp Map 45	Stretches from the dam in Old Game Camp along to the end of the fence line.	400m	20m	Brush-cut & Initial	None
P S6 B Sunny Dale to Kommetjie Rd Map 46	Stretches from Kommetjie Road to the end of the last house in Sunny Dale.	300m	20m	Brush-cut and chainsaw work	Initial Clear

The Cape Peninsula FPA has a number of operational standards that must be adhered to when contractors construct and maintain firebreaks. These are:

- All alien vegetation within the firebreak is to be treated with the relevant registered herbicide.
- All logs, stacks, dumped garden material and old cleared material must be moved at least 20m above and away from the firebreak (Figure 8).
- All initial cleared material must be removed from site and dumped at a registered dumping site.

- The Fire Danger Index (FDI) will be communicated by the Project Manager when no brush-cutters or chainsaws are to be used due to Orange/Red FDI's for the day.
- Contractors to be in possession of basic firefighting equipment such as fire beaters, rake hoes and knapsack sprayers and relevant emergency telephone numbers.
- Litter to be removed daily.
- No open flames for cooking or any other use.
- No smoking in the field.
- No working on weekends or public holidays unless arranged in advance.
- Working times between 07h30am and 17h00.
- Safety equipment is to be worn at all times.

Figure 8: A well-maintained firebreak above Noordhoek where all excess plant material has been removed (Pierre Gallagher, CPFPA)

○ Budgeting adequately for firebreak maintenance

Annual costs for constructing and maintaining a firebreak network can be considerable so they need to be effectively positioned in the landscape. For example, the costs incurred for maintaining firebreaks in the West Ward of the Cape Peninsula FPA amounted to almost R 1.7 million for 133.5 kilometres (Table 3); this works out to R 12.72 per metre of firebreak length, or R 12,718.39 per kilometre. The value of the assets that are being protected is considerably more than this (Figure 9).

Table 3: Firebreak maintenance costs for the Cape Peninsula FPA (West Ward) during 2014/15.

FIREBREAKS	CITY & PRIVATE	TMNP NORTH	TMNP CENTRAL	TMNP SOUTH	TOTAL (m) / (R)
Length (m) [1]	40 220 m	47 220 m	21 277 m	13 190 m 11 600 m	133 507 m
Total cost (Rand)	R 441 640	R 481 380	R 368 499	R 175 700 R 57 000	R 1 524 219
Management Fee	R 173 775	CoCT contribution: R 361 021			R 173 775
TOTAL					R 1 697 994
Cost/m	R 12,72/m				

Note 1: The average width of these firebreaks is 20 metres.

Where possible the shortest, straightest route should be followed as this is often the least expensive option. The cost of preparing a firebreak needs to be carefully considered in relation to the value of the assets being protected as you do not want to over invest in firebreaks (Figures 8 and 9).

However, saving costs by not preparing adequate firebreaks could result in considerable legal fees should a fire start and spread from your property in the absence of adequate firebreaks despite actions being taken to prevent it spreading to neighbouring properties.

Figure 9: A well-maintained firebreak above Fire Hoek showing its effectiveness in protecting valuable property (Pierre Gallagher, CPFPA)

4.2 Invasive alien plant stack burning

Stack burning is often used as part of invasive alien plant control operations. In essence invasive alien plants (IAPs) are cut down, immediately treated with herbicides if species coppices and stacked in roughly circular piles. The rationale for this is that any seeds that are released as the cut plants dry are concentrated in small areas and killed during the subsequent severe[1] fire, and stacking facilitates access for follow-up (Esler & Boucher 2004; Cilliers *et al.* 2005; Behenna, Vetter & Fourie 2008). The piles of dead vegetation are burnt later under favourable weather conditions often during winter months of June, July and August (Figure 10). Another technique is to stack the cut down plants in windrows on the contour and then burn these rows at a later stage. This is done to minimise the risk of soil erosion, but it is not the best practice in terms of reducing fire risk. Where windrow stacking is applied to prevent erosion, only logs and thick branches with their finer branches and foliage removed should be used, because windrows consisting of slash are not recommended (Appendix 11.5). Stacks need to be properly extinguished (Figure 11) because some of the large material can smolder for hours and potentially flare-up again if the weather change.

Figure 10: Typical stacks being burnt on the WUI at Camps Bay (Pierre Gallagher, CPFPA)

[1] Severe fire is a combination of the intensity of a fire (i.e. energy output per second) and the period of time for which it burns (Keeley 2009). So a sever fire is one that is intense and burns for a long time as is typical of a burning stack.

Figure 11: Fire fighters ensuring that the stack is completely doused. (Pierre Gallagher, CPFPA)

There is valid criticism of stacking because the soil temperatures reached under the stacks during a fire is high enough to destroy seeds of both fynbos and alien plants, especially if the seeds are stored close to the soil surface (Holmes *et al*. 2000; Behenna *et al.* 2008; Ngubane 2014). In general, few or no seeds of indigenous species will survive and germinate where stacks are burnt, resulting in little or poor vegetation recovery and the potential for localised soil erosion (Figure 12). However, seeds of some species (e.g. pelargoniums) seem to be buried deeply enough to survive because this species is one of the few to germinate where stacks were burnt (G. Forsyth and D. Le Maitre pers. obs.). The severe fires in piles can also result in an effect known as water repellency where resins vapourised by the heat of the fire cool and condense on the soil particles, making them water repellent (Scott & Van Wyk 1990; Scott 1997; Scott *et al.* 2000; Van Wilgen & Scott 2001; Shakesby & Doerr 2006; Le Maitre, Kotzee & O'Farrell 2014a). This can lead to severe soil erosion during the winter after a fire and may increase wind erosion, and the effects can persist for decades *(Rhoades et al.* 2015). In addition, severe fires can burn up all the organic matter in the topsoil, leaving only the mineral soil particles behind (Scott & Van Wyk 1990; Doerr *et al.* 2006). This mineral soil is like fine talcum powder and is easily eroded by wind and water. To reduce the effect of high soil temperatures stack burning only takes place during wettest months, e.g. June, July and August and preferably conducted on days when the relative humidity is high. Stacked material is also sorted as not to include logs/branches of more the 15 cm diameter. Windrows should not be used as the fires are very difficult to contain when burning, and where soils are susceptible to water repellence (e.g. sands) this method should be avoided at all cost.

Figure 12: Undesirable effects of stack burning (Greg Forsyth, CSIR)

Critics feel that it is better to leave the cut stems where they are felled and conduct a prescribed burn at a later stage as this will also stimulate the soil stored fynbos seed to germinate but, in this case, the burn should take place at an ecologically suitable time. The application of fire after clearing invasive alien plant species which have long-lived, soil-stored seed banks, such as Australia acacias, stimulates germination and hence assists in reducing their seed banks. Of course the plants that do then germinate need to be treated before they reach maturity and this may involve many follow-up treatments.

Where IAPs are cleared close to the WUI, fire managers agree that this increases the dry fuel available. The longer the delay before there is suitable (safe) weather to burn this material (whether stacked or not), the greater the risk to properties and other assets. In general, the window period for prescribed burning is far too limited to rely on prescribed burning to deal with the debris created by IAP clearing. Therefore, where IAPs are cleared in close proximity to the WUI, the material is stacked and burnt during the wetter months as a safety precaution.

Stack burning should be considered if the area from which the invasive alien vegetation is to be cleared is small or where the position of the vegetation is such that a prescribed burn would present too high a risk of uncontrolled fire spread. A perimeter firebreak of at least 5 m needs to be prepared before any cutting of the material to be stacked takes place to prevent the possibility of runaway fires. Stacks should contain the vegetation cut from the surrounding 45m^2 of land (Appendix 11.5). In addition:

- The number of stacks created will depend on the size of the area being cut.

- In terms of the current burning permit stacks should not be positioned closer than 100 m from the urban edge.
- The basal diameter of stacks should not be more than 2.5 m, must not be greater than 1.5m high and the distance between the stacks should be at least 5 times the basal diameter.
- Only one stack should be burnt at a time unless adequate resources are available and conditions are suitable.
- Tracer belts down to mineral soil of a minimum one-meter width must be placed around each stack. This belt can be raked and the combustibles placed on the stack.
- Only branches of less than 150mm should be burnt. Large diameter branches should not be burnt but left in situ.
- Material that is to be burnt must only be vegetation from the locality, not household or building material such as plastics, wooden pallets or cardboard boxes.
- Never construct stacks under or near power lines. Smoke and ash can cause power lines to arc, and the heat will damage the lines. Consider the radiant heat together with the smoke that the stack will generate.
- Even when all these measures have been taken, it is essential to maintain staff on site to patrol and mop-up after a fire and to monitor weather forecasts to ensure that staff are not withdrawn until conditions definitely are safe.

4.3 Prescribed burning

There is a view that if an entire region were to be burnt on a rotation of 12 to 15 years, which is within the range for the desired fynbos fire regime (van Wilgen *et al.* 1992; Van Wilgen *et al.* 2010), then the problem of wildfires would largely be solved and that fuels would not build-up to any great extent. However, logistically this is extremely difficult, if not impossible, to achieve in practice and the records show that wildfires burn most of the area in the fynbos (van Wilgen 2013). There is no evidence of differences in the wildfire regime in fynbos after two decades under prescription burning or other changes in the management policy (Brown *et al.* 1991; Seydack, Bekker & Marshall 2007). There are various reasons for this, including periods of extreme fire danger and adverse weather conditions (e.g. strong winds) when very young veld burns or areas where biomass and fuel recovery is rapid due to the presence of invasive alien species.

A successfully executed prescribed burn is a very cost effective way of managing fynbos as many 100s of hectares can be burnt in a single day. Areas that have recently been burnt, whether through prescribed burning or a wildfire, offer greater protection than firebreaks to adjacent assets during the early stages of veld recovery as the vegetation when young is greener (higher live moisture content , the canopy has not yet closed and there is limited available dead material). However, there is always a risk when conducting prescribed burns and the weather needs to be chosen with great care. Also prescribed burns need to take the fynbos fire regime into consideration. If the primary focus of prescribed burning were to be on limiting fuel loads then in all likelihood it would be to the longer term detriment of the fynbos ecology (van Wilgen *et al.* 1992; van Wilgen 2013).

There seems to have been little, if any, research into the ideal size of a prescribed burn in the fynbos (Esler *et al.* 2014). However, in most cases, the size of the fire is determined by two main considerations: (a) the availability of safe natural boundaries or safe locations for man-made boundaries (Figures 13 to 15); and (b) keeping such burns to a size such that they can be carried out within daylight hours although ignition can begin before first light, typically less than 500 ha. The main ecological consideration is to avoid small fires (less than 200-300 ha) because seed-eaters migrate into these areas after fires (Esler *et al.* 2014). This is not always possible especially undertaking prescribed burning on the WUI where fire managers have to adopt a cautious approach (Philip Prins, pers. comm.). They are known to have a significant impact on the survival of seeds until they germinate, as shown by poor regeneration of serotinous Proteaceae after winter and spring fires compared with summer or autumn fires in the western part of the biome (Bond, Vlok & Viviers 1990; Van Wilgen & Viviers 1990; Bond 1994). In the eastern part of the biome the bimodal and variable rainfall regime results in less marked effects on regeneration, but spring and autumn fires generally result in good regeneration (Heelemann *et al.* 2008; Kraaij, Cowling & Van Wilgen 2013; Kraaij & Wilgen 2014). However, little is known about how large a fire needs to be to minimise this effect. Very large fires can also result in substantial reductions in the habitat for some animals such as sunbirds and (particularly) sugarbirds which depend on nectar from mature Proteaceae and are highly territorial so they cannot simply migrate (Esler *et al.* 2014).

Figure 13: A prescribed burn within TMNP Cape Point using brush-cut tracers to provide a safe control line. (Pierre Gallagher, CPFPA)

Figure 14: A prescribed burn within TMNP Cape Point 2014 (Pierre Gallagher, CPFPA)

Figure 15: A prescribed burn within TMNP Game Camp (Pierre Gallagher, CPFPA)

The response of vegetation to wildfire is reasonably well understood by the general public, but the use of fire for conservation purposes remains controversial (Philip Prins pers. comm. 2016). Most residents of suburbs close to TMNP, and citizens in general, remain broadly ignorant with respect to the ecological role of fire. Wildfires are still regarded as "ecological disasters" by many and residents and landowners often voice objections if prescribed fires are carried out, especially on the WUI. The impression created by the media is still one of "harm and destruction" and the fact that fire forms an integral role in the ecological management of Fynbos is still not understood by many.

Experience elsewhere with prescribed burning is that it can also be useful ecologically but does little to limit wildfire spread and impacts. Keeley *et al.* (2011) maintain that unless chaparral areas are continuously burnt at 1 to 2 year intervals then is not possible to conclude that this fuel treatment is effective in the long term. Gibbons *et al.* (2012) in discussing the results of their study of the 2009 wildfires in south-eastern Australia indicate that prescribed burning was most effective when undertaken close to houses and at least every 5 years.

Choosing suitable weather is essential for maintaining control of a prescribed burn as is limiting the burn to a manageable size and having practical boundaries. Juhnke and Fuggle (1987) state that suitable weather for burning fynbos needs to be limited to the following conditions:

- wind speeds (hourly maximum <16 km/h),
- temperature (daily maximum between 18°C and 28°C) and
- relative humidity (daily minimum between 15% and 45%).

However the number of days per year when weather conditions are suitable is limited (van Wilgen & Richardson 1985; Van Wilgen & Scott 2001; van Wilgen 2013; Kraaij *et al.* 2013). Opportunities for conducting prescribed burns are further limited by administrative issues. For example no prescribed burning is allowed over weekends or public holidays and, together with limitations due to air pollution regulations, especially close to cities and large towns. Air pollution tends to accumulate during calm conditions and this could become a further limitation. Climate change is likely to increase the number of days per season with a high or extreme fire danger (Midgley *et al.* 2005; Forsyth *et al.* 2015), reducing the number of safe days even more.

Prescribed burning in commercial forestry context also includes selective under canopy burning under pines or gums, particularly in high risk areas.

4.4 Vacant plots and corridors of unmanaged land

The clearing of vegetation from vacant erven in the proximity of the WUI is often overlooked in reducing the fuel hazard along the WUI. However, when wildfires occur in the proximity of residential areas there is a likelihood of spot fires occurring ahead, and downwind, of the main fire front. They are caused by hot embers and firebrands which are initially transported in the air by wind and then drop where they can ignite flammable vegetation (Koo *et al.* 2010; Albini, Alexander & Cruz 2012). This can happen even though such vegetation is 100's of metres away from the fire front. This enables a fire to "leap frog", even before reaching a firebreak, into a suburb as was the case during the recent Simonstown fire in November 2015 when several houses were burnt down or damaged. This fire spread particularly rapidly into the residential area, after spotting across the firebreak, because overgrown vacant plots acted as a conduit for its spread. Burning embers were blown from one plot of vacant land to the next until the fire reached the Main Road in Simonstown (Philip Prins, pers. comm. 2016).

A similar situation arises if vegetation remains unmanaged in public or privately owned open spaces within built-up areas adjacent to the WUI. These "fingers" of vegetation often occur where land is too steep to build on, for example, ravines leading from the mountain side into a residential area. This is what is described as vegetation connectivity (Alexandre *et al.* 2015). The management of these areas is often neglected allowing them to become overgrown by invasive alien plants (IAPs) and thus increasing fuel loads. Fingers create a particularly high fire risk as they can serve as conduits, allowing wildland fires to enter and cause damage within formally built-up areas (Figure 16).

Figure 16: A view of "fingers" of unmanaged vegetation within a built-up area. (Pierre Gallagher, CPFPA)

Managing high fuel loads on vacant residential plots and public open spaces in the vicinity of the WUI is essential for reducing this hazard. This needs to be routinely done and can be achieved by mowing or brush cutting and removing dead vegetation and other flammable material ahead of each annual fire season. Municipal by-laws can be used to enforce this but in other cases where this is not working national legislation needs to be enforced to get landowners to clear their properties (Philip Prins, pers. comm.). The substantial benefits of not having homes accidently damaged or destroyed within built-up areas during adjacent wildfires makes this a cost effective action.

4.5 FireWise Landscaping

Firescaping refers to designing, planting and maintaining gardens of houses on the WUI to reduce the likelihood of a fire catching alight and spreading. The pamphlet, 'Firescaping your garden' recently published by FireWise[2] describes ways of landscaping gardens surrounding such houses to increase the fire-resistance of these gardens (Anonymous 2015). The pamphlet lists actions that homeowners should take in the home ignition zone (the area immediately surrounding houses) as:

- Assessing the vulnerability of your property to potential damage by fire,
- Deciding on a survivable space or a defensible space (Keeley *et al.* 2011; Syphard, Brennan & Keeley 2014) of at least 10 m around houses but sometimes as wide as 60 m where fuel loads are heavy (Figure 17),
- Firescaping gardens within the survivable space, and
- Reducing fuel loads in the survivable space.

Figure 17: A view of where lawns have provided some defensible space but where woody vegetation has allowed the fire to reach buildings, Muizenberg Wildfire 2015 (Pierre Gallagher, CPFPA)

[2] The concept of FireWise communities originated in United States of America www.fire.org) and is now been adopted in South Africa (www.fireisesa.org.za). Firewise emphasises community responsibility in creating fire safe communities and emergency response but also individual homeowner responsible for fire proofing homes and "firescaping" gardens.

Three areas of varying fire resistance should be landscaped within the survivable space: a low resistance zone within 3 m of a house, a buffer zone further than 10 m from a house and a medium resistant zone between the other two zones. Actions including mowing, pruning and clearing of vegetation fuels, and the planting of suitable fire resistant indigenous plants within each of the zones. For example, in the low resistant zone should contain mainly lawn, paved surfaces and low-growing plants. A good basic rule is to site houses at least three times the vegetation height away from the edge of vegetation that a fire could potentially reach. This is to escape direct contact with flames (radiant heat) but it will not prevent ember attack.

The likelihood of a fire igniting and spreading in urban areas is a function of fuel availability and distribution (Keeley *et al.* 2011). These fuels include the construction material of houses, garden plants and house attachments such as decks. They note that the primary factor in home ignitions from wildfires is the proximity of plants to structures and that palm and pine trees are problematic in WUI as they can act as ember catchers. This is not dissimilar to situations of the WUI in fynbos where palm trees have been observed to catch fire in gardens or other situations well away from the fire front (Simonstown fire, January 2000, (Scott *et al.* 2000) A similar situation occurred in Simonstown during the November 2015 fire, as observed by Philip Prins: "I was standing at the Incident Command Post on a piece of lawn immediately below the main road and approximately 50m from where I was standing a huge palm tree was set alight by burning embers. Due to the strong south easterly wind embers from the palm tree were blowing in all directions and started a new fire below the road. Due to the height of the palm tree, and the arrangement of leaves that actually act as "ember traps", it is difficult to extinguish such a fire once the tree is well alight. Palm trees should definitely not be used in any fire prone areas especially near houses as embers emanating from these trees posed a big fire threat". The most effective fuel treatment against fires in south-eastern Australia was reducing vegetation from 90% to 5% cover within 40 m of houses as this could potentially reduce loss by an average of 43% (Gibbons *et al.* 2012).

Measures taken to reduce garden fuels in the proximity of homes are practical and inexpensive ways for individual homeowners to take and by so doing, collectively reduce the exposure and vulnerability of communities on the WUI to damaging wildfires.

5 ADDITIONAL MEASURES

Some additional measures have been found to be useful elsewhere but are not consistently or widely practiced in South Africa. The first involves taking fires into account when planning the location of developments in the landscape, be they dwellings or other infrastructure, or valuable, long-lived crops such as vines or fruit orchards. The second is fire-proofing such structures, especially buildings used as dwellings or for storing valuable or flammable goods. The last one is taking actions to raise awareness about avoiding fire ignitions, particularly in or along the WUI.

5.1 Planning developments in fire-prone landscapes

All the fuel reduction and safe-space preparations can only go so far in protecting structures when they are located in the path of a severe wildfire known as a fire storm[3]. Defending buildings, and the replacement of those burnt in wildfires, comprises a substantial portion of costs associated with wildland fires in the WUI (Gude *et al.* 2013). Homes and other structures are often vulnerable to damage by wildfires because their locations expose them to wildfires through radiant heat and ember attack (Syphard *et al.* 2013; Alexandre *et al.* 2016), especially the structures in informal settlements (Figure 18). Costs for making poorly or haphazardly located homes or other structures fire-safe can be prohibitive and do not guarantee immunity from wildfires (Syphard *et al.* 2013). Careful location of structures in the landscape to take account of topography and the likely directions of the wind can mitigate wildfire losses during in severe weather (Winter, McCaffrey & Vogt 2009; Keeley *et al.* 2011; Stidham *et al.* 2014). Such planning can be supported by using fire behaviour simulation models to examine possible fire behaviour under different fire weather and fuel conditions in different landscape settings (Syphard *et al.* 2013, 2014; Alexandre *et al.* 2015).

The same applies to the planning and design of areas which will contain valuable, long-lived crops such as orchards, vineyards and forest plantations. The fields or compartments should be consolidated into blocks, wherever possible, to avoid complicating fire suppression operations by having lengthy edges adjacent to flammable vegetation. The design should take the potential for exposure to radiant heat from burning material and ember attack under typical fire weather conditions and fire intensities. The design should also include safe access routes for firefighters and escape routes for the inhabitants in the event of a wildfire. A narrow winding track may create a rural atmosphere but could become impossible to traverse safely in the face of a wildfire.

[3] An exceptionally intense and uncontrollable fire which generates its own winds, see https://en.wikipedia.org/wiki/Firestorm

Figure 18: An aerial view of the WUI of Mandela Park in Hout Bay (Pierre Gallagher, CPFPA)

We have learnt through experience not to place buildings in the flood zones of rivers, but only very recently is there a growing awareness of the potential benefits of curtailing further development in locations with high fire hazards (Syphard *et al.* 2013). In USA the 2012 International Code Council's Wildland Urban Interface Code4 has been added to zoning codes to deal with the WUI issues.

The Cape Peninsula FPA are now included among the bodies who comment on some proposed developments on the WUI. However it should be brought to the attention of metros and local municipalities, in fire prone areas, that all developments on the WUI must be scrutinised by the local FPA (Philip Prins pers. comm. 2016).

5.2 Making houses fire-resistant or more fire proof

This strategy for reducing the risk of losing dwellings or other structures does not fall within the scope of this study, but we believe it is very important to consider it as part of a holistic approach to the WUI problem. Increasing fire-resistance complements the FireWise Landscaping (discussed above) which focuses mainly on reducing fuel loads in the vicinity of buildings to minimise exposure to radiant heat or flames. It focuses on identifying features of buildings that make them particularly prone to ember attack, ignitions caused by burning embers landing among flammable materials or in locations where such material can accumulate. These can include the materials that all or part of the house is built from (e.g. wood, or the type of paint) as well as the structure of the house (Wilson

[4] International Wildland-Urban Interface Code: http://publicecodes.cyberregs.com/icod/iwuic/2012/

1988; Cohen 2000; Tolhurst & Howlett 2003; Cao, Boruff & McNeill 2016). Design features that make houses particularly vulnerable are open gaps under the roof eaves which allow embers into the roof space, and ventilators or gaps allowing airflow under suspended flooring or raised decks. There are many areas that can collect flammable material, the most obvious being roof gutters where flammable leaf litter often accumulates unnoticed by homeowners. Grasses or other fine fuels growing against walls are another prime example. Such areas need to be cleared at the start of each fire season and periodically checked during the fire season. Gas canisters should preferably be placed on the leeward side of the house to avoid being exposed to both ember attack and radiant heat generated by the advancing fire. Owners of houses in the WUI need to be particularly careful, but embers can be carried well into urban areas and result in houses burning down while neighbours are left undamaged (Scott *et al.* 2000). Standards and guidelines have been developed by the Australians[5] and in the USA[6] and similar ones could be developed for South African conditions. Special solutions will be required for informal settlements in the WUI. Homeowners on the WUI are often ignorant of these safety measures and need to be informed, especially at the beginning of the fire season. FPAs can play important role in this but due to lack of sufficient funds for fire awareness programs this is not happening.

FPAs in the Fynbos Biome are largely concentrating on owners of large properties (e.g. farmers and local authorities) and not on communities or individual homeowners on the WUI. There therefore to be more attention and focus on developing Firewise communities throughout the WUI as budgets are currently concentrated on suppression with too little investment in prevention measures.

5.3 Awareness and ignitions

Attention also needs to be given to reducing accidental ignition of fires through raising fire awareness. Unfortunately, raising fire awareness will not prevent all ignitions. For example high winds could cause an electric transmission pole to blow over and set the veld alight during weather suitable for the rapid spread of a wildfire. Or a car crash could result in the car being set alight. However many fires are known to have been caused by human carelessness and ignorance and some of these have resulted in devastating damage. Again, this falls outside the scope of this study but forms an essential part of developing an effective strategy for reducing the risks posed by wildfires in the WUI. Again, insufficient funds are being made available for fire prevention.

6 DISCUSSION

Fires in the fynbos are inevitable because fynbos is fire-prone and as the population expands and human activity increases along the WUI there are more and more sources of accidental and deliberate ignitions. The questions are simply: "When?" And "How intense will the fire be?" Wildfires are influenced by three main factors; weather, landscape and available fuel. Wildland fires spread

[5] The Australian Standards AS 3959 on safety requirements of building in a bushfire prone area http://www.as3959.com.au/

[6] FEMA Avoiding wildfire damage: A checklist for homeowners http://www.fema.gov/pdf/hazard/wildfire/wdfrdam.pdf; International Wildland-Urban Interface Code http://publicecodes.cyberregs.com/icod/iwuic/2012/

more rapidly and are more intense during periods of hot, dry and windy weather, which is termed extreme fire weather. Topography plays an important role in the spread of fire and fires tend to be "channelled" by ridges and valleys, spreading more rapidly on steep slopes and along narrow kloofs (Geldenhuys 2011). The more fuel available, especially dry fine fuel, the higher the probability that a fire will ignite and spread once ignited. Of the three factors, the physical landscape and weather conditions cannot be modified. Worse still, the global climate change predictions for the Fynbos Biome indicate that weather conducive to the spread of runway wildfires will increase in future (Midgley *et al.* 2005; Forsyth *et al.* 2015). Fuel is the only one of the factors that can be addressed to some extent.

Fire and conservation managers in the Fynbos Biome, as elsewhere in similar Mediterranean-type climates, use several measures to reduce fuel loads in the vicinity of the WUI. These include preparing firebreaks, conducting prescribed burns of various types and encouraging property owners to reduce fuel loads in the proximity of houses, so called firescaping of gardens.

There is a view that if a mosaic of different ages of vegetation is established, runaway wildfire would be relatively easy to contain. However it has been shown that under conditions of severe fire weather this is not the case as relatively young vegetation burns readily. To ensure that the fynbos is safe at all times, prescribed burns would need to be conducted at a frequency that would be detrimental to the ecology of the fynbos. However, prescribed burning can be effective if used in conjunction with other fuel management techniques (van Wilgen *et al.* 1992). Prescribed burning is particularly useful when used as part of the treatment of the invasions by alien woody plants that greatly increase fuel loads. Prescribed burning should be used primarily to achieve ecological goals with an incidental benefit being that young vegetation provides addition protection to the WUI. Conducting safe prescribed burns is also dependant on the occurrence of sufficient days of suitable weather for burning each year.

Fire managers are cautious about safety and hence the weather conditions under which they are prepared to carry out a prescribed burn, as there is always a chance that the burn does not go according to plan and results in a wildfire. Consequently many prescribed burns in the fynbos have been carried out under cool weather conditions or at times of the year that are not ideal for fynbos ecology (Bond *et al.* 1990; van Wilgen *et al.* 1992; Bond 1994). Under conditions of global climate change there are likely to be fewer opportunities for conducting prescribed burns and longer periods of high and extreme fire danger (Midgley *et al.* 2005; Forsyth *et al.* 2015). Training in prescribed burning needs to be accelerated and should be combined with meteorological training as to enable managers to determine the optimum weather conditions for prescribed burning. The lack of fire managers with the relevant practical experience to conduct prescribed burns is a real issue and has resulted in many managers being reluctant to carry out prescribed burning.

Creating a well thought out and maintained firebreak network using the experience of the behaviour of past fires as a guide (anecdotal evidence), together with firescaping gardens (and fire proofing buildings), offers a practical and effective way of protecting assets from wildfires along the WUI (Van Wilgen & Scott 2001). In the Fynbos Biome firebreaks are increasingly prepared by brush cutting the veld. This has a number of advantages over burnt firebreaks. The operation is much less weather dependant, there is little danger of causing an accidental fire and brush cutting can be done annually. Any adverse ecological impacts are confined to small areas in the landscape, thereby ensuring that the social and economic benefits outweigh any potential ecological risks. Firebreaks are of limited use if fuel loads on the inside of the firebreaks are not managed. Embers emanating from a fire front can easily be blown across a firebreak and set fire to vegetation on the inside of the firebreak. It is therefore important that gardens on the inside of firebreaks are firescaped to reduce fuel loads and that houses are constructed of less fire prone materials. The firebreak network and the maintenance of defensible spaces need to be managed as an integrated system if the maximum risk reduction benefits are to be realised.

We have some information on how much it costs to construct and maintain firebreaks, and the costs of carrying out prescribed burns, but we do not have much information on the total value of the assets we are protecting. This makes it difficult to assess what the cost savings of such mitigating measures could be if they prevent or minimise damage to property or livelihoods or loss of life. Every situation is specific so it is difficult quantify or to generalise. Nevertheless there are real benefits from having a well maintained firebreak network and effective FireWise landscaping in the WUI, including avoiding potential losses of assets, avoiding reputational damage should an asset (house) be damaged or destroyed, creating a feeling of security and ensuring the access and safety of fire fighters.

There needs to be clarity about the responsibilities of individuals versus that of authorities in mitigating wildfire risks on the WUI. Fire authorities need to have a say in urban planning decisions on the WUI, while individual property owners must maintain defensible spaces around their houses. We recommend that formal firebreak agreements are signed between landowners (e.g. Local authority, nature reserves or forestry companies) to ensure commitment from both parties and to facilitate sharing of costs.

In considering all the potential benefits of the range of possible fuel treatments for mitigating risk to people and property on the WUI, the most important is fuel management. In most circumstances a combination of well-maintained firebreaks on the perimeter of residential areas and well maintained defensible spaces within these areas is a cost effective way to substantially reduce the risk to people and their assets posed by wildfires on the WUI.

7 SUMMARY OF KEY POINTS

The main factors influencing the severity of fires in the Fynbos Biome are:

- Topography
- Weather (preceding and at the time)
- Fuel (load and structure)

A Fire Protection Association (FPA) cannot change the landscape or the weather but to some extent fuel load and structure can be managed. FPAs located in the Fynbos Biome tend to focus on five main issues (themes) in their endeavour to manage fuels in the WUI. These are:

- Firebreak construction and maintenance;
- Stack burning of invasive alien plants;
- Prescribed burning;

- Clearing of vegetation from vacant plots; and
- FireWise landscaping.

The salient features of each of these fuel management practices are now listed.

Firebreaks

These provide a safe position to undertake fire suppression activities from. But if left unattended they will rarely be sufficient to stop a fire on their own. For firebreaks to work well they need to be:

- Well maintained to ensure that there is no or little vegetation on them (they need to be less fire prone than the surrounding vegetation). Without causing any erosion
- As far as possible they should be constructed parallel or at an acute angle (<60°) to the direction of the prevailing wind.
- We recommend that formal firebreak agreements are signed between landowners.

Firebreaks fail for a number of reasons:

- Being badly positioned in the landscape (rights angles to prevailing wind and perpendicular to steep slopes;
- Too vegetated;
- Vegetation being protected(on inside of the firebreak) is highly flammable
- Too narrow;
- Weather during fire too severe
- Unmanaged fuels within the area being protected (e.g. vacant lots), increasing the vulnerability to embers and firebrands carried across the firebreaks

Stack burning

The rationale behind stacking the invasive alien plants that can be cut down during clearing operations is to contain localised high fire risk by making fire more manageable. There are advantages and disadvantages associated with this practice:

Advantages

- Reduces the risk of fire escaping;
- Kills seeds of cut invasive alien plants; and
- Creates access for follow up operations.

Disadvantages

- High local fire severities can result in long term damage to soils;
- They can eliminate indigenous soil stored seedbanks; and
- On steep soils the lack of vegetation recovery could result in bare areas becoming vulnerable to soil erosion.

Prescribed burning

Prescribed burning is typically carried out to burn larger areas of veld (100 to 500 ha) (reference) for the following purposes:

- To regenerate moribund veld;
- To create a mosaic of variable aged veld; and
- To reduce risk of extensive wildfires

Prescribed burning is not widely practiced with by far the majority of the Fynbos Biome burning in wildfires (van Wilgen *et al.* 2010), partly due to episodes of severe fire weather when even young veld can burn. The difficulty of limiting accidental and intentional ignitions during severe fire weather means they will always occur so prescribed burning on its own will not solve the fire risk on the WUI.

Unmanaged land

Vegetation management is often neglected on vacant residential plots and public land along the WUI. Fuels often build-up unnoticed in such areas and during wildfires they are vulnerable to ember attacks thereby allowing fire to penetrate into residential areas. It is important that fuel build-up is regularly attended to in these areas and municipal by-laws can be useful in this regard. For example, within the Cape Metro, the issuing of notices in terms of the Community Fire Safety By-Law can be served on errant landowners to clear their land of vegetation that is likely to cause a fire hazard. The landowner is given 21 days to comply where non-compliance or failure to comply with this notice and the provisions of the Community Fire Safety By-Law is an offence and the landowner will be held liable for the prosecution / prescribed fine (or both) for each contravention.

Fire Wise landscaping

The aim of FireWise landscaping properties is to create defensible areas around houses and thereby reduce the vulnerability to damage and destruction by wildfires. Common measures taken include:

- Minimise flammable vegetation (e.g. Palm trees and other fire, dead fuels);
- Reduce radiant heat in the immediate vicinity of buildings;
- Follow FireWise practices; and
- Take mitigating measures against ember attack.

In conclusion

Fuel management measures that need careful consideration on the WUI are:

- Firebreaks designed and maintained to best protect assets; and
- Fuel management on individual properties to reduce vulnerability of houses to wildfires, including along access routes.

Using these two measures in combination will do much to achieve the protection of assets from the risk posed by wildfires on the WUI. Managing fuel reduction on the WUI is a shared private and public responsibility and FPAs are well placed to co-ordinate fuel reduction activities to the benefit of individuals and the community. We also recommend:

- That the planning of developments on or near the WUI should take account of fire spread patterns under the influence of topography and the weather conditions, particularly winds, likely to occur during wildfires; and
- Improving the fire-resistance of structures located where they are likely to be exposed to ember attack from wildfires.

8 AREAS FOR FURTHER INVESTIGATION

In section 4 we listed the preparation and maintenance of firebreaks, stack burning as part of clearing IAPs, prescribed burning, maintenance of vegetation on vacant land and firescaping gardens as common fuel reduction measures undertaken by Fire Protection Associations (FPAs) in the Fynbos Biome.

Much of how to undertake these activities is well known and written into FPA standard operating procedures. However we believe there are still some gaps in our knowledge that should be addressed to enable FPAs to increase the effective measures to be taken to protect value assets along the WUI. These are listed below:

Firebreaks

- Areas where firebreaks have consistently failed or succeeded should be identified and the reasons for such failures or successes should be assessed and used to develop guidelines for their strategic location in the landscape to make them as effective as possible.
- Regular burning of firebreaks in fynbos increases fine fuels, grasses and restios and this decreases the effectiveness of the firebreaks over the longer term. But we have no similar information on the longer term effects of brush cutting.
- FPAs need to understand how to optimise their investments in constructing and maintaining firebreaks in relation to the value of the assets protected. This will require a series of case studies and, possibly, a synthesis which could develop efficient ways of estimating such costs benefits without needing every situation to be assessed. At present the value of the assets is

not taken into account when budgeting for fire management. We believe that this disjunction needs to be addressed.

- Systems are needed that can reliably predict suitable weather for firebreak burning in advance. This will enable fire managers to make full use of periods of suitable weather.

Stack burning

- Following a study by Ngubane (2014) the University of Stellenbosch's Centre for Invasion Biology in collaboration with the City of Cape Town have established a long-term monitoring program. This is investigating the ecological advantages and disadvantages of stacking cut invasive alien plants and then burning this material, or spreading the cut margin more evenly in a treated area before conducting a prescribed burn.
- Three years of data has been collected so far but the data has not been analysed yet (Mirijam Gaertner pers. comm. 2016). Once these results become available we will be in a better position to develop guidelines for optimising this practice.

Prescribed burning

- Prescribed burning in the fynbos has been well researched and is primarily aimed at maintaining the diversity and functioning of the fynbos rather than fuel reduction except where it is carried out as part of invasive alien plant treatments. More work is needed on determining the ecologically acceptable fire intervals. There are some rules of thumb for serotinous Proteaceae but little work on other species guilds and the fauna.
- There are some basic guidelines on weather conditions that are suitable for prescribed burning, but systems are needed that can reliably predict suitable weather in advance. This will allow the fire managers to be properly prepared to take full advantage of the limited periods of suitable weather.

Creating defensible space

- We can learn much from experience elsewhere including the FireWise programme but to date there has been little or no local research. We also have a unique situation where informal settlements or RDP housing are located in the WUI and these places are particularly vulnerable to poor fuel management.
- We also need design principles to be formulated so that developments are planned from the outset to incorporate firescaping in defensible spaces, fire-resistant structures, and fire spread patterns into their design.
- Little attention has been given to the optimal placing of valuable long lived agriculture crops (orchards and vineyards and timber plantations) in the landscape to minimise the potential for fire damage (scorching and burning). Guidelines are required.
- We need to view the firebreak network and the creation of defensible spaces as an integrated system and not as disconnected entities. Very little work has been done on how such an approach would be developed and applied in practice and guidelines are required.

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11 APPENDICES

11.1 Chapter 4: Veldfire prevention through firebreaks

Chapter 4 places a duty on owners to prepare and maintain firebreaks. The procedure in this regard and the role of adjoining owners and the fire protection association are dealt with.

Provision is also made for the making of firebreaks on the international boundary of the Republic. The Minister is given the power to exempt any owner from making a firebreak for good reason

12. Duty to prepare and maintain firebreaks

(1) Every owner on whose land a veldfire may start or burn or from whose land it may spread must prepare and maintain a firebreak on his or her side of the boundary between his or her land and any adjoining land.

(2) (a) If an owner referred to in subsection (1) intends to prepare and maintain a firebreak by burning, he or she must determine a mutually agreeable date or dates with the owners of adjoining land for doing so, and inform the fire protection association for the area, if any.

(b) If agreement cannot be reached, such owner must give to the owners of adjoining land and the fire protection association for the area, if any, at least 14 days written notice of the day or days during which he or she intends burning firebreaks, fire danger permitting.

(3) An owner of adjoining land who has agreed on a day in terms of subsection (2)(a) or who receives a notice in terms of subsection (2)(b) must—

(a) burn his or her firebreak on the boundary concerned on the same day or days; or

(b) be present at such burning or have his or her agent attend; and

(c) ensure that a sufficient number of persons are present on his or her side of the boundary to prevent any spread of fire when the firebreak is burned.

(4) An owner may not burn a firebreak, despite having complied with subsection (2), if—

(a) the fire protection association objects to the proposed burning; or

(b) a warning has been published in terms of subsection 10(1)(b) because the fire danger is high in the region; or

(c) the conditions are not conducive to the burning of firebreaks.

(5) The owner must inform the owners of adjoining land and the fire protection association, if any—

(a) if burning cannot be done on the agreed day or days referred to in subsection (2)(a) or any of the days referred to in subsection (2)(b); and

(b) of the additional days on which he or she intends to burn because of the failure to do so on the day or days set in terms of subsection (2)(a) or (b).

(6) It is not necessary for the owner to give 14 days notice of the additional days.

(7) Owners of adjoining land may agree to position a common firebreak away from the boundary.

(8) Should an owner intend to be absent for a period longer than 14 days during the period or part of any period in which burning normally takes place, he or she must give all owners of adjoining land an address and telephone number, if any, at which he or she may be contacted.

(9) If an owner of adjoining land—

(a) is not present on the agreed or notified day or days; or

(b) has not given an address and telephone number, if any, as required in subsection (8) the owner may proceed with the burning in his or her absence.

(10) A fire protection association may make rules different from subsections (2) to (6) if the new rules are approved by the Minister, in which event members are bound by the new rules and exempt from subsections (2) to (6).

Requirements for firebreaks

13. An owner who is obliged to prepare and maintain a firebreak must ensure that, with due regard to the weather, climate, terrain and vegetation of the area—

(a) it is wide enough and long enough to have a reasonable chance of preventing a veldfire from spreading to or from neighbouring land;

(b) it does not cause soil erosion; and

(c) it is reasonably free of inflammable material capable of carrying a veldfire across it.

Exemption from duty to prepare and maintain firebreaks

15. (1) The Minister may exempt any owner or group of owners from the duty to prepare and maintain a firebreak or firebreaks for good reason.

(2) The exemption may be subject to conditions.

(3) The Minister must consult the fire protection association for the area, if any, before granting any exemption.

Exemption from prohibitions on damaging plants

16. The right or duty to prepare and maintain a firebreak in terms of this Chapter prevails over any prohibition in any other law on the cutting, disturbance, damage, destruction or removal of any plant or tree, except that the owner must—

(a) where possible, transplant any plant which is protected in terms of any law; or

(b) where it is safe and feasible, position the firebreak so as to avoid such plant or tree.

11.2 Extract from SANPark's Firebreak Report for 2015/16 Fire Season

South African
NATIONAL PARKS

Firebreak Inventory Report

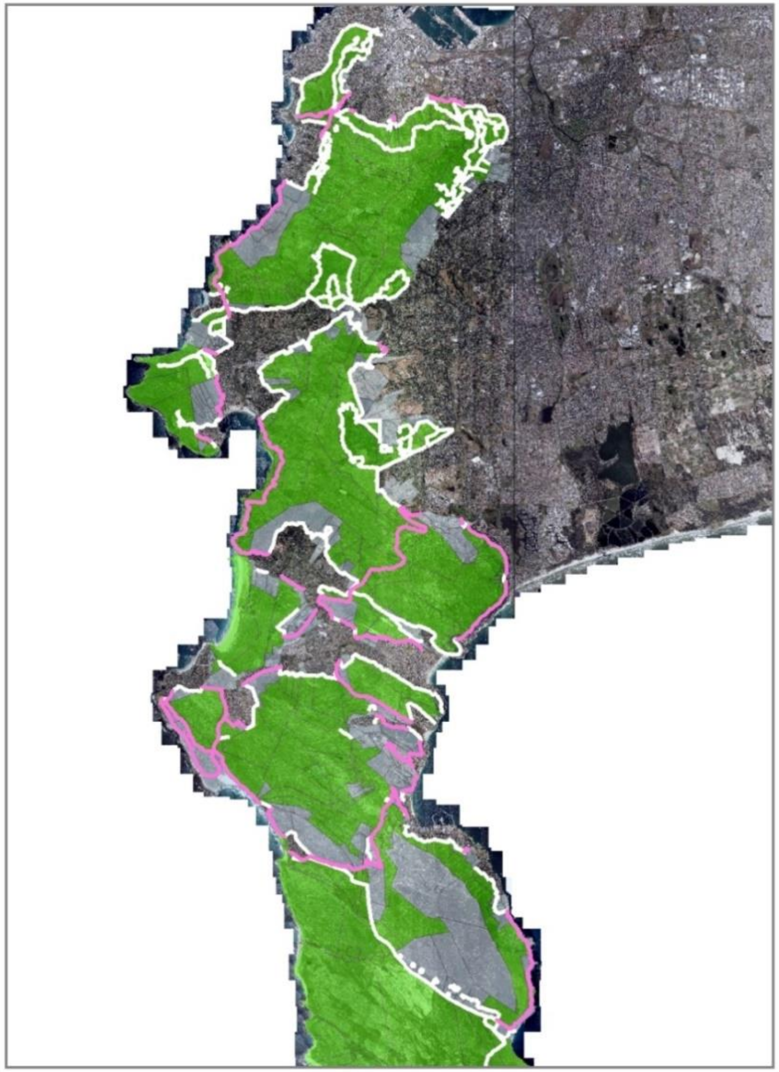
Table Mountain National Park

City of Cape Town

Year: 2015-16 Fire Season

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

Version 1 October 2015



FIREBREAK INVENTORY REPORT FOR TABLE MOUNTAIN NP: 2015-16 FIRE SEASON

Map: 20 COCT C7 - Black Hill Road **Management:** City of Cape Town **Section:** Central

C_C7 - Black Hill Road

Length: 4,120m	Width: 15m	Gradient: 5-20°	Method: Brush Cut	Maintained by CoCT
Description: Stretches along the tarred surface of Glencairn Expressway/Black Hill Road, from Kommetjie Road towards Main Road up to Glen Heights Urban Edge.				
Field Notes: 1.5 meters of road verge on both sides to be kept clear				

South African National Parks V1.0 October 2015

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

11.3 Extract from Southern Cape FPA's Eastford Fire Management Unit 2015/2016

FB Number	Description & Current Status	Maintenance & Responsibility
Firebreak 1 (blue)	The Knysna river is flowing with fresh water. It widens to the south and narrows to the north. In the north vegetation gets thick, but is also indigenous and wet.	SANParks, together with Working for Water are taking care of this river. This includes water quantity and quality checks and alien removal. Being done as necessary.
Firebreak 2 (orange)	The N2 is two lanes wide with clean road verges or both sides. The Lagoon is just south of the N2, with masses of sea water.	SANRAL ensures that the road verges are clean on the N2. This includes cutting of grass and clearing of overhanging branches. Being done every 3 months. Knysna municipality re-act to accidents on the road verges and SANParks looks after the Knysna Lagoon. Is being monitoring constantly.
Firebreak 3 (purple)	A large distribution power line of Eskom runs across the FMU, from east to west. Certain areas are well cleaned while other areas are overgrown. Although certain areas are overgrown it is still a break in the vegetation, to a certain extent.	Eskom needs to keep its power line servitudes clean of any vegetation. This isn't to say that it has to be slashed to ankle height, but rather that any falling or swaying trees will not touch the power line. It should be cleared yearly.
Firebreak 4 (red)	Cape Pine in order to protect their plantations has large 10m firebreaks along their boundary.	Forestry companies always have good firebreaks in place. Cape Pine borders the FMU. This is maintained yearly. Pines can grow very high and can create spot fires, thus a 10m break may not even stop the fire. But is an access point so that we can fight the fire.
Firebreak 5 (green)	Knysna Municipality has created this firebreak to protect the town of Knysna form fires coming from the Northwest. It is a break in the fuel load, but currently needs maintenance.	Knysna Fire Brigade has constructed and maintains this firebreak. Done yearly.

FB Number	Description & Current Status	Maintenance & Responsibility
Firebreak 6 (yellow)	This is an internal road, two lanes wide. All the road verges are not clean, but the tar road in itself is the firebreak. Road verge cleaning will improve the effectiveness of the firebreak.	This internal road, the Old Kaapse Weg road, stretches right through the middle, from south to north. It is a secondary road and EDEN Roads Department is responsible for the maintenance of the road. Overhanging branches must be cut back to stop a crowning fire.
FB Number	Description & Current Status	Maintenance & Responsibility
Firebreak 1 (blue)	The Knysna river is flowing with fresh water. It widens to the south and narrows to the north. In the north vegetation gets thick, but is also indigenous and wet.	SANParks, together with Working for Water are taking care of this river. This includes water quantity and quality checks and alien removal. Being done as necessary.
Firebreak 2 (orange)	The N2 is two lanes wide with clean road verges or both sides. The Lagoon is just south of the N2, with masses of sea water.	SANRAL ensures that the road verges are clean on the N2. This includes cutting of grass and clearing of overhanging branches. Being done every 3 months. Knysna municipality re-act to accidents on the road verges and SANParks looks after the Knysna Lagoon. Is being monitoring constantly.
Firebreak 3 (purple)	A large distribution power line of Eskom runs across the FMU, from east to west. Certain areas are well cleaned while other areas are overgrown. Although certain areas are overgrown it is still a break in the vegetation, to a certain extent.	Eskom needs to keep its power line servitudes clean of any vegetation. This isn't to say that it has to be slashed to ankle height, but rather that any falling or swaying trees will not touch the power line. It should be cleared yearly.
Firebreak 4 (red)	Cape Pine in order to protect their plantations has large 10m firebreaks along their boundary.	Forestry companies always have good firebreaks in place. Cape Pine borders the FMU. This is maintained yearly. Pines can grow very high and can create spot fires, thus a 10m break may not even stop the fire. But is an access point so that we can fight the fire.

FB Number	Description & Current Status	Maintenance & Responsibility
Firebreak 5 (green)	Knysna Municipality has created this firebreak to protect the town of Knysna form fires coming from the Northwest. It is a break in the fuel load, but currently needs maintenance.	Knysna Fire Brigade has constructed and maintains this firebreak. Done yearly.
Firebreak 6 (yellow)	This is an internal road, two lanes wide. All the road verges are not clean, but the tar road in itself is the firebreak. Road verge cleaning will improve the effectiveness of the firebreak.	This internal road, the Old Kaapse Weg road, stretches right through the middle, from south to north. It is a secondary road and EDEN Roads Department is responsible for the maintenance of the road. Overhanging branches must be cut back to stop a crowning fire.

11.4 Fire belt specifications for forest plantations

From Teie, W. C., 2003. Fire Manager's Handbook on Veld and Forest Fires (Strategy, Tactics and Safety). South African Edition. Edited by C. F. Pool, South African Institute of Forestry. Menlo Park. Pretoria.

Type	Position	Prescription
External belts	Bordering on scrub areas	2 to 3 strips of equal width (200m to 1000m) (External protection of plantations should not only consist of block burns) Fynbos areas within a plantation must also periodically be burnt
	Bordering on agricultural land	If the agricultural land is free of inflammable material throughout the fire season the a 10 m wide belt will suffice if not prepare a 20 m strip that must be clear of inflammable material throughout the fire season
	Bordering on other plantations	20 m strip of inflammable material. No silvicultural litter on the strip
	Bordering on railway lines	15 m open strip on border of rail reserve. The rail reserve needs to be keep free of inflammable material
	Bordering on rivers	Remove all IAPs from the area 10 m of either side of the river (water feature – vlei, canal, and swamp). If a belt is prepared parallel to a river it must be at least 10 m away from the bank of the river as not to disturb the riverine vegetation. Width determined by local conditions. If a belt crosses a river the belt must continue through it.
Internal belts	Next to roads	5 to 8 metres wide. Grade roads before fire season to eliminate vegetation growing on "middelmannetjies". Drainage ditches must be kept free of inflammable material. (herbicide or brush cut) Note potential erosion
	Next to indigenous forests	These can be used as firebreaks but where connecting belts are used between forest patch a tracer belt must be prepared on the edge of the indigenous forest to protect it
Tracer belts		Major source of expenditure when preparing for burning a wider belt. Difficult to prescribe standard width but they need to be wide enough to prevent fire from jumping over them while control burning is done. Note ravines, slope, wetlands
	Rule of thumb	On level ground the tracer should be a wide as the surrounding vegetation is high. On steep slopes the width of the tracer must be adjusted to the amount of fire to which they will be exposed. EG upper trace 2 to 4 x the height of the vegetation while lower belt can be half the height of the vegetation. Note exposure to wind and the wider the tracer the faster on a go.

Type	Position	Prescription
		Material removed from tracer should do be ...... as to be a fire hazard. Disturb it away from the tracer in the area to be burnt. Valley bottoms and most areas need special attention – don't falsely try to save money. Note that Bracken ferns (*Pteridium aquilinum*) recover quickly from fire
	In summary	1 to 3 metre wide Use cultivation methods if no danger of soil erosion Mowing maintains grass cover and prevents erosion Herbicides at least three weeks before frost

11.5 Guidelines for Fynbos and Stack Burning

A guideline was compiled by Philip Prins and Clinton Dilgee of the Table Mountain National Park, together with Pierre Gallagher of Cape Peninsula FPA, in May 2016. An extract is provided below.

South African NATIONAL PARKS

Guidelines for Prescribed Burning and Fuel Reduction (Stack) Burning within Table Mountain National Park

Although a number of diverse types of burning practices are exercised the two most common being used in Table Mountain National Park (TMNP) are Prescribed Burning in a block form for essential biodiversity and ecological reasons and Fuel Reduction Burning / Stack Burning to reduce material yielded from alien vegetation clearing.

Within the Cape Metropolitan Area both activities are controlled by a permitting system whereby a burning application is applied for through the City of Cape Town Air Quality Management Department together with the City of Cape Town (CoCT) Fire and Rescue Services to conduct open burning in terms of Sub-section 20 (1) of the Air Quality Management By-law, 2010 and to burn combustible material (excluding waste material) in terms of Sub-section 35 (4) of the Community Fire Safety By-law.

Procedure to obtain said permit:

- Completed Open Burning Permit Application form to be accompanied by a detailed burn plan, detailed map/s, a letter from the Cape Peninsula Fire Protection Association (CPFPA) confirming your FPA membership in good standing and status and a five year fire management strategy and annual plan of operations;
- Relevant local printed media publishing one's intention of open burning and to allow the public the right to object for a valid reason;
- All of the above submitted to Air Quality Management Department; and
- Conduct a site meeting with relevant Air Quality Management practitioner and Fire and Life Safety Officer from the City Fire and Rescue Services and seek approval.

PRESCRIBED BURNING FOR BIODIVERSITY PURPOSES:

Priority areas for prescribed burning are determined by the TMNP Prescribed Burn Priority Framework developed by the SANParks Cape Research Centre (CRC) and the TMNP Fire Management Department taking into account various attributes such as:

i) the ecological score, which will be determined by the vegetation type and status, veld age(frequency), etc.;
ii) access, the management score, which will be determined by access to the site, availability of water sources, existing firebreaks, etc.;
iii) the infrastructure score, which will be determined by the proximity of infrastructure and its flammability;
iv) the tourism impact of proposed burnt area (no impact, low/moderate/high impact);
v) the alien vegetation in terms of no aliens, standing aliens, alien cleared and stacked;
vi) the proximity to the WUI,
vii) heritage sites and structures in proposed burnt areas; and
viii) the completion of the prescribed burn plan.

Inputs from all relevant TMNP Conservation Departments should be taken into account as the highest scoring areas according to the Prescribed Burn Priority Framework may not always be the immediate priority.

Prescribed burning should primarily take place between the middle of March to the end of April as weather conditions dictate. Days with favourable conditions such as mild temperatures (<25°C), moderate wind speeds (<20km/hr) and 2-3 days after light rains provide the prime conditions for prescribed burns to be carried out safely. It is also considered viable to conduct burning in the months of October and November as suitable burning weather is greatly limited. The provisional guideline is that the minimum area burnt in a prescribed burn should be at least 25 ha to minimise the impacts of herbivores. Ideally the proportion of the veld burnt in fires >500ha should be 75% as this will counter any edge effects and is a reasonable size considering the size of the Park (Forsyth 2007). Fewer large prescribed burns will therefore be more effective than attempting to conduct numerous small burns as there is a limited number of suitable burning days in any year.

It is important that when a prescribed burn is planned the ecological procedures as described in the Parks Fire Management Plan (Forsyth and Bridgett, 2004) be carefully followed.

Preparation of control lines:

All control lines constructed with the intention of burning need not necessarily be of the same dimensions. Control lines on the leeward side of the area to be burnt need not be as wide as the windward control lines unless the preparation of control lines are specifically to keep the option open on prevailing wind. This is not always advised in that unsuspecting wind shifts will most commonly occur as generated by the fire itself. There are times that gradient and/ or funnelling will be the overwhelming factor in wind direction and fire behaviour. It is advised to utilise existing firebreaks, young veld and other features such as management tracks to limit preparation work required. In preparing the area, a large amount of combustible fuel will be generated and such fuels must be spread at least 20m within the area to be burnt. Vegetation should never be massed on the verge of the cut control line as intense heat and the increase of embers being fanned over the constructed control line will be drastically increased.

Open Burning Permit conditions for a prescribed burn:

1. Adequate control lines will be made around perimeter of area/s to be burnt as required.
2. Immediate neighbours to be notified prior to the proposed burning, with the following Departments being notified on the day of the burn: CoCT Air Quality Management, CoCT Fire and Rescue Services and the Cape Peninsula Fire Protection Association.
3. Prescribed/Ecological/Biodiversity burning operations are limited to the following months: February, March, April, September, October and November. Burning is subject to weather conditions below;
4. Under no circumstances is any fire to be left unattended until it is completely extinguished with no glowing embers left;
5. Smoke must be managed in such a way to limit traffic hazards or nuisance to neighbouring properties;
6. Burning must be limited to the approved areas only;
7. The controlling authorities as mentioned above have the right to suspend or prevent any burning activities should the need arise;
8. The extinguishing medium and associated equipment/resources are to be readily available at all times while burning takes place;
9. Observe the conditions of the National Veld and Forest Fire Act No. 101 of 98 with specific reference to the National Fire Danger Rating System (SAWS);
10. The landowner accepts full responsibility for any damages, which may occur to any property as a result of the spreading of the fire outside the boundaries of the property and shall be liable for all costs incurred by fire-fighting resources extinguishing runaway fires;
11. Prescribed/Ecological/Biodiversity burning: A trained person in possession of an accredited qualification with a minimum of IC Type 5 (Fire Boss 1) to be present at all times when burning.
12. Weather Conditions:
    a. Only burn when weather conditions are favourable and limited to: Temperature: less than 28°C, Humidity: more than 25%, Wind less than 20km/h.
    b. Conditions are also applicable for forecasted weather for at least 3 days post burn.
    c. All burning operations are subject to the official SAWS Fire Danger Index, available daily from Fire Services Control Room. No burning to take place on Orange and Red days without special written permission from all of the above mentioned authorities.

FUEL REDUCTION/ STACK BURNING:

Burning of cut and stacked vegetation is referred to as fuel reduction or stack burning and is also subjected to the issuing of a Burning Permit through the City of Cape Town Air Quality Management by the same procedures. Materials of differing types and volumes will always be generated during alien clearing operations and with the exorbitant costs of chipping and transport, the burning of stacks is a proven cost effective means of removing cut vegetation. Considerably lower in risk, stack burning is weather dependant and must adhere to the relevant guidelines as stated in the issued Open Burning Permit. With fuel reduction burns commencing in May, and continuing until August, the operation should coincide with good rains and complement the most important factors again being wind, temperature and humidity. The common practise of burning during rainfall should continue as this augments the reduction of risk and assists with the mopping up activities.

Stacking in windrows is not recommended as it is extremely difficult to control when burning and depending on the type of soils can cause water repellency.

Construction of stacks:

This standard provides a procedure for the construction of vegetation in stacks in order to allow safe and efficient burning:

- material that is to be burnt must only be vegetation from the locality, not household or building material such as plastics, wooden pallets or cardboard boxes
- stacks should not be greater than ±2m in length or width, and must not be greater than ±1,5m high
- logs over 150mm in diameter should not be added to the stacks, instead they should be laid flat on the ground to prevent erosion and provide habitat
- material must be dead and dry before being burnt

Burn safety measures for stack:

- Before lighting the stack, ensure that you have suitable tools handy (hay forks and rake hoes) to conduct the burn and control possible spot fires;
- Ensure that there is sufficient water supply to extinguish the burn and that hoses have appropriate water pressure that can reach around the pile;
- Stacks should be lit on the leeward side first and allowed to burn 50% of the stack before closing off;
- A stack may only be lit entirely if there is absolutely zero wind or on the windward side if the material is excessively wet but this is not advisable;
- The number of simultaneously lit stacks is dependent on the available resources and ultimately cannot be dictated;

- Allow stacks to burn out as much as possible before extinguishing as this will limit water required and save time;
- Complete extinguishing the stacks immediately after the burn is finished. The spreading of burnt material using rake hoes post burn assists in allowing the smouldering material to be properly extinguished;
- Progress with mop up throughout the operation and do not leave all burnt stacks till the end (time constraints);
- The use of a blower is advisable for wetter material;
- To increase productivity and if resources allow it: split crews into a burning unit and a mopping up unit;
- Set up the entire area and charge hoses before the first stack is ignited;
- Always have a trained responsible representative on scene with the allocated permit at hand; and
- Always follow the prescribed Open Burning Permit conditions.

Open Burning Permit conditions for Fuel Reduction/ Stack Burning:

1. Adequate control lines will be made around perimeter of area/s to be burnt as required.
2. Immediate neighbours to be notified prior to the proposed burning, with the following Departments being notified on the day of the burn: CoCT Air Quality Management, CoCT Fire and Rescue Services and the Cape Peninsula Fire Protection Association.
3. No burning shall commence after 12:00 on any Friday. No burning on weekends and on any public holiday;
4. Stack/fuel reduction burns are limited to between 07:00 and 16:00 daily and all burning material must be extinguished before leaving the site. Burning is subject to weather conditions below.
5. Stack/fuel reduction burns are limited from 01st May to 15th October;
6. Under no circumstances is any fire to be left unattended until it is completely extinguished with no glowing embers left;
7. Smoke must be managed in such a way to limit traffic hazards or nuisance to neighbouring properties;
8. Burning must be limited to the approved areas only;
9. The controlling authorities as mentioned above have the right to suspend or prevent any burning activities should the need arise;
10. The extinguishing medium and associated equipment/resources are to be readily available at all times while burning takes place;
11. Observe the conditions of the National Veld and Forest Fire Act No. 101 of 98 with specific reference to the National Fire Danger Rating System (SAWS);
12. The landowner accepts full responsibility for any damages, which may occur to any property as a result of the spreading of the fire outside the boundaries of the property and shall be liable for all costs incurred by fire-fighting resources extinguishing runaway fires;
13. Stack/fuel reduction burns: A suitably trained and competent person to be present at all times when burning;
14. Weather Conditions:
    a. Only burn when weather conditions are favourable and limited to: Temperature: less than 28°C, Humidity: more than 25%, Wind less than 20km/h.
    b. Conditions are also applicable for forecasted weather for at least 3 days post burn.

c. All burning operations are subject to the official SAWS Fire Danger Index, available daily from Fire Services Control Room. No burning to take place on Orange and Red days without special written permission from all of the above mentioned authorities.

Equipment maintenance:

Before attempting to burn any form of material, the basic tools at hand should be serviced and properly tested prior to the operation.

- Drip torches should be checked for leaks and depending on the type sealed, repaired or replaced. After-market wicks should be replaced and breather screws must be in situ;
- Fire beaters should be adequately checked for any breakages. Handles often break at the join between handle and conveyor belting;
- Rake hoes must be sharp and handles must be checked for cracks; and
- All other mechanical equipment such as pumps, branches/nozzles, standpipes, hoses, etc. should be serviced in house or alternatively by the dealer.

Fuel mixes and alternatives:

The industry standard for a fuel / drip torch mix is three parts diesel to one part petrol mix (3:1). This is not to be followed categorically as dryer fuels require a lower ignition temperature and therefore less petrol may be incorporated and vice versa. In the prevailing economic times alternatives to diesel is available and should be considered. Expired fuels is one option with water contaminated fuels being a sought after commodity. Used oils, with paraffin or Jet A-1 fuels can be incorporated. Gas ignitors are common in grasslands and savanna but not suitable for igniting heavier fuels and fynbos.