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GEF FYNBOSFIRE PROJECT

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

RISK TO COMMUNITIES AT THE WILDLAND-URBAN INTERFACE

April 2015

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1. INTRODUCTION

Wildfires are increasingly affecting humans and their assets worldwide. Climate change and developments in fire-prone landscapes compound this problem (Moritz *et al.* 2014). This is most pronounced along the wildland-urban interface (WUI) where urban development borders on and intermingles with, flammable wildlands (Theobald and Romme 2007).

The WUI is where residents and their assets are exposed to death or injury and damage from wildland fires. Gill *et al.* (2013) describe assets as something we value and fire prone assets can be social, economic and environmental in nature. Examples of social assets include human lives and homes, businesses, houses, schools and sheds, while environmental assets could include wetlands or biodiversity.

In South Africa we have three main fire prone ecosystems (Le Maitre *et al.* 2014). These are the grasslands, savanna and fynbos biomes. In the fynbos biome, the focus of this study, WUIs are 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 and van Wilgen 2008). The fires in January 2000 made headlines and led to the creation of the Ukuvuka campaign (Combrinck *et al.* 2003) which aimed to educate the public about fires, improve fire management and reduce the risk to lives and livelihoods. This campaign also played a role in the initiation of the Working on Fire programme and establishment of Fire-Wise communities in 'South Africa is being promoted by the Working on Fire programme. The Fire-Wise initiative started in the United States with the aim of enabling fire prone communities to prepare and to protect themselves from wildfires.

Despite fire managers in the fynbos biome being aware of high risk areas, there has been no systematic analysis of wildland-urban interfaces in the biome that can be used to identify high risk areas and direct interventions aimed at reducing those risks. As the WUI expands so does the need for increased hazard reduction, but, although people often know there are fire hazards where they live it does not mean that they will take actions to increase their safety (Moritz *et al.* 2014).

In assessing the risk posed by wildland fire to communities on the WUI we adopted a case study approached. Our case studies were located in the Gordon's Bay and Plettenberg Bay municipal areas and aimed at: i) defining the features of the wildland-urban interface; ii) characterising populations and assets at risk from veldfires; iii) developing a template for assessing risks and iv) using this information to assist communities in planning for wildfires. The outputs of this assessment are databases of information relating to the risks associated with the WUI that can be used by the relevant fire protection associations (FPAs) to improve their existing wildfire plans.
We developed two approaches to assessing the risk on the wildland-urban interface (WUI) that can be incorporated into local disaster management planning and that we believe can be used throughout the fynbos biome. The first method is better suited for delineating the WUI and assessing the risk where there is a clear distinction between built-up areas and wildlands. We applied this method to the Helderberg Basin WUI in the vicinity of Gordon's Bay and Somerset West. The second approach is more appropriate for more rural areas where individual homes

and other buildings are scattered throughout a wildland dominated landscape. We applied the second approach to the areas surrounding the town of Plettenberg Bay in the Southern Cape.

1.1 Defining the Wildland-Urban Interface

The WUI can be defined as the location where homes and structures are built among forests, shrubs or grasslands (Radeloff *et al.* 2005) and descriptions of a WUI typically do so in terms of the presence of humans in the proximity of flammable vegetation (Herrero-Corral *et al.* 2012). This is where most human fatalities, home loses and fire-suppression expenditure occur (Moritz *et al.* 2014).

Wildlands are places where there is enough fuel (e.g. litter, dead branches, fine plant material) to sustain a vegetation fire. These areas include nature reserves, vacant land (often invaded by woody and herbaceous invasive alien plants), timber plantations, orchards, vineyards and agricultural land. Delineating the WUI is important for managing fire hazards as it is where residents are at risk from wildland fires (Whitman *et al.* 2013).

Typically the WUI is a continuous observable line with development on one side and wildland on the other. However it can also include "fingers" of vegetation that protrude into build-up areas, "islands" of development that are detached from but in the proximity of built-up areas and what Theobald and Romme (2007) refer to as occluded areas of isolated wildland within an urban area. Fingers often occur where land is too steep to build on.

The management of these areas also is often neglected allowing them to become overgrown by invasive alien plants (IAPs) and thus increasing the fuel load. Fingers are particularly important because they can serve as conduits, allowing wildland fires to enter and cause damage within formally built-up areas.

Property losses on the WUI can be substantial. For example, in Australia the potential for large numbers of houses to be destroyed by wildfires at the edge of is substantial with 84 buildings being lost on average per annum (McAneney *et al.* 2009) and 552 wildland fire related deaths occurring from 1990 to 2008 (Haynes *et al.* 2010). Extreme weather conditions can lead to very severe losses and during the so called Black Saturday event in 2009 in Victoria, Australia 173 people lost their lives and 2029 homes were lost (Gill 2013 and Haas *et al.* 2013). In the chaparral vegetation of southern California over the past 50 years about 500 homes have been lost each year from wildfires but since 2000 the number has doubled (Syphard *et al.* 2014). Similarly in Colorado 507 residences were destroyed in the 2012 Waldo Canyon fire and 346 in the 2013 Black Forest fire (Haas *et al.* 2013).

Losses on the WUI interface in the fynbos biome have thus far not been as severe as in Australia, southern California and the Mediterranean Basin that have similar climates and vegetation. However damage to property on the WUI does occur in the fynbos biome. For example, 14 structures, including 8 houses, were destroyed and over 50 other structures badly damaged during the January 2000 fires on the Cape Peninsula (Combrinck *et al.* 2003). Newspapers report that 35 houses and backyard shacks were destroyed in January 2010 in the township of Kwanokuthula near Plettenberg Bay during a wildfire. A hotel and several houses were damaged or destroyed during a wildfire on the slopes of the Helderberg near Somerset West in April 2011.

1.2Risk on the Wildland-Urban Interface

The ISO 31000 Standard of 2009 (ISO 31000: 2009) defines risk as: "The effect of uncertainty on objectives" and notes that risk is often expressed in terms of a combination of the likelihood of occurrence and the associated consequence of an event.

The same approach was adopted for the National Veldfire Risk Assessment (Forsyth *et al.* 2010) that defined risk as comprising of two elements, "the likelihood of something happening and the consequences if it happens." The "something" in this case, is a wildland fire on the wildland-urban interface. So in the case of wildland fire:

Risk = a function of the likelihood of a wildland fire and the consequence for a vulnerable asset should a wildland fire (hazard) occur.

This is consistent with the procedure specified for risk assessments by Fire Protection Associations in the preparation of their business plans in Terms of the National Veld and Forest Fire Act No. 101 of 1998 (Forsyth *et al.* 2010).

We have used the same approach in developing systematic steps to analyse the risk on the Helderberg Basin (Gordon's Bay) and Plettenberg Bay wildland-urban interfaces. This was done using the risk to human life and economic assets found on the WUI. The likelihood of a wildland fire occurring was assessed by identifying the hazard posed by different fuel types and loads along the WUI. The consequences of a wildland fire on the WUI were assessed in terms of human life and economic assets using the location and type of buildings as a measure of the vulnerability of human lives and economic assets. Risk classes were defined based on the different combinations of likelihood of a wildfire occurring at any given place and the consequences should this happen.

Often higher fuel loads are found in areas having steeper slopes, presumably because these are more difficult and costly to manage. Fuel accumulation increases the likelihood that fires will become uncharacteristically large and intense (Syphard *et al.* 2009). High fuel loads on steep slopes compound the fire problem because fire spreads more rapidly on steep slopes making it more difficult for fire fighters to contain. Most building damage occurs during infrequent extreme events associated with droughts, high fuel loads, limited resources and failure to mitigate risk (McAneney *et al.* 2009).

Moritz *et al.* (2014) believe that responsibility for mitigating risk must be shared between government and the private land owners at risk. Reducing wildfire losses also depends on better land use planning and appropriate mitigation methods (Syphard *et al.* 2014). The challenging issue is tackling the problem of where people choose and are allowed to build (Moritz *et al*. 2014) and how they build.

Gill *et al.* (2013) identified three general responses to wildland fire problems, particularly on the WUI: *solve it, live with it or minimise it*. They argue that solving it is not possible and simply trying to live with it is not an option. This means that the only real option is to minimise it adverse impacts. They suggest four strategies to minimise these effects; i) control fuels, ii) to

increase the resistance of assets, iii) move or avoid placing assets where fire risks are high, and iv) enhance recovery from disasters and promote adaptation by improving preparedness and responses. We have followed this pro-active strategy in developing our stepwise approach by identifying assets at risk and recommending approaches to minimise the effects of the inevitable wildfires on those assets.

2. HELDERBERG BASIN WILDLAND-URBAN INTERFACE

2.1 Introduction

The Helderberg Basin is surrounded by rugged sandstone mountains in the north and east, False Bay in the south-east and Somerset West on the western side. The mountainous terrain features the Helderberg, Somerset West Sneeukop, Sir Lowry's Pass and the slopes of the mountains below the Steenbras Dam in the east (Figure 1). The basin is drained by the Lourens and the Sir Lowry's Pass rivers. The area is subject to periodic fires with four large fires in the recent past (February 2001, December 2008, February 2009 and April 2011) which caused damage to properties in both Gordon's Bay and Somerset West.

The Cape Peninsula Fire Protection Association (FPA) is focussed on integrated fire management in the peri-urban and rural parts of the City of Cape Town including the Table Mountain National Park. The Cape Peninsula FPA is particularly interested in reducing fire related risks along the WUI as this is where the greatest potential exists for damaging wildland fires.

In discussion with the Cape Peninsula FPA it was decided that it would be most beneficial to the FPA to delineate the WUI not only in the vicinity of Gordon's Bay but to extend it to include the Sir Lowry's Pass area and Somerset West (Figure 1). This area includes the entire eastern boundary of Cape Peninsula FPA's East Ward and in the text we will refer to the WUI in this area as the Helderberg Basin WUI.

In defining and characterising the WUI for the Helderberg Basin we worked closely with Ms Andrie Sommers, the manager of the East Ward of the Cape Peninsula Fire Protection Association.

2.2 Description of the Helderberg Basin Wildland-Urban Interface

Large sections of the Wildland-Urban Interface (WUI) have distinct boundaries where wildland vegetation (fuel) is found on one side of the WUI and formal housing (suburbia) on the other (Figure 1). It is 107.6 kilometres long and includes fingers, islands and occlusions. It starts at the R44 road to Stellenbosch in the north-west, and then borders residential suburbs, the Helderberg College, Helderberg Nature Reserve and Erinvale Golf Estate on the lower slopes of the Helderberg. It then runs through the lower sections of the large farms of Lourensford Estate, Vergelegen and Morgenster before skirting residential areas on the Skapensberg. Next it winds through a number of small holdings, small farms and homeowners and property owner associations in the vicinity of Sir Lowry's Pass Village.

The WUI now crosses to the south of the National Road (N2) near the foot of Sir Lowry's Pass and continues towards Gordon's Bay. It forms a boundary between a number of small holdings on the lower slopes of the mountain and undeveloped properties on the upper slopes. Much of this area has been invaded by woody alien plants and these small holdings are exposed to any wildland fires approaching from the south-east. Some houses were destroyed or badly damaged by wildfires in this area during 2001 and 2008.

The WUI continues on the mountainside above the City of Cape Town's pumped water storage scheme's dam before continuing in a more or less straight line immediately above the suburbs of Mansfield and Mountainside to "Die Vyf Huise" at the start of the service road to the Steenbras Dam on the southern side of Gordon's Bay. There is now a break in the WUI until the Sunbird Lodge which is at the mouth of the Steenbras River.

The Silverboomkloof Natural Heritage Site can be considered an occluded area along the WUI (Item 1 in Figure 1) while close by there are fingers of vegetation contiguous with wildland fuels on the outside of the WUI extending into suburbia (total length 8.2 km). One example is along Oldenland Road in Helderrand where tall *Eucalyptus* trees on public opening space land protrude into the residential area of World's View (Item 2 in Figure 1).

Islands of development form a significant component of this WUI with a total perimeter of 30.7 km, more than a quarter of the total length of the WUI. These areas are completely surrounded by wildland fuels and vulnerable to fire on all sides (Items 3 & 4 in Figure 1). Examples of islands include numerous houses on the Wedderville and Knorhoek Estates, the Bezweni Lodge near Sir Lowry's Pass and the Sunbird Lodge at the mouth of the Steenbras River.

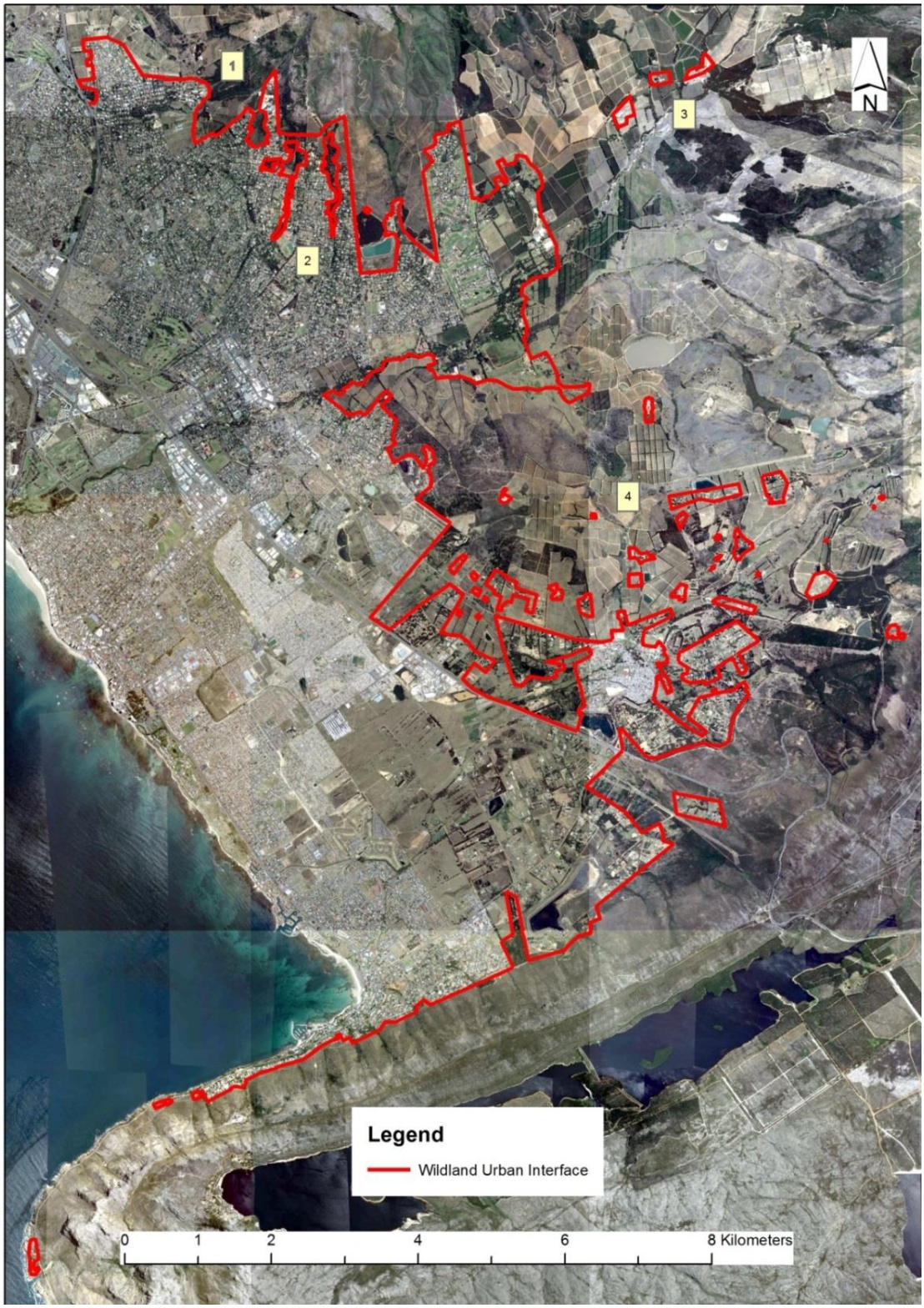

Figure 1: The Helderberg Basin Wildland-Urban Interface running from Gordon's Bay in the South to the R44 road in the north-west. It is 107.6 kilometres long and includes occlusions (No 1), fingers (2) and islands (3, 4).

(Digital aerial photograph extract: Chief Directorate: National Geo-spatial Information, 2013)

The hilly and mountainous terrain found along the Helderberg Basin WUI is steep to very steep in places. The average slopes found along the WUI were classified into four percentage based classes; Mild (0 <5%), Moderate (5 <15%), Steep (15 <25%) and Very Steep (>25%) (Figure 2). Almost a third of the area has steep to very steep slopes making fire-fighting more difficult, and increasing the potential rate of spread should a fire occur. The mountainsides above Gordon's Bay, a section of the Schapenberg and Silverboomkloof are particularly steep (Figure 3).

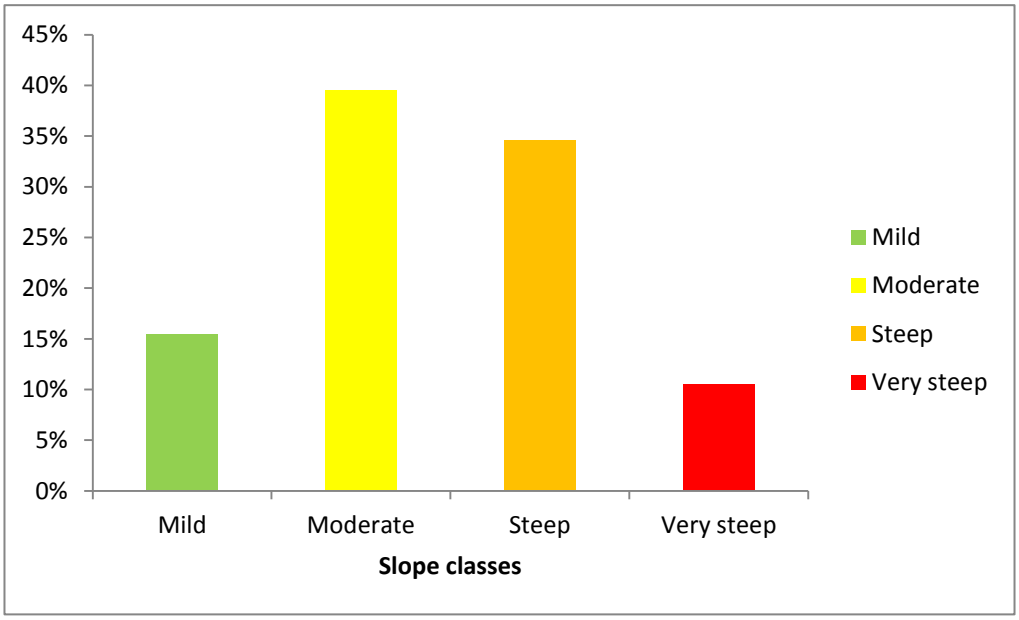

Figure 2: Average slope classes expressed as percentages along the Helderberg Basin Wildland-Urban Interface. Mild slopes are 0 <5%, moderate slopes 5 <15%, steep slopes 15 <25% and very steep slopes (>25%).

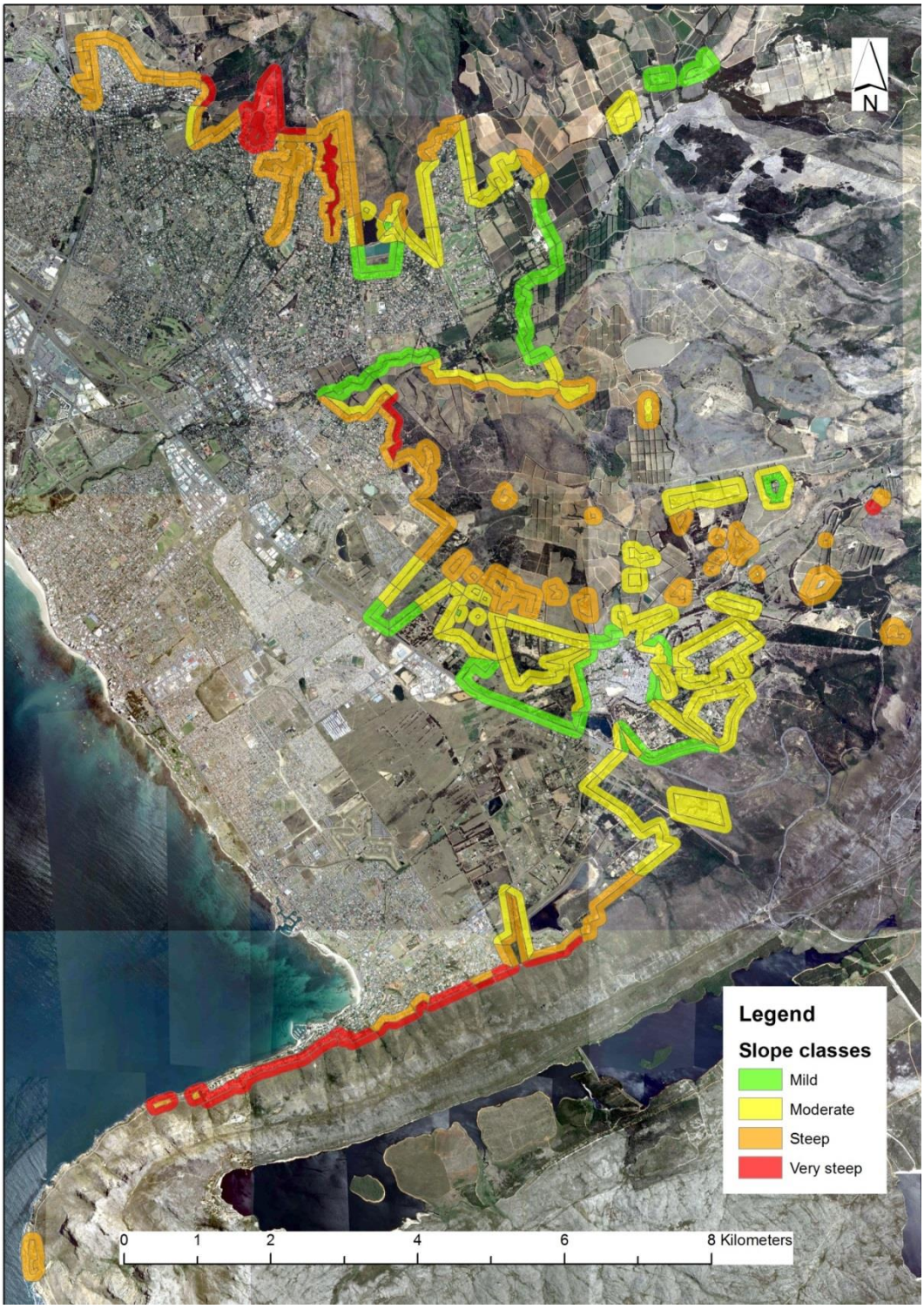

Figure 3: The distribution of the average slopes immediately downslope (inside buffer) and upslope (outside buffer) of the Helderberg Basin Wildland-Urban Interface.

(Digital aerial photograph extract: Chief Directorate: National Geo-spatial Information, 2013).

2.3 Method used to delineate the Helderberg Basin Wildland-Urban Interface and assess the adjacent wildland fire risk

A sequence of steps was followed to delineate the WUI and assess the fire risk posed to people and property in the area (zones) immediately adjacent to it (Figure 4). These steps are discussed in more detail below.

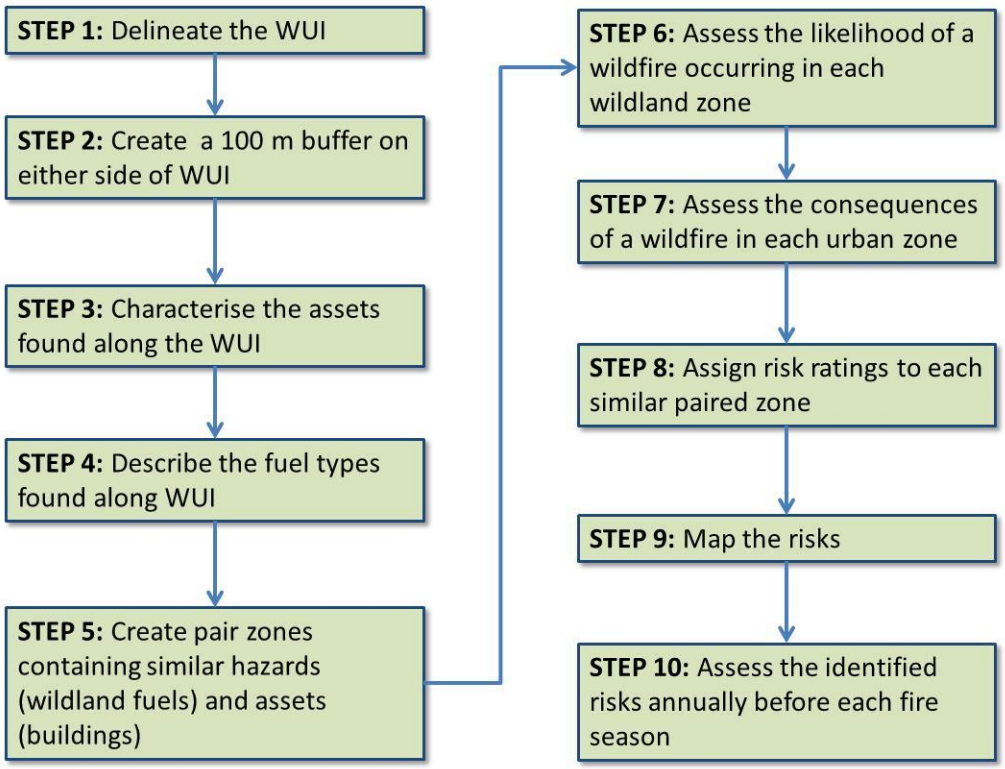

Figure 4: Steps followed to delineate the Wildland-Urban Interface and assess the hazards and risks along it.

Step 1: Delineate the Wildland-Urban Interface

Identify an observable line which best represents the boundary between wildlands on one side and developed areas on the other. Typically the boundary forms a continuous observable line with development on one side and wildland on the other, but it can be broken in places to accommodate special situations. These include:

(i) Islands where residential, commercial or farm buildings are entirely or almost entirely surrounded by wildland (Figure 5),

(ii) Occlusions (Theobald and Romme 2007) where wildland is entirely surrounded by a built-up area, and

(iii) Fingers where vegetation linked to the wildlands protrude into urban areas.

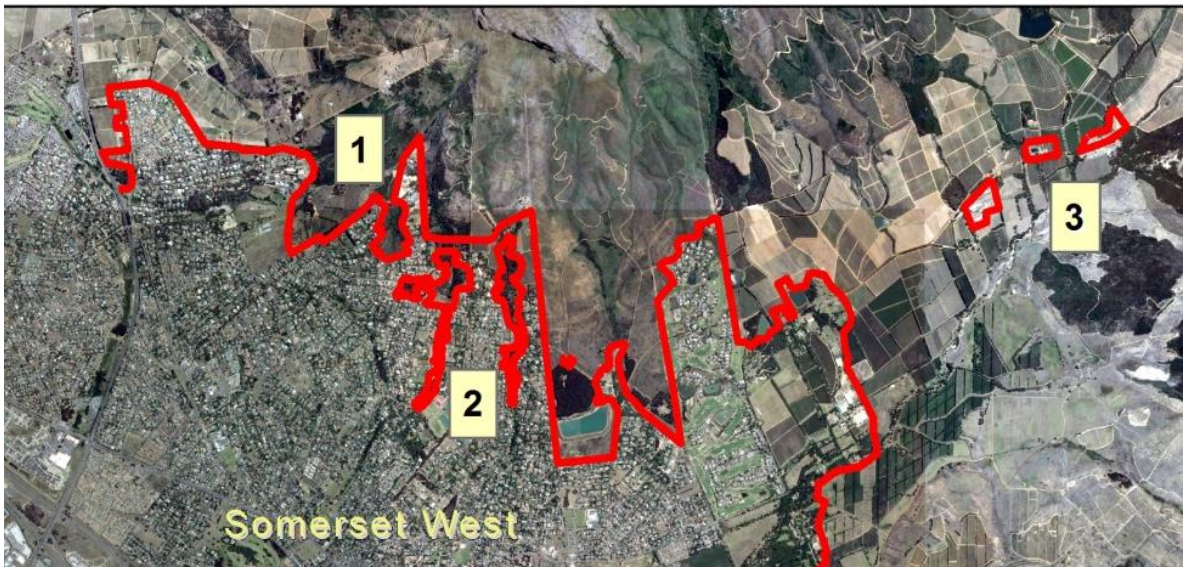

Figure 5: A portion of the Helderberg Basin WUI in the vicinity of Somerset West separating wildland and agricultural fuels from urban and peri-urban areas. Numbered features include: (1) occlusion of vegetation at Silverboomkloof, (2) fingers of wildland fuels protruding into the urban area, and (3) islands of development surrounded by flammable vegetation.

(Digital aerial photograph extract: Chief Directorate: National Geo-spatial Information, 2013).

Residential areas include clusters of buildings on farms such as: staff housing, offices, workshops and cellars. Isolated high value buildings such as wine cellars, restaurants or lodges were included as islands. The Bezweni Lodge on the Casa Maris property is an example of an island surrounded by flammable vegetation, while the Silverboomkloof Natural Heritage Site is an example of an occlusion where the wildland is almost completely surrounded by a built-up area (Figure 5).

The position of the boundary was determined by visual interpretation from recent (2013) ortho corrected digital aerial photographs obtained from the Chief Directorate: National Geo-spatial Information (NGI), South Africa's national mapping organisation. The initial line, including fingers of wildland penetrating the built-up area, inclusions and islands were digitised on screen using ArcMap 10.3 software. Initial results were presented to the Cape Peninsula FPA's East Ward Committee and some adjustments were made in response to their comments.

Step 2: Create a buffer on either side of the Wildland-Urban Interface

A 100 metre wide buffer was created on either side of WUI using ArcMap 10.1 software. The width of the buffer needs to be sufficient to include the hazard (wildland fuel) and assets (buildings representing the built-up areas where people live and work). This could be at any sensible scale which strikes a balance between excluding important features and becoming too general to highlight crucial places. In this case 100 metres on either side was considered sufficient to create an inside and outside buffer (Figure 6). Similarly Galiana-Martin *et al.* (2011) and Lampin-Maillet (2011) used 100 metre buffers to define the WUI boundary. However, buffer distances need to be evaluated on a case by case basis.

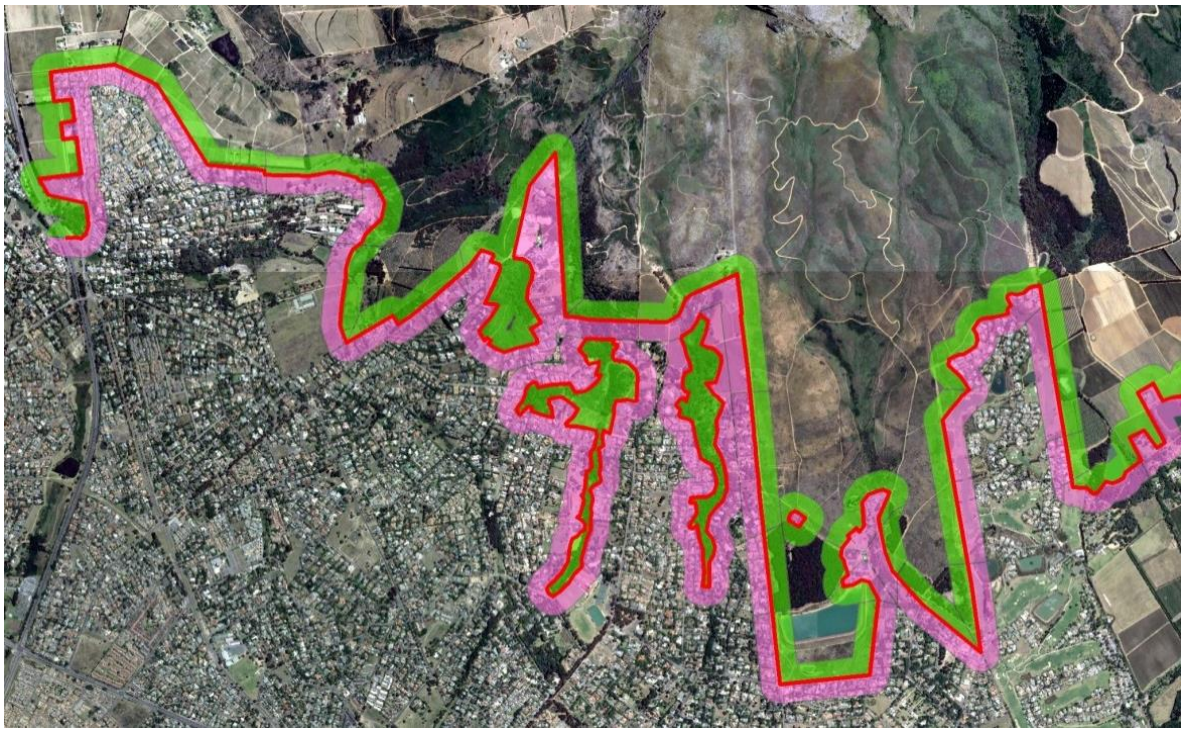

Figure 6: The 100m wide urban (inside) buffer and the adjacent outside 100 wide wildland buffer containing different types of wildland fuel along a portion of the Helderberg Basin Wildland-Urban Interface.

(Digital aerial photograph extract: Chief Directorate: National Geo-spatial Information, 2013).

Step 3: Characterise the assets found along the Wildland-Urban Interface

The WUI buffer was then overlaid on recent (2013) geo-corrected 1: 10,000 aerial photographs using GIS software (Step 1). Then the underlying areas were examined to determine the settlement types and characterise the communities found along the WUI (Table 1).

Table 1: The settlement types and their associated fire characteristics identified along the Helderberg Basin Wildland-Urban Interface

Settlement type	Sub-type	Description
Formal residential	Residential suburb	Single erven with good service infrastructure such as fire hydrants and hard surfaced roads.
	Golf Estate	Large formal houses with landscaped gardens and good established service infrastructure (e.g. Erinvale).
Informal residential	Informal dwellings	Structures constructed from flammable materials and build close to each other in a haphazard pattern thereby restricting access to fire-fighting services
Residential small holdings	Homeowners association	Large plots (± 1 Ha) with single dwellings and outbuildings often with restricted access (single entrance road) (e.g. Tre Donne, Boskloof, High Riding and Wedderville home owners associations).
	Property owners association	Sub-divided large farms with large plots > 1 ha < 25 ha with a number of structures embedded within fynbos. Land used for agriculture (e.g. Knorhoek and Wedderville farming partnership).
	Small holding	Free standing buildings with limited services. Properties are mainly for residential use but sometimes have guesthouses and are < 10 ha in size. Often only have a single entry road.
Commercial farms	Small farm	Mainly vineyards and single houses and sheds with some fynbos and limited services. Often only have a single entry road. Range from 20-135 ha (e.g. Journeys End, Waterkloof, Kings Kloof, Myrtle Grove, Top Cliff, Highbury Vineyards, Ingwe Wines and Goodeverwachting).
	Large farm	Wine cellars, buildings (including historical buildings), vineyards, deciduous fruit orchards, olive orchards, sawmills, restaurants and staff housing. Services mainly provided by the farms themselves. Size 200 - 4000ha (e.g. Morgenster, Vergelegen and Lourensford Estate).
Outlying commercial, recreational and social buildings	Infrastructure	Bulk water supply of City of Cape Town and staff housing with good service infrastructure
	Nature reserve	Offices, workshops, staff housing and restaurants with good service infrastructure
	Educational institution	(including lecture rooms), fields and orchards (164 ha) – Helderberg College
	Resort	Short stay accommodation units (e.g. Bezweni Lodge, Sunbird lodge)
Vacant land		Often infested with invasive alien plants.

The combinations of different settlement types and fire hazards, and the abrupt changes between these, make the Helderberg Basin WUI complicated to manage. For a detailed description of each section of the WUI see Appendix A.

Step 4: Describe the fuel types found along the Wildland-Urban Interface

Vegetation types adjacent to the WUI were classified into four fuel categories; low, medium, high and extreme, and given a likelihood rating based on the frequency at which they are likely to burn (Table 2).

Table 2: Wildland fuel types on the Helderberg Basin Wildland-Urban Interface and the likelihood of wildland fires occurring in each type[1].

Type	Description	Type (Fuel load)	Likelihood rating[1]
Natural veld non-flammable	< 4 years old fynbos and renosterveld, and indigenous forest and thickets	Low	Rare (100 years)
Agriculture less flammable	Vineyards, orchards and irrigated fields	Low	Unlikely (25 years)
Agriculture more flammable	Annual crops and old fields (fallow land)	Moderate	Possible (15 years)
Natural veld flammable	> 4 years old fynbos and renosterveld	High	Possible (15 years)
Invaded natural veld	Invaded by > 50% woody IAPs	High	Likely (10 years)
Timber plantations	Plantations are mainly pine	Extreme	Unlikely (25 years)
Woodlots	Woodlots are mainly eucalyptus	Extreme	Likely (10 years)

[1] *Adapted from AS/NZS 4360:2004* ***(Forsyth et al. 2010)***

The structure of the typical fuel types (classes) on the Helderberg Basin WUI range from vineyards with light fuel loads to pine plantations with extremely high fuel loads (Figure 7).

Figure 7: Typical fuel types present along the Helderberg Basin Wildland-Urban interface: (i) Vineyards with low fuel loads; (ii) Mature fynbos with high fuel loads; (iii) Fynbos invaded with alien vegetation with high fuel loads, and (iv) A pine plantation with an extreme fuel load.

(Photographs – G. Forsyth)

The medium fuel class currently predominates along the WUI and occupies 32.2% of the area. This is closely followed by the high fuel class at 30.0% with the extreme fuel class covering 22.4% of the area. Lastly the low fuel class represents 14.7% of the fuel (Figure 8).

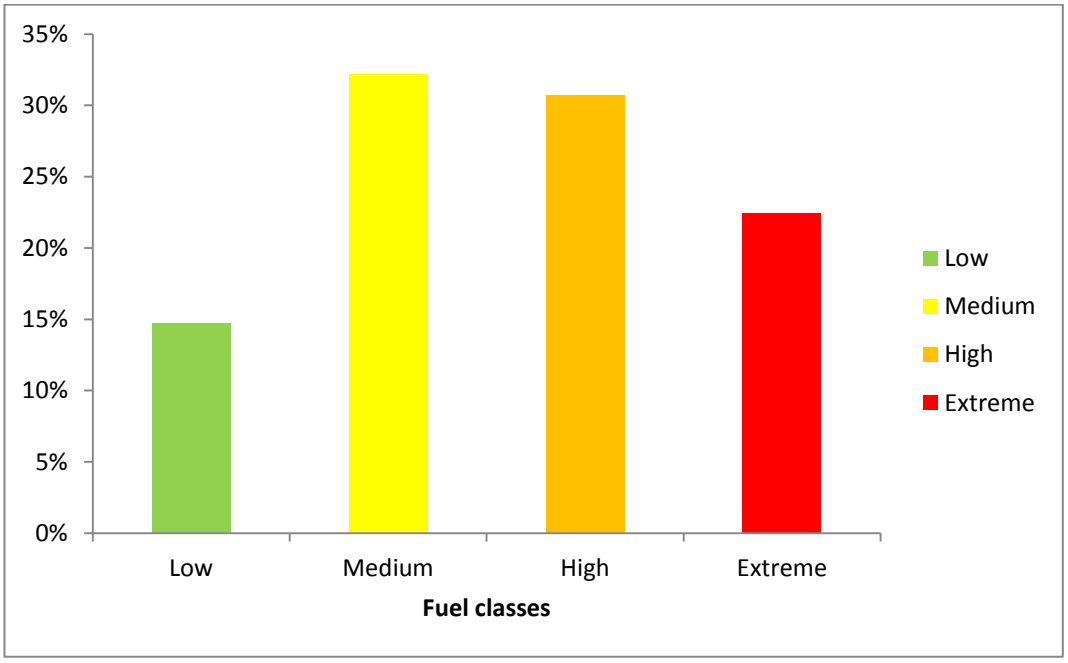

Figure 8: Fuel classes expressed as percentages along the Helderberg Basin Wildland-Urban interface.

There is a linear mosaic of fuel classes along the Helderberg Basin WUI (Figure 9) with extreme fuel loads corresponding with steep slopes in steep places (Figures 3 and 9).

Step 5: Create paired zones containing similar hazards and assets along the Wildland-Urban Interface

Create paired zones having similar hazards (wildland fuels) and assets (buildings) within a 100m buffer zone on either side of the WUI (Figure 6). We identified 127 paired zones and details of these are contained in Appendix A.

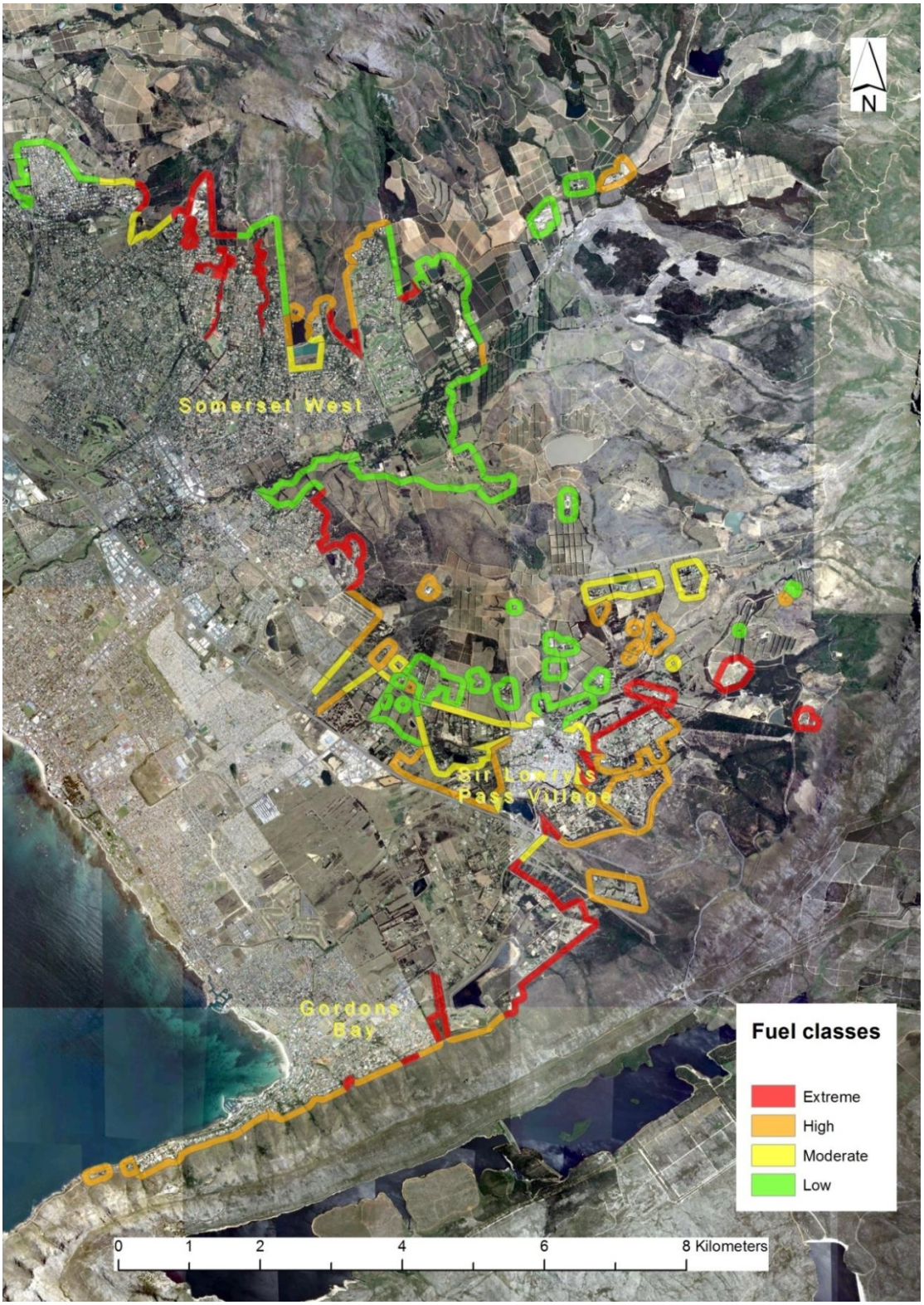

Figure 9: The distribution of fuel classes along the Helderberg Basin Wildland-Urban interface.

(Digital aerial photograph extract: Chief Directorate: National Geo-spatial Information, 2013)

Step 6: Assess the likelihood of a wildfire occurring in each wildland zone

Determine the likelihood of a fire occurring in each wildland zone and spreading to an adjacent built-up area (urban zone) (Table 3), taking fuel types and the frequency of past fires into consideration.

Table 3: Qualitative and quantitative indicators of likelihood i.e. the likelihood that a specific fire risk scenario will eventuate[1]

Likelihood rating	Indicative frequency	Description
Almost certain	once in 5 years	Is expected to occur
Likely	once in 10 years	Will probably occur
Possible	once in 15 years	Might occur at some time; as likely as not
Unlikely	once in 25 years	Could occur at some time
Rare	once in 100 years	May only occur in exceptional circumstances

[1] Adapted from AS/NZS 4360:2004 **(Forsyth *et al.* 2010)**

The likelihood was modified to take into consideration zones having steep slopes as wildland fires will spread more rapidly and be more difficult to contain on steep ground. We identified zones with slopes > 25% and increased the likelihood of a fire occurring by one level in these zones. For example, if the likelihood of a fire occurring in a zone was assessed as "Possible" and that zone had an average slope of >25%, the zone was then assigned an increased likelihood rating of "Likely" (Table 3).

Step 7: Assess the consequences of a wildfire in each urban zone

We determined the consequences of a wildland fire occurring in any paired zone and it spreading to an adjacent built-up area using the information contained in Table 4. This was done for impacts on human life and properties (economic) but this could also be done for other types of assets such as the environmental assets (Table 5).

Table 4: The consequences of a wildland fire occurring on Helderberg Basin Wildland-Urban Interface in terms of human lives and economic assets[1]

Level of consequence		Consequence end points	
		Life consequence criteria	Economic consequence criteria
1	Catastrophic	Death of one or more persons in the scenario	Depressed economy of the municipality. Extensive and widespread loss of assets. Major impact across a large part of the community. Long-term external assistance required to recover.
2	Major	Extensive injuries to people in the scenario, requiring emergency hospitalisation; or, evacuation required	Serious financial loss, affecting a significant portion of the community. Could require external funds (e.g. Disaster Management) to recover.
3	Moderate	Medical treatment required but full recovery possible.	Localised damage to property. Short-term external assistance required to recover.
4	Minor	Minor injuries only – first aid treatment required.	Minor financial loss. Short-term damage to individual assets. No external assistance needed
5	Insignificant	No injuries	Inconsequential or no damage to property

[1] Adapted from AS/NZS 4360:2004 **(Forsyth *et al.* 2010)**

Table 5: The settlement types identified on the Helderberg Basin Wildland-urban Interface and the consequences of a fire for life and the economic consequences were assigned

Type	Description	Consequence to life	Economic consequence
Formal residential	Residential suburb	Minor	Moderate
	Golf Estate	Minor	Moderate
Informal residential	Informal settlements	Catastrophic	Minor
Small holdings	Homeowners association	Moderate	Moderate
	Property owners association	Moderate	Moderate
	Small holding	Moderate	Minor
Commercial farms	Small farm	Moderate	Moderate
	Large farm	Minor	Major
Outlying commercial, recreational and social buildings	Infrastructure - Bulk water supply	Moderate	Major
	Nature reserve	Minor	Moderate
	Educational institution	Moderate	Moderate
	Resort	Major	Moderate
Vacant land	Often infested with invasive alien plants.	Insignificant	Insignificant

Step 8: Assign risks ratings to each similar paired zone

We then used a combination of likelihood and consequence ratings to determine and assign a risk level for each paired zone. This was done from a human safety (life) and an economic (property) perspective (Table 6).

Table 6: Levels of risk assessed as the product of likelihood and consequence[1]

Likelihood Rating	Consequence Rating				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	Extreme	Extreme
Possible	Low	Medium	High	High	Extreme
Unlikely	Low	Low	Medium	High	Extreme
Rare	Low	Low	Low	Medium	High

[1] Adapted from AS/NZS 4360:2004 **(Forsyth *et al.* 2010)**

The relationship between likelihood and consequence could differ for different Wildland-Urban Interfaces and therefore adjustments will need to be made to the level of risk contained in each cell to reflect this (AS/NZS 4360:2004).

Step 9: Map the risks

Map the fuel hazards in the wildland (outside) buffer and social and economic (or any other) risks in the urban (inside) buffer, and assign these to each paired zone. This was done for both social (life) and economic risks (Appendix A).

The risk to human life posed by wildland fires along the WUI is mainly in the medium class (42.6%) while 32% of the area falls in the high risk class (Figure 10).

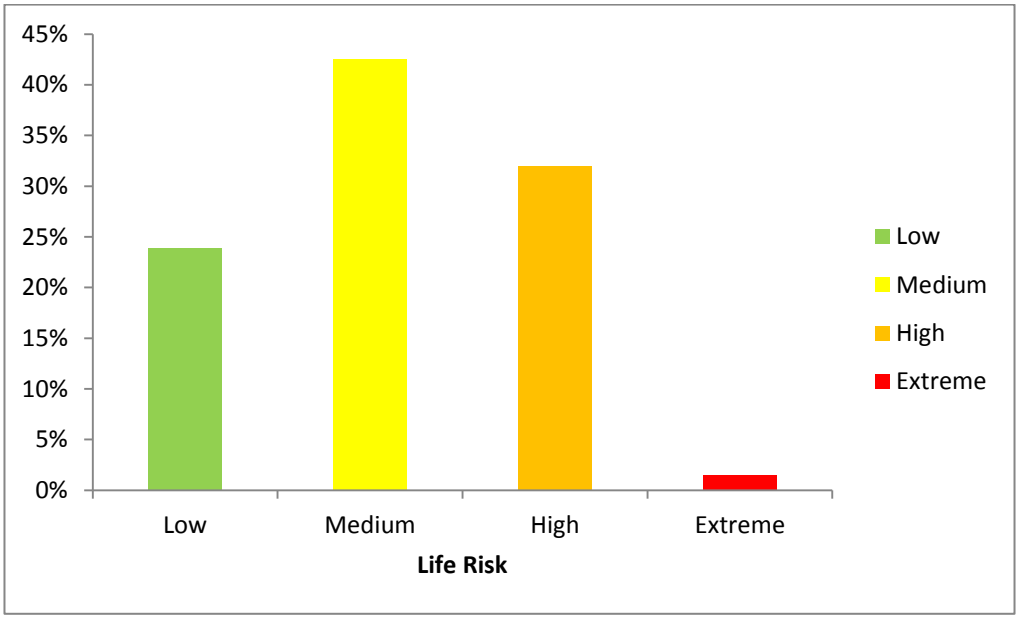

Figure 10: Levels of risk to human lives along the Helderberg Basin Wildland-Urban interface presented in four classes.

Only a very small area has an extreme risk (1.5%) and this is where the informal settlement in Sir Lowry's Pass Village borders on wildland vegetation. Some mitigation has recently taken place here by establishing a FireWise community (Anon. 2013). Most of the area having a low risk to human lives (23.9%) is situated where the WUI runs through intensely farmed areas on flat to mildly sloping land. The distribution of the levels of risk to human lives along the Helderberg Basin WUI is shown by risk classes in Figure 11.

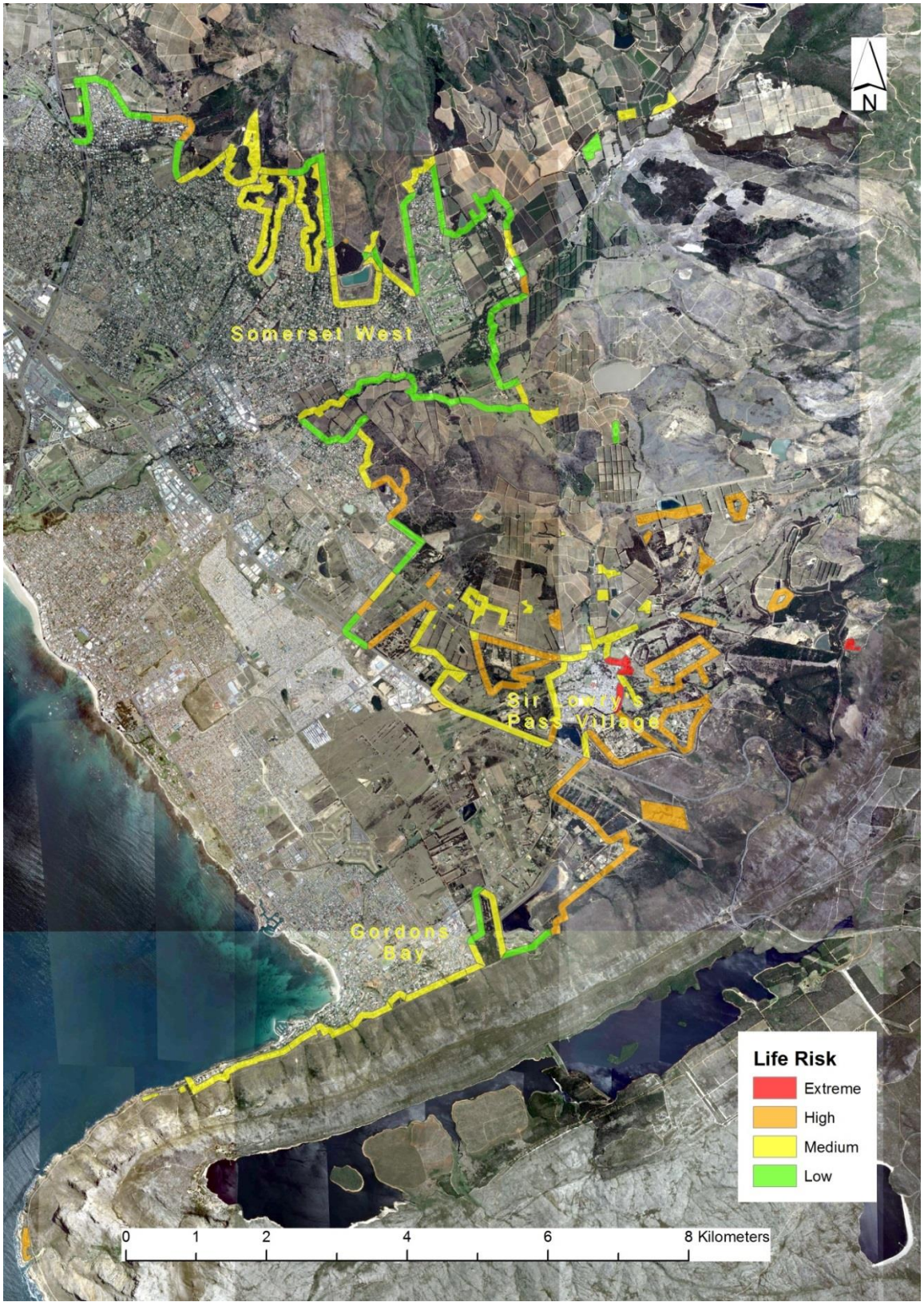

Figure 11: The potential level of risk to human life along the Helderberg Basin Wildland-Urban interface.

(Digital aerial photograph extract: Chief Directorate: National Geo-spatial Information, 2013)

The risk posed by wildland fires to economic assets along the WUI is predominantly in the high class (54%) but no areas fall into an extreme risk class (Figure 12).

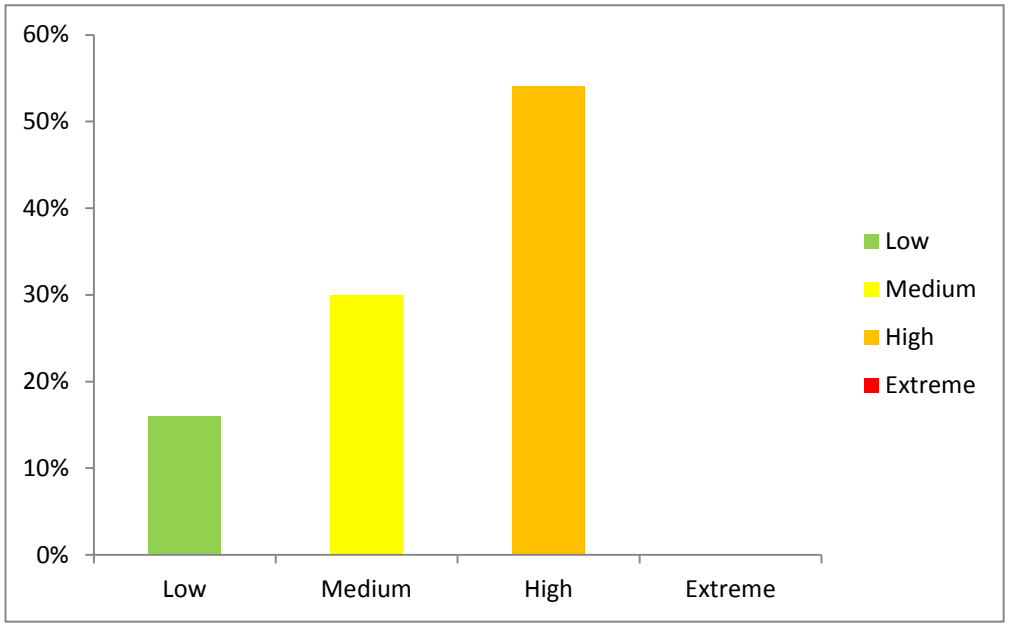

Figure 12: Levels of economic risk along the Helderberg Basin Wildland-Urban interface presented in four classes.

An extreme risk would be where a wildland fire has the potential to damage the regional economy but in the case on the Helderberg Basin WUI we believe that the effects would be local rather than regional. Most of the high risk area occurs were residential suburbs or clusters of houses are located on steeper slopes in the proximity of flammable vegetation (Figure 13). Areas having a low economic risk cover 16% of the area and these are where there are fewer buildings and the adjacent vegetation is either very young fynbos or less flammable vineyards and orchards. As the post-fire age of the fynbos increases the hazards and risks will have to be reassessed.

Figure 13: The distribution of the potential level of economic risk along the Helderberg Basin Wildland-Urban interface.

(Digital aerial photograph extract: Chief Directorate: National Geo-spatial Information, 2013)

Step 10: Assess the identified risks annually

Risks along the WUI should be reviewed annually before the start of each fire season to determine if they are decreasing, remaining the same or increasing. This is especially so if a wildfire has occurred or prescribed burning taken place, or if more urban development has happened during the preceding 12 months. Mitigating actions taken to reduce risk such as preparing fire breaks, provision of more fire hydrants, or creating defendable spaces around buildings also need to be taken into consideration on an annual basis.

2.4 Discussion

The total length of the Helderberg Basin WUI is 107.6 kilometres. This includes the length of islands, occluded areas and fingers (Figure 1). This is a substantial length of WUI for the Cape Peninsula FPA Eastern Ward to manage.

Areas identified as islands have a total external perimeter of 30.7 kilometres and include holiday resorts, isolated farm buildings such as cellars, farm houses and restaurants. Two prominent "fingers" containing tall mature *Eucalyptus* trees were identified bordering on Parel Valley and Oldenland roads in the suburb Helderrand. Collectively their external perimeters total 8.2 kilometres.

There is only one area along the WUI that can be considered to an occluded area. This is Silverboomkloof Natural Heritage Site in the suburb of Spanish Farm. It has an external perimeter of 1.5 kilometres and was set aside to protect the Silver Trees (*Leucandendron argenteum*) that occur there. Adjacent to the Natural Heritage Site but within the inclusion are undeveloped private properties that are infested with woody invasive alien plants that pose a considerable fire hazard.

In the vicinity of the southern boundary of the Helderberg Nature Reserve there are stands of mature *Pinus radiata* trees which increase the fuel load substantially. However, these trees are due to be harvested by February 2015 (pers comm. Roy Ernstzen) thus reducing the hazard. Fuel loads are lower in vicinity of Erinvale Golf Estate, with its watered greens and fairways serving as a "green" firebreak. However on the northern boundary some houses are close to fynbos vegetation.

The intensely cultivated farms that generally occupy the lower gentler slopes, for example the vineyards and orchards of Lourensford Estate, have lower fuel loads. Lourensford Estate also has three islands with one containing a sawmill that is adjacent to a stand of *Eucalyptus* and Black Wattle trees. However, these trees are in the process of being removed (pers comm. Andrie Sommers) and this will reduce the fuel load.

Often higher fuel loads are found in areas having steeper slopes presumably because these are more difficult and costly to cultivate or build on. For example, Silwerboomkloof, the *Eucalyptus* belts protruding into the residential area in the vicinity of Parel Valley and Oldenland Roads in Helderrand, the area behind Boskloof Eco-Estate on the Schapenberg, as well as woodlots in the vicinity of Knorhoek and the mountain slopes to the south of Sir Lowry's Pass.

The WUI is particularly fragmented in the south-eastern slopes of the Shapenberg, the Wedderville and Knorhoek areas, and the areas near the foot of Sir Lowry's pass. Here fuel loads are high, especially where invasive alien trees have invaded the natural veld or where *Eucalyptus* woodlots have been established. The Bezweni Lodge consisting of a number of buildings on the mountain slopes just north of the lower hairpin bend of Sir Lowry's pass is particularly exposed to wildland fires. It forms an island in the fynbos and large stands of *Eucalyptus* trees and other invasive plants border on it. It also only has a single access road that runs through an area with a high fuel load. Fuel accumulation increases the likelihood that fires will become uncharacteristically large and intense (Syphard *et al.* 2009). The railway line between Somerset West and Caledon also passes through this area and is a source of regular ignitions (pers comm. Andrie Sommers).

The boundary between the small holdings along Sweetwaters Road and the wildland is of concern. Much of the area is covered in invasive alien vegetation and this area is exposed to wildland fires approaching from the south-east. Some houses in this area were destroyed or badly damaged by wildfires during 2001 and 2008.

A large part of the residential area along the WUI is well serviced by tarred roads and the City of Cape Town's fire hydrant network. However some suburbs bordering directly on the wildland are built on steep ground and may hinder assess to the adjacent wildland in the event of a wildland fire.

We have been able to determine the relative levels of risk posed to human life and buildings (economic assets) along the Helderberg WUI using the sequential steps outlined above. The risk to life was rated as high mostly for the property owners association and small holding settlement types in the Sir Lowry's Pass area with a few instances, including the informal settlement area of Sir Lowry's Pass Village, where it was extreme. The level of economic risk was not deemed to be extreme anywhere along the WUI. High potential economic risk levels were identified for some formal suburbs, smaller farms and property owners associations.

The information produced should be used as a guide for developing mitigation actions such as clearing of invasive alien plants and prescribed burning of mature fynbos in the vicinity of the WUI. It can also be used to decide on where firebreaks are most needed and feasible.

Residents in the proximity of the Helderberg WUI have access to electronic and print media. This offers the Cape Peninsula FPA many avenues for improving the awareness of wildland fires within these communities.

2.5 Recommendations

The wildland fire risks determined along the Helderberg Basin WUI should be use by the Cape Peninsula FPA East Ward to advise land owners and users on how to mitigate their risk, especially in those areas identified as high and extreme. The approach advocated by FireWise (Erasmus 2011) of getting communities to co-operate in matters of integrated fire management will assist in reducing fire risk, compiling with the National Veld and Forest Fire Act No. 101 of 1998, and abiding with FPA rules.

It is recommended that:

1. Efforts to recruit new FPA members should be focused on properties identified as having high or extreme risk.
2. More FireWise communities should be established, in addition to those in Gordon's Bay and Sir Lowry's Pass Village, in areas identified as having high or extreme risks.
3. The information contained in this risk assessment should be reviewed and improved on annually before the start of each fire season.
4. FPA awareness and prevention and protection measures, including law enforcement, training, construction of firebreaks should also be focussed on properties with high and extreme risks.
5. A list of fire-fighting resources (equipment, training and infrastructure) should be compiled for each property along the WUI starting with the properties (or groups of properties) identified as having high or extreme risks.
6. A further step would be an assessment of the types of buildings found along the WUI in terms of their ability to withstand wildfires. For example, buildings that would withstand wildland fires without any assistance on the part of fire-fighting services or property owners who have sufficient fire-fighting resources and know how where some assistance during a wildfire would be necessary, and lastly where the fire-fighting authorities would probably not be able to assist. The FireWise property check list would aid doing this (Erasmus 2011).
7. Establish what mitigation is in place and decide on what should be put in place for each risk class within each risk zone on individual property to reduce the level of risk. This should include first response capabilities, the position and condition of firebreaks, and where invasive alien plant management is needed.
8. Clarify what risk reduction activities local authorities (including Fire Protection Associations) are responsible for and which are individual property owner responsibilities, for example, who is responsible for managing vegetation fuel.
9. Make the results of any WUI wildland fire risk assessment available to local authorities for incorporation into their emergency response plans.
10. Influence local authorities to improve property and building regulations to design-in wildfire risk mitigation by restricting the use of flammable building and roofing materials for structures built along the WUI.

3. PLETTENBERG BAY WILDLAND-URBAN INTERFACE

3.1 Introduction

We defined the WUI for Plettenberg Bay in collaboration with Paul Gerber, chairman of the Southern Cape Fire Protection Association (FPA). Unlike the Helderberg Basin WUI the development in the Plettenberg Bay area is fragmented with pockets of urban and rural development located within flammable vegetation over an extensive area. The view of the Southern Cape FPA is that the WUI extends well beyond the town of Plettenberg Bay and includes all settlements, farms, small holdings and resorts in five of their fire management units in the vicinity of Plettenberg Bay. It was therefore decided that it would be most beneficial to the Southern Cape (FPA) to use an approach to delineate the WUI that would identify all buildings exposed to wildland fire hazards and risks in the Plettenberg South, Fisantehoek, Wittedrif, Crags, and Keurbooms fire management units (Figure 14).

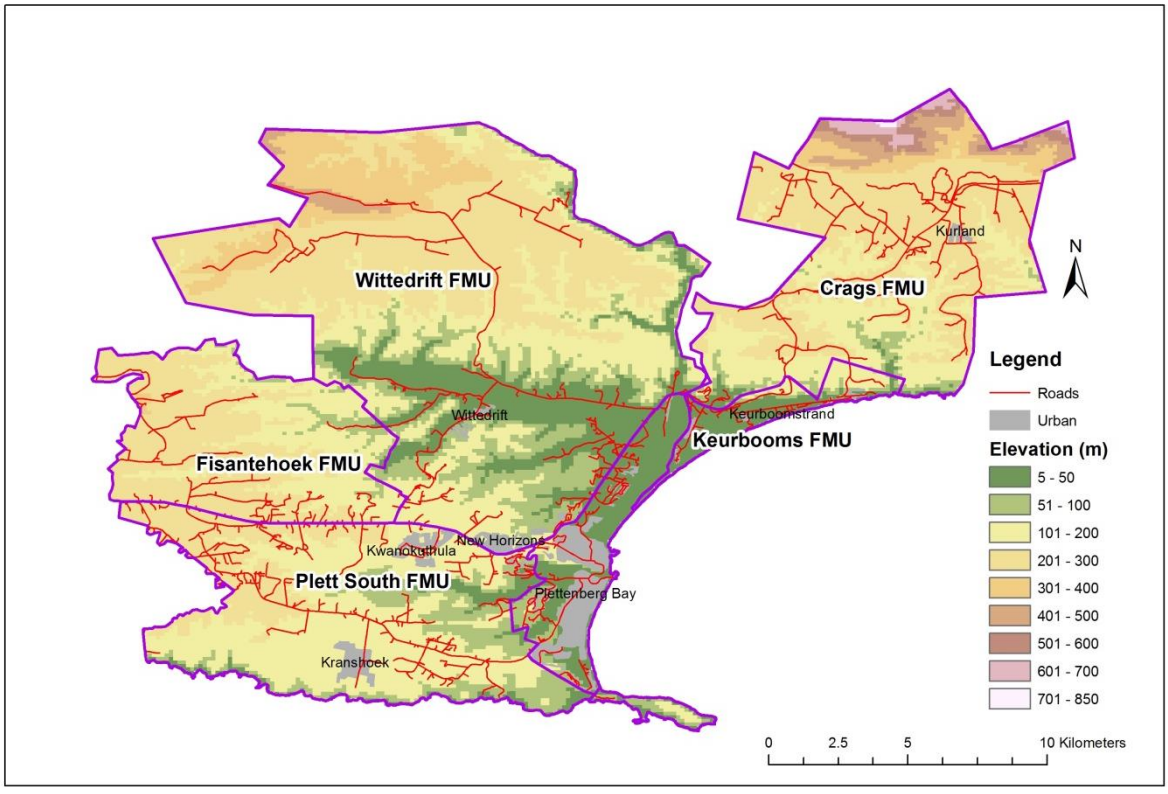

Figure 14: The topography of the fire management units included in the Plettenberg Bay Wildland-Urban Interface study.

3.2 Description of the Plettenberg Bay Wildland-Urban Interface

The five fire management units making up the Plettenberg Bay Wildland-Urban Interface (WUI) contain mixtures of indigenous forests, fynbos shrublands and commercial timber plantations, lightly to moderately-populated commercial farms and smallholdings, and densely-populated formal and informal settlements. The formal settlements range from high-value properties (holiday homes and resorts, golf estates, and retirement complexes), to low-cost government-sponsored housing settlements. The informal settlements house people that have very limited mechanisms for coping with natural disaster when compared to the affluent people residing in the area.

Landowners include public entities such as South Africa National Parks and CapeNature, corporations such as CapePine (a commercial timber forestry company), and private landowners from across the socio-economic spectrum in South Africa. This range of land ownership and use, together with the diversity of vegetation fuel types found in the area, makes for a complex and fragmented WUI.

3.3 Method used to delineate the Plettenberg Bay Wildland-Urban Interface and assess adjacent wildland fire risk

A sequence of steps was followed to delineate the Plettenberg Bay WUI and assess the fire risk posed to people and property along it (Figure 15).

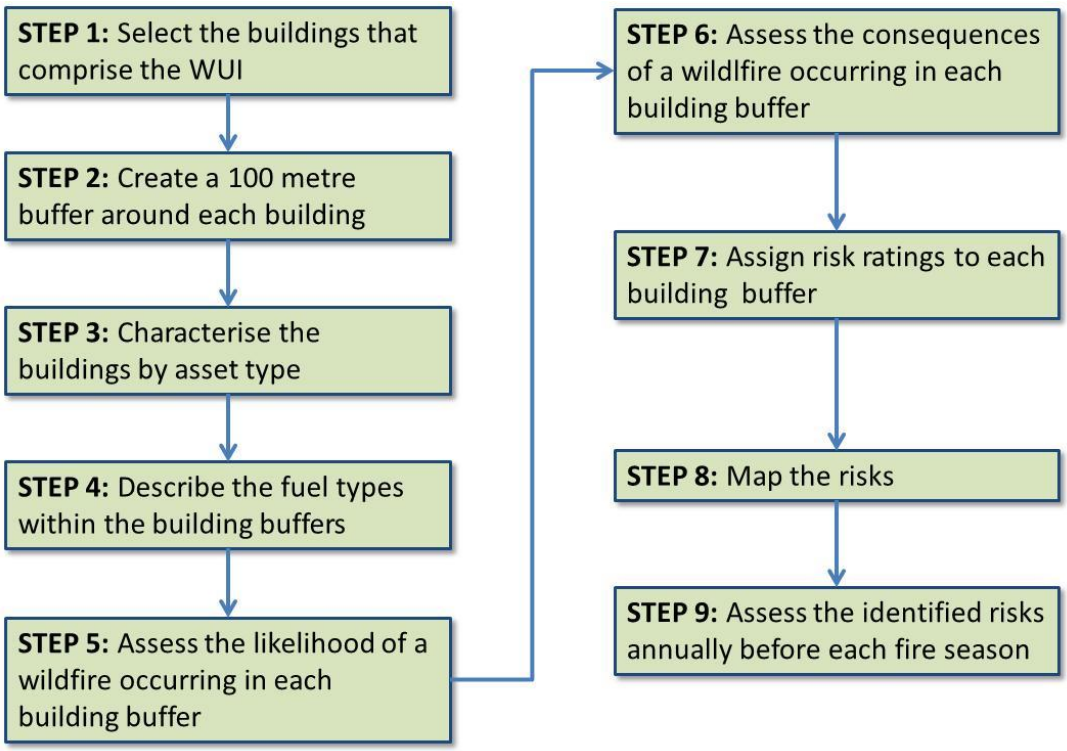

Figure 15: Steps followed to delineate the Plettenberg Bay Wildland-Urban Interface study and to assess the hazards and risks adjacent to it.

Our approach to determining the WUI here differed from that followed in the Helderberg Basin where we define zones along a mostly continuous boundary. Plettenberg Bay is predominantly a peri-urban and rural area where individual or clusters of buildings are scattered on the landscape rather than a distinct line between development and wildland.

The first step was to decide on where and how to delineate the WUI. In consultation with Paul Gerber, the manager of the Southern Cape Fire Protection Association (SCPFA), decided to assess the WUI in five fire management units in the vicinity of Plettenberg Bay that are within the Bitou Municipality. These were Plettenberg South, Fisantehoek, Wittedrif, Keurbooms and Crags. These vary in size with Wittedrift the largest, covering 14 285 ha, and Keurbooms the smallest at 836 ha (Table 7).

Table 7: Area (ha) of the fire management units in the vicinity of Plettenberg Bay

Fire Management Unit	Hectares
Crags	7 551
Fisantehoek	4 238
Keurbooms	836
Plettenberg South	6 529
Plettenberg Bay Town	1 826
Wittedrift	14 285
Total	**35 460**

Step 1: Select the buildings that comprise the Wildland-Urban Interface

We identified the buildings located within 100 metres of the edge of the urban areas of Plettenberg Bay, Kwanokuthula, New Horizons, Kranshoek, Wittedrift and Kurland as well as all the buildings situated in the fire management units of Plettenberg South, Fisantehoek, Wittedrift, Keurbooms and Crags from recent (2010) geo-corrected digital aerial photographs available from the Chief Directorate: National Geo-spatial Information, South Africa's national mapping organisation.

We then captured the locality of these 3704 buildings (Table 8) by means of on-screen digitising using these geo-corrected digital aerial photographs as a back-drop. This data has a fine resolution of 0.5 metres making it ideal for this purpose. The buildings were then grouped according to the settlement types in each fire management unit (Table 8).

Table 8: Settlement types and the number of buildings identified in each for the Plettenberg Bay Wildland-urban Interface

Settlement type	Crags	Fisantehoek	Keurbooms	Plettenberg South	Plettenberg Bay - Town	Wittedrift	Total Buildings
Country estate	22	9	3	6		13	53
Farm	341	121		140		389	991
Industrial	13		1	45		29	88
Nature reserve				20			20
Recreation and tourism	97	14	6	78		63	258
Residential - formal	73		180	481	438	229	1401
Residential - informal	33				7	29	69
Small holding	73	121	7	415	44	33	693
Small holding – Life style	106	6	5	7		7	131
Totals	**758**	**271**	**202**	**1192**	**489**	**792**	**3704**

The buildings were also categorised by type and sub-type (Table 9). The logic was that buildings located immediately on the urban edge and in the peri-urban and rural parts of the five fire management units represent the places where people and their assets are most exposed to wildland fires.

The positions of these buildings were then plotted against four slope classes: Mild <5%, Moderate >5 to <15%; Steep >15% to <25% and very steep >25% in the five fire management units in the vicinity of Plettenberg Bay (Figure 16). Each building was then assigned its underlying slope in percentage. Most buildings are located on mild slopes with the exception of Wittedrift where buildings on moderate slopes predominate (Figure 17).

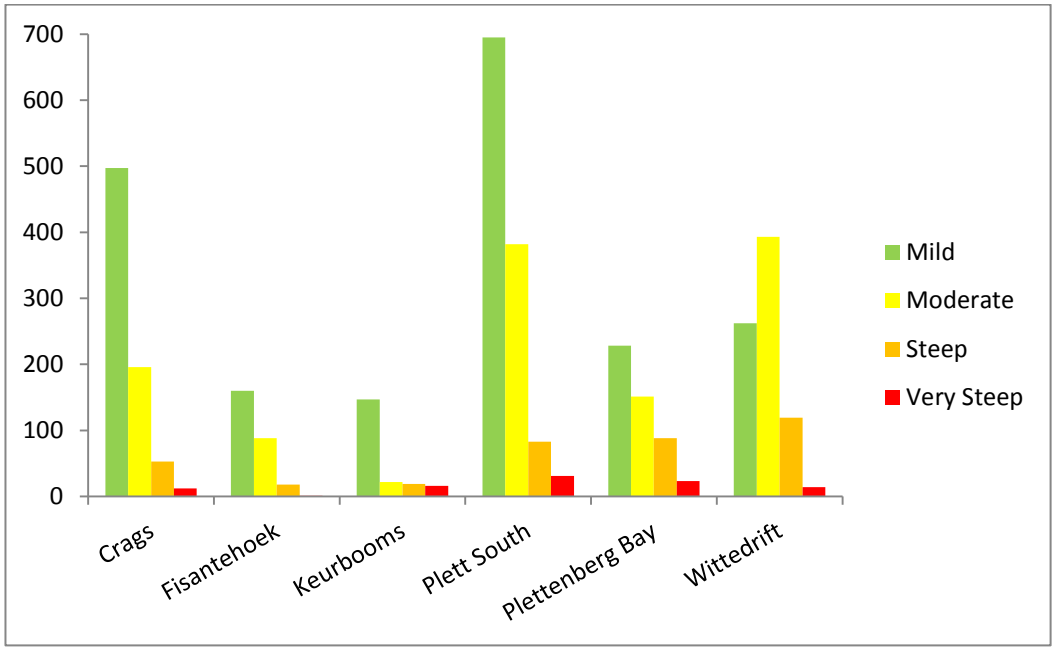

Figure 16: Slope classes for the 3704 buildings on the Plettenberg Bay Wildland-Urban Interface grouped by fire management units. Most buildings are built on mild to moderate slopes (< 15%) with very few occurring on very steep slopes (> 25%)

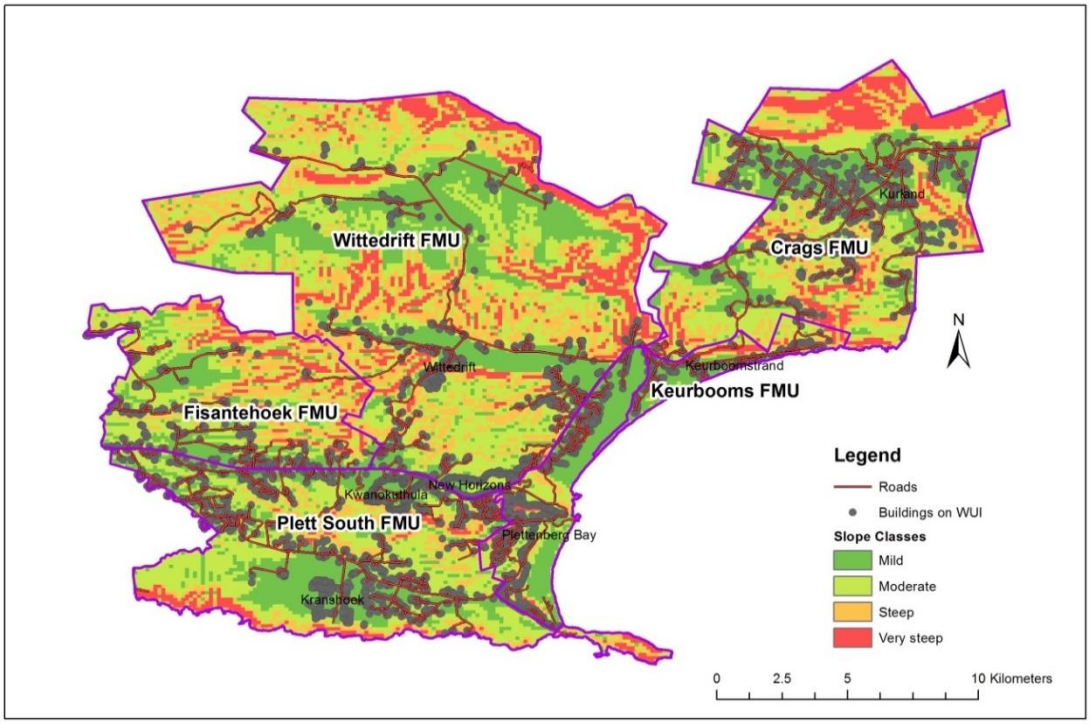

Figure 17: The Plettenberg Bay Wildland-Urban Interface showing the localities of buildings and % slope classes within the constituent fire management units. Most buildings are located on mild slopes.

Step 2: Create a buffer around each building

A circular 100 metre radius buffer was created around each of the 3704 selected buildings using ArcMap 10.1 software. The width of the buffer needs to be sufficient to include the hazard (wildland fuel) and assets (buildings representing the built-up areas where people live and work). This could be at any workable scale. In this case 100 metres on either side was considered sufficient.

Step 3: Characterise the buildings by asset type

Each building was then classified within each settlement type and assigned a building type to use when assessing the consequences of a building being damaged or destroyed by a wildland fire (see Step 6). The building types occurring in each settlement type are listed in Table 9.

Table 9: Settlement and building types identified on the Plettenberg Bay Wildland-Urban Interface.

Settlement type	Building type	Number	Notes
Country estate (n = 53)	B&B	6	Bed and Breakfast accommodation
	Chalet	3	Tourist accommodation for self- catering short stays
	Dwelling	21	Permanent accommodation
	Entrance gate	1	
	Hotel	18	Up-market tourist accommodation
	Shed	4	Small sheds including pump houses
Farm (n = 991)	B&B	7	Bed and Breakfast accommodation
	Cellar	1	
	Club house	1	
	Crop tunnel	1	Typically plastic tunnels used for growing flowers and vegetables
	Dwelling	704	Permanent accommodation including staff housing, and guest houses with none or limited municipal services. Often with only a single entrance road. Fire-fighting services mainly provided by the farms themselves.
	Entrance gate	1	
	Hotel	1	Up-market tourist accommodation
	Office	3	
	Packing or processing shed	7	Sheds with high commercial value including facilities for cut flowers and mushroom production
	Reservoir	2	

Settlement type	Building type	Number	Notes
	Shed	250	Small sheds including pump houses
	Shed (large)	6	
	Shop (farm stall)	4	
	Stable	3	
Industrial (n = 88)	Brick field	16	Brick stacks and offices
	Fire station	1	Satellite fire station at Kurland
	Hanger	21	Hangers at airfield with reasonable service infrastructure.
	Office	5	
	Petrol station	2	Service stations situated along the N2 highway
	Reservoir	10	
	Sawmill	2	Small sawmill
	Shed	2	Small sheds
	Warehouse	29	
Nature reserve (n = 20)	Chalet	2	Tourist accommodation for self- catering short stays
	Dwelling	16	Permanent accommodation
	Shop	2	
Recreation and Tourism (n = 258) Including Birds of Eden, Monkey Land, Elephant Sanctuary, etc.	Aviary	2	
	B&B	1	Bed and Breakfast accommodation
	Braai facility	3	
	Chalet	204	Tourist accommodation for self- catering short stays
	Dwelling	24	Permanent accommodation
	Entrance gate	1	
	Maze	1	Tourist attraction
	Office	8	
	Restaurant	1	
	Shed (small)	9	
	Shed (large)	1	Large shed to house elephants
	Shop	1	
	Sports field	2	Polo and rugby fields
Residential –	Church	2	

Settlement type	Building type	Number	Notes
formal (n =1402)	Club house	2	
	Crop tunnel	1	
	Dwelling (n 1349)	704	Houses on single plots with good service infrastructure such as fire hydrants and hard surfaced roads
		52	Large formal houses with landscaped gardens and good established service infrastructure on golf estates
		189	Houses in gated communities mostly with single entrance roads
		382	Small "RDP" houses
		22	Permanent accommodation in "Bosdorps" comprising small, often wooden, houses for forest and conservation workers
	Hotel	9	Up-market tourist accommodation
	Office	2	
	School & lecture hall	12	
	Shed (small)	16	
	Shop	1	
	Shopping mall	3	Collection of shops
	Warehouse	4	
Residential - Informal (n= 69)	Dwelling	69	Structures constructed from flammable materials and built close to each other in a haphazard pattern thereby restricting access by fire-fighting services
Small holding (n = 693)	B&B	1	Small commercial operations catering for tourists
	Cellar	2	
	Chicken broiler shed	10	Sheds with high commercial value
	Crop tunnel	5	Typically plastic tunnels used for growing flowers and vegetables
	Dwelling	514	Free standing houses with limited fire-fighting services. Properties are mainly for residential use but sometimes have guesthouses. Often only have a single entry road. Dwellings sometimes in proximity to areas infested with invasive alien plants.
	Kennel	1	Dog kennels
	Office	2	
	Packing and processing shed	3	Sheds with high commercial value including facilities for cut flowers and mushroom production
	Petrol station	1	High commercial value
	Restaurant	4	Medium commercial value
	Shed (small)	137	
	Shed (large)	1	High commercial value
	Shop	11	
	Veterinary surgery	1	Commercial and social value
Small holding	B&B	1	Small commercial operations catering for tourists

Settlement type	Building type	Number	Notes
- Life style (n =131)	Dwelling	120	Permanent and temporary homes on land often managed by property owner associations
	Hotel	1	Boutique hotels
	Shed (small)	9	Predominantly small sheds and / or garages

Step 4: Describe fuel types within the building buffers

To determine the prevailing fuel types in the area, we started with the vegetation coverage created by Jan Vlok as part of the Garden Route Initiative (Wessels *et al.* 2009). He classified the vegetation into flammable and non-flammable types. We disregarded all the non-flammable vegetation types such as Outeniqua Plateau Forest, Tsitsikamma Riverine, Plateau and Mountain Forests, and Keurbooms Thicket Forests, while retaining the flammable types such as Rondevlei Sandplain Fynbos, Upland Grassy Fynbos, Knysna Enon Fynbos, Noetsie Proteoid Fynbos and Tsitsikamma Mountain Fynbos. However this dataset represents the potential vegetation cover of the area prior to any land transformation taking place (Figure 18).

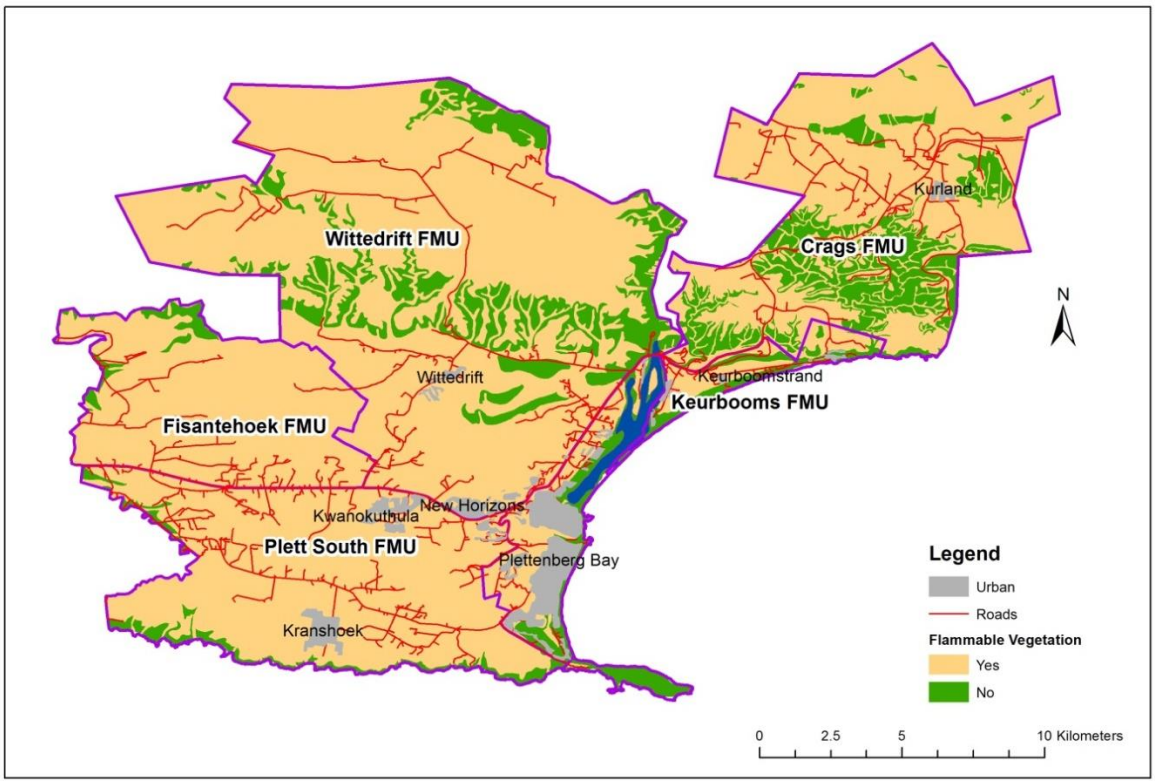

Figure 18: The Plettenberg Bay Wildland-Urban Interface showing the constituent fire management units, flammable vegetation (Wessels 2009) and built-up areas.

To overcome this limitation we obtained recent spatial data from the Western Cape Agricultural Department Agricultural showing where the natural vegetation had been transformed by agricultural fields. This data also classifies the production system into a number of broad classes such as annual crops, horticulture and viticulture, old fields, irrigated fields and small holdings. These classes are useful for gaining an understanding of the vegetation available to provide fuel for wildland fires. We supplemented this data with land cover information compiled during the Garden Route Initiative (GRI 2010) as it contains additional information, such as the location of timber plantations and areas heavily infested by invasive alien plants, both of which increase the flammability of the veld (Figure 19).

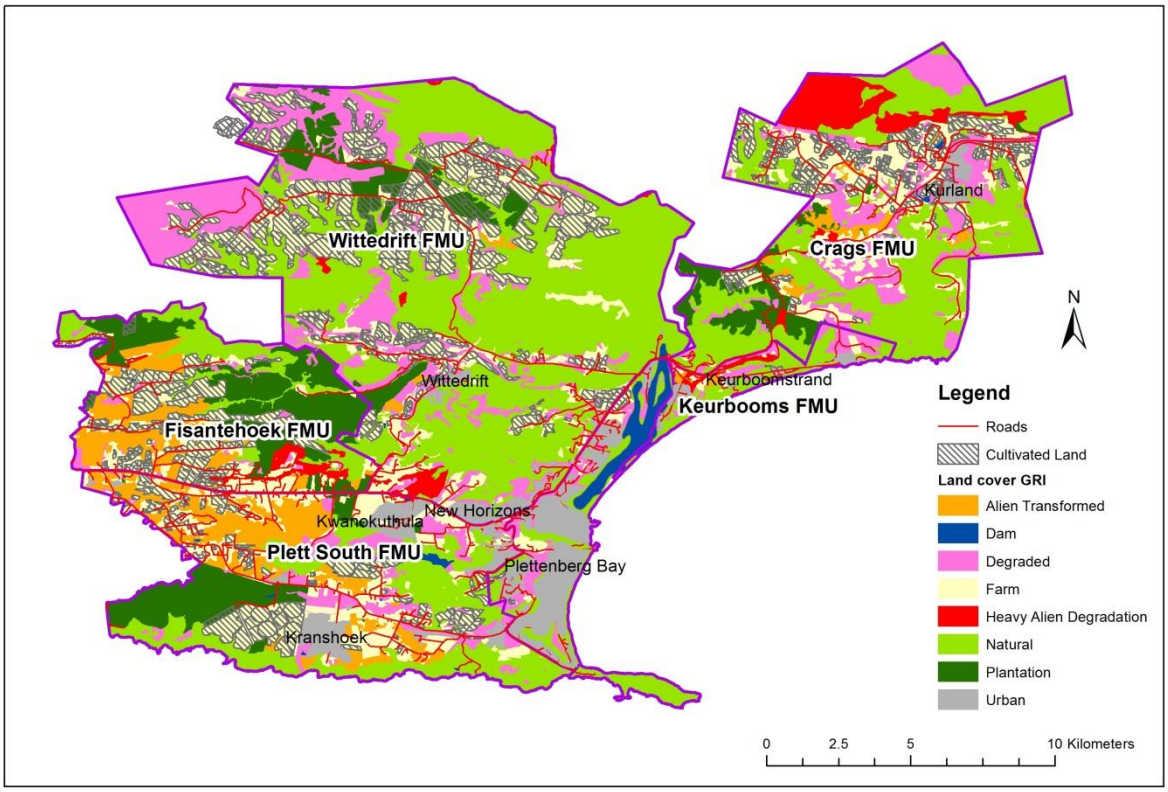

Figure 19: The Plettenberg Bay Wildland-Urban Interface showing the constituent fire management units, land cover (GRI 2010) and agricultural fields.

These transformed areas and the remaining natural veld were then classified in terms of fuel hazards (Table 10). In all cases the agricultural data took precedence as this was the most recent data available. The vegetation fuels adjacent to the WUI were classified into four fuel categories; low, moderate, high and extreme and assigned a likelihood rating (Step 5) based on the frequency at which they are likely to burn (Table 10 and Figure 20).

Table 10: Wildland fuel types applicable to the Plettenberg Bay Wildland-Urban Interface and the likelihood of wildland fires occurring in each type[1]

Type	Description	Fuel class (fuel load)	Likelihood rating[1]
Agriculture	Horticulture / viticulture	Low	Unlikely
	Pivot irrigation	Low	Unlikely
	Shade net	Low	Unlikely
	Small holdings	Low	Unlikely
	Cultivation land (Annual crops / pastures)	Moderate	Possible
	Old fields	Moderate	Possible
Natural vegetation	Fynbos and other natural vegetation	High	Likely
Transformed land	Urban	Not applicable	
	Dam	Not applicable	
	Degraded land	Moderate	Possible
	Alien transformed	High	Likely
	Heavily alien degraded	Extreme	Almost certain
	Timber plantation	Extreme	Likely

[1] Adapted from AS/NZS 4360:2004 **(Forsyth *et al.* 2010)**

Figure 20: Typical fuel types present in the Plettenberg Bay Wildland-Urban Interface: (i) Pastures in the foreground with low fuel loads; (ii) Mature fynbos with high fuel loads (iii) Vegetation with invasive alien trees, in the proximity of houses, having a high fuel load, and (iv) Fynbos heavily invaded by *Pinus pinaster* with an extreme fuel load.

(Photographs – G. Forsyth).

The fuel classes contained within the buffered (100m) areas of all the buildings in Plettenberg Bay WUI were then expressed as percentages for each fire management unit (Figure 21).

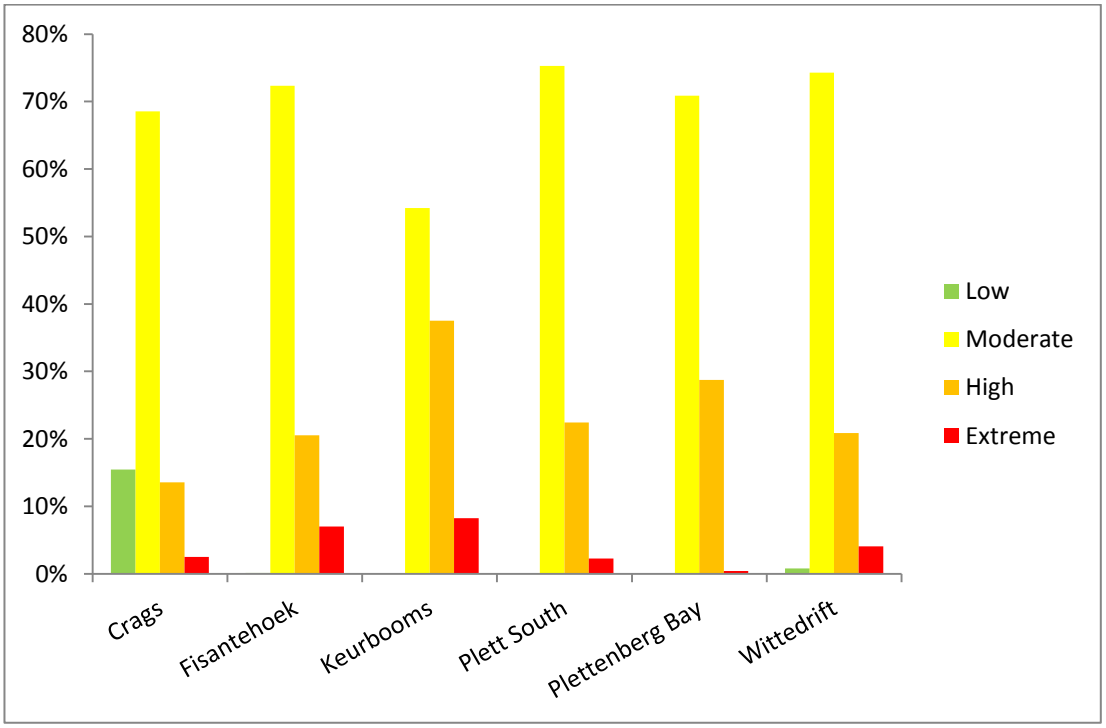

Figure 21: Flammable fuel expressed as a percentage of the Plettenberg Bay Wildland-Urban Interface (only for the 100 metre buffer areas) for each fire management unit.

The moderate fuel class dominates the WUI in all of the five fire management units. It ranges from 54.2% in Keurbooms to 75.3% in Plettenberg South while extreme fuel classes range from 0.4% in Plettenberg Bay to 8.3% in Keurbooms. Keurbooms at 37.5% has the highest proportion but not the largest, in the high fuel class, of all the fire management units (Figure 22). This is due to the present of heavy invasion alien plant infestations.

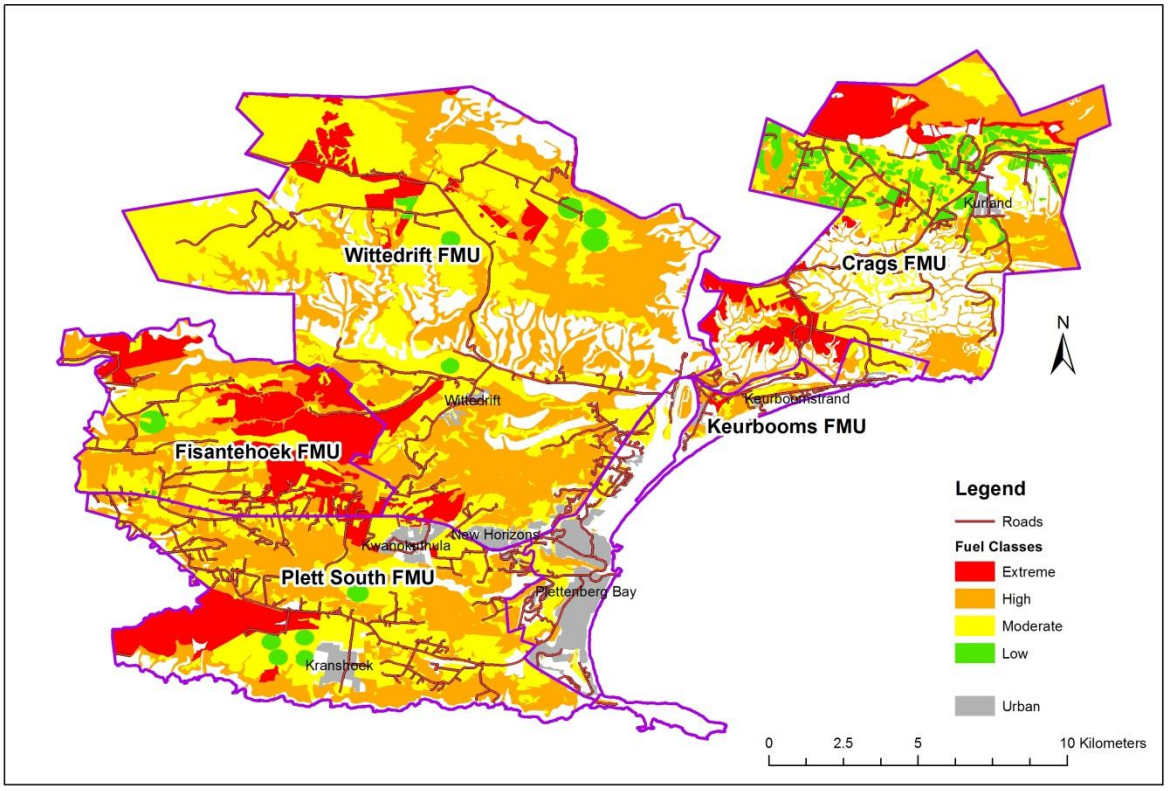

Figure 22: The spatial distribution of four fuel classes that buildings on the Plettenberg Bay Wildland-Urban Interface are exposed to.

Step 5: Assess the likelihood of a wildfire occurring in each building buffer

The likelihood of a fire was based on the following factors: type of vegetation; degree of invasion of the natural veld by flammable alien vegetation; and the extent of land transformation in the area. Examples of transformed vegetation include flammable timber plantations that have replaced fynbos, or fynbos that has been converted to less flammable vineyards or irrigated pastures.

Information on the post-fire age of the vegetation would have been useful but we were unable to reliably locate the spatial extent of veld fires during recent years. This would have been useful to accurately determine the post-fire age of the vegetation, and is, in turn, needed to estimate fuel loads (see Step 4 above). Reliable data from SANParks and CapeNature is not applicable to this area and the MODIS satellite imagery available since 2002 through the Advanced Fire information System (AFIS) was not very helpful as the nature of the terrain and vegetation in this area results in many active fires and burn scars going undetected. Fire records on private land are scarce and in most cases landowners and fire-fighting authorities here do not record the spatial extent of the fires. The Bitou Municipality does not currently map the extent of wildland fires. Fire incidents are recorded only if the municipality respond to a wildland fire. Such records are paper based and the exact location and extent of fires is not systematically recorded. Hopefully over time the Southern Cape FPA will remedy this situation. We therefore based the likelihood of a wildland fire occurring

solely on the vegetation type present. A likelihood rating was then assigned to each of the 3698 selected buildings guided by information contained in Tables 3 and 8. In addition, for buildings on slopes > 25% the likelihood rating was increased by one level. For example if the likelihood of a fire occurring at a building was assessed as being "Possible" but that building was on a slope >25% the likelihood rating was increased to "Likely".

Of the 3704 buildings identified, 163 did not have any wildland fuel within 100 m, and they were added to the rare class (Figure 23).

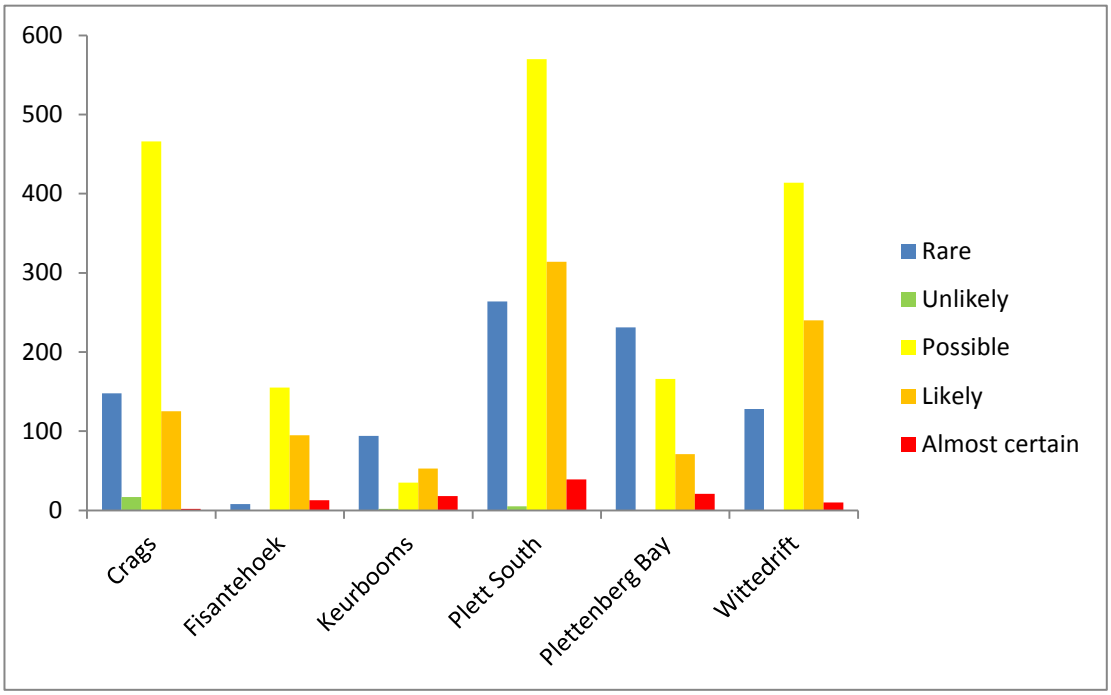

Figure 23: Buildings on the Plettenberg Bay Wildland-Urban Interface categorised by likelihood ratings from rare to almost certain. The data contains 3704 buildings (including 163 buildings having no fuel within the 100 m buffer) and is presented per Fire Management Units and the town of Plettenberg Bay.

The buffered buildings were then intersected, using ArcMap 10.1 GIS software, with the fuel hazard data determined in Step 4 to extract the fuel hazards that each building is exposed to.

Step 6: Assess the consequences of a wildfire within each building buffer

The consequences of a wildland fire occurring in any 100 metre building buffer and then spreading to that building were assessed. Information contained in Table 11 was used to decide what level of consequence to assign to each building.

Table 11: The consequences of a wildland fire occurring on Plettenberg Bay Wildland-Urban Interface in terms of live and economic assets[1]

Level of consequence		Consequence end points	
		Life consequence criteria	Economic consequence criteria
1	Catastrophic	Death of one or more persons in the scenario	Depressed economy of the municipality. Extensive and widespread loss of assets. Major impact across a large part of the community. Long-term external assistance required to recover.
2	Major	Extensive injuries to people in the scenario, requiring emergency hospitalisation; or, evacuation required	Serious financial loss, affecting a significant portion of the community. Could require external funds (e.g. Disaster Management) to recover.
3	Moderate	Medical treatment required but full recovery possible.	Localised damage to property. Short-term external assistance required to recover.
4	Minor	Minor injuries only – first aid treatment required.	Minor financial loss. Short-term damage to individual assets. No external assistance needed
5	Insignificant	No injuries	Inconsequential or no damage to property

[1] Adapted from AS/NZS 4360:2004 **(Forsyth *et al.* 2010)**

This was done for both impacts on human life and properties (economic) but this can also be done for other classes of assets. For example a single house burning down on a small holding may have a minor or moderate consequence depending on the use of the building.

We classified each building identified in Step 6 into different asset types and assigned a life and economic consequence to them should a wildland fire occur and impact them (Table 12). This was gone in consultation with Southern Cape FPA staff.

Table 12: Building and settlement types identified on the Plettenberg Bay Wildland-Urban Interface and the consequences of a wildland fire on human life and economic assets

Type	Description	Consequence to life	Economic consequence
Country estate	B&B	Moderate	Moderate
	Chalet	Moderate	Minor
	Dwelling	Moderate	Moderate
	Entrance gate	Insignificant	Insignificant
	Hotel	Moderate	Moderate
	Shed	Insignificant	Minor
Farm	B&B	Moderate	Moderate
	Cellar	Minor	Moderate
	Club house	Minor	Minor

Type	Description	Consequence to life	Economic consequence
	Crop tunnel	Insignificant	Moderate
	Dwelling	Moderate	Minor
	Entrance gate	Insignificant	Insignificant
	Hotel	Moderate	Moderate
	Office	Minor	Minor
	Packing and processing shed	Moderate	Major
	Reservoir	Insignificant	Minor
	Shed (including pump houses)	Insignificant	Minor
	Shed (large)	Insignificant	Moderate
	Shop (farm stall)	Minor	Moderate
	Stable	Insignificant	Minor
Industrial	Brick field	Insignificant	Minor
	Dwelling	Minor	Minor
	Hanger (Airfield)	Insignificant	Moderate
	Office	Minor	Minor
	Fire station	Minor	Moderate
	Petrol station	Catastrophic	Moderate
	Reservoir	Insignificant	Minor
	Sawmill	Minor	Moderate
	Shed	Insignificant	Minor
	Warehouse	Minor	Major
Nature Reserve	Chalet	Moderate	Minor
	Dwelling	Moderate	Minor
	Shop	Minor	Moderate
Recreation and Tourism	Aviary	Insignificant	Moderate
	B&B	Moderate	Moderate
	Braai facility	Insignificant	Insignificant
	Chalet	Moderate	Minor
	Dwelling	Moderate	Minor
	Entrance gate	Insignificant	Insignificant
	Maze	Insignificant	Minor

Type	Description	Consequence to life	Economic consequence
	Office	Minor	Minor
	Restaurant	Minor	Moderate
	Shed (small)	Insignificant	Minor
	Shed (large)	Minor	Moderate
	Shop	Minor	Moderate
	Sports field (Polo and rugby)	Insignificant	Minor
Residential – formal	Church	Minor	Minor
	Club house	Minor	Minor
	Crop tunnel	Insignificant	Moderate
	Dwelling (single plot, golf estate)	Minor	Minor
	Dwelling (gated)	Moderate	Minor
	Dwelling (RDP & Bosdorp)	Moderate	Minor
	Hotel	Moderate	Moderate
	Office	Minor	Minor
	School & lecture hall	Major	Major
	Shed (small)	Insignificant	Minor
	Shop	Minor	Moderate
	Shopping mall	Major	Major
	Warehouse	Minor	Major
Residential - Informal	Dwelling	Catastrophic	Minor
Small holding	B&B	Moderate	Moderate
	Cellar	Minor	Moderate
	Chicken broiler shed	Minor	Major
	Crop tunnel	Insignificant	Moderate
	Dwelling	Moderate	Minor
	Kennel	Minor	Minor
	Office	Minor	Minor
	Packing and processing shed	Moderate	Major
	Petrol station	Catastrophic	Moderate
	Restaurant	Minor	Moderate
	Shed (small)	Insignificant	Minor
	Shed (large)	Insignificant	Moderate
	Shop	Minor	Moderate
	Veterinary surgery	Minor	Minor
Small holding - Life style	B&B	Moderate	Moderate
	Dwelling	Moderate	Minor
	Hotel	Moderate	Moderate
	Shed (small)	Insignificant	Minor

Step 7: Assign risk ratings to each building buffer

We interpret veldfire risk to be a function of the likelihood of a fire occurring and the consequences of any such fire (Forsyth *et al.* 2010). We therefore used a combination of likelihood and consequence ratings to determine and assign a risk level for each building (Table 13). We did this from both a human safety (life) and an economic (property) perspective.

Table 13: Levels of risk, assessed as the product of likelihood and consequence[1]

Likelihood Rating	Consequence Rating				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	Extreme	Extreme
Possible	Low	Medium	High	High	Extreme
Unlikely	Low	Low	Medium	High	Extreme
Rare	Low	Low	Low	Medium	High

[1] Adapted from AS/NZS 4360:2004 **(Forsyth *et al.* 2010)**

The relationship between likelihood and consequence could differ for different Wildland-Urban Interfaces and therefore adjustments will need to be made to the level of risk contained in each cell to reflect this (AS/NZS 4360:2004). The life and economic risk levels assigned to each building. Summaries of these are contained in Tables 14 and 15, respectively.

Table 14: Buildings identified on the WUI classified in four life risk classes for each fire management unit

Fire Management Unit	WUI buildings with a life risk				Total
	Low	Medium	High	Extreme	
Crags	198	37	517	6	758
Fistantehoek	73	8	190		271
Keurbooms	98	93	11		202
Plett - South	404	76	710	2	1192
Plettenberg Bay	237	175	76	1	489
Wittedrift	255	111	417	9	792
Totals	**1265**	**500**	**1921**	**18**	**3704**

The risk to human life posed by wildland fires along the WUI is predominantly in the high risk class in all fire management units except for Keurbooms and the town of Plettenberg Bay (Figure 24). Here buildings on the WUI are predominately in the low risk class. Only a few buildings were classified as having an extreme risk to life. Most of these are found in the Crags and Wittedrift.

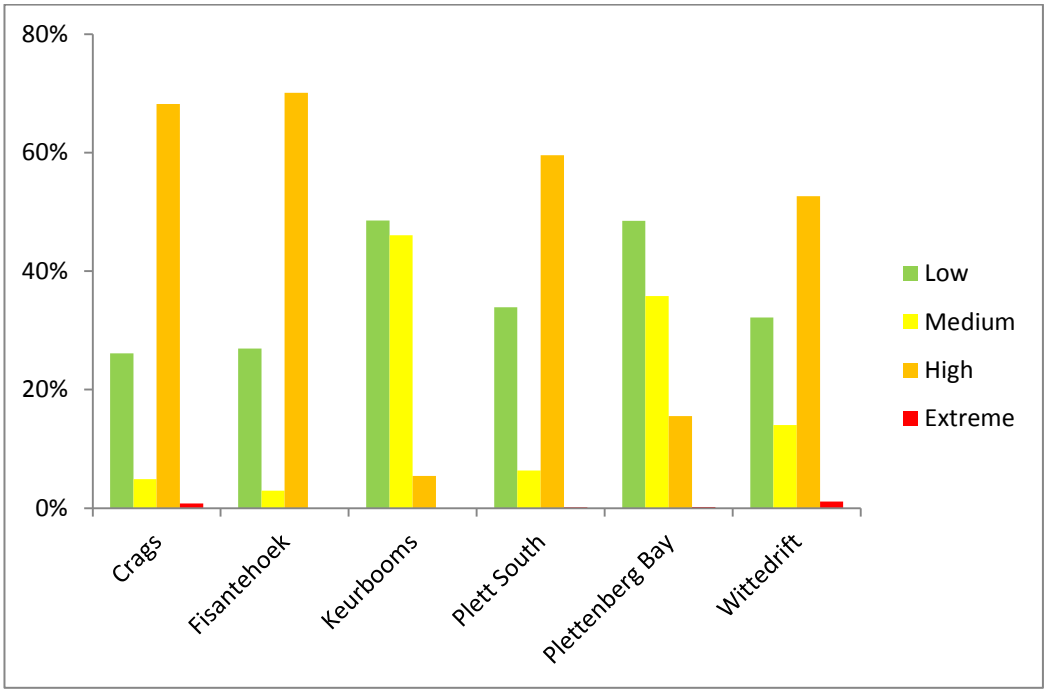

Figure 24: Levels of risk to human lives for the Plettenberg Bay Wildland-Urban Interface presented in four risk classes for each fire management unit.

The risk posed by wildland fires to economic assets (buildings) for the Plettenberg Bay WUI is predominantly in the medium risk class for all fire management units (Table 15 and Figure 25). Only in Plettenberg South, Crags and Wittedrift were a small number of buildings identified as being exposed to an extreme economic risk. In Plettenberg South and Wittedrift these buildings were at educational facilities. Extreme risk economic risks are where a wildland fire has the potential to damage the area's economy but in the case on the Plettenberg Bay WUI we believe that mostly effects would be local rather than regional (Table 9).

Table 15: Buildings identified on the WUI classified in four economic risk classes for each fire management unit

Fire Management Unit	WUI buildings wildland fire economic risk				Total
	Low	Medium	High	Extreme	
Crags	160	550	48		758
Fistantehoek	8	246	17		271
Keurbooms	96	102	4		202
Plett - South	269	879	43	1	1192
Plettenberg Bay Town	227	245	17		489
Wittedrift	113	635	40	4	792
Totals	**873**	**2657**	**169**	**5**	**3704**

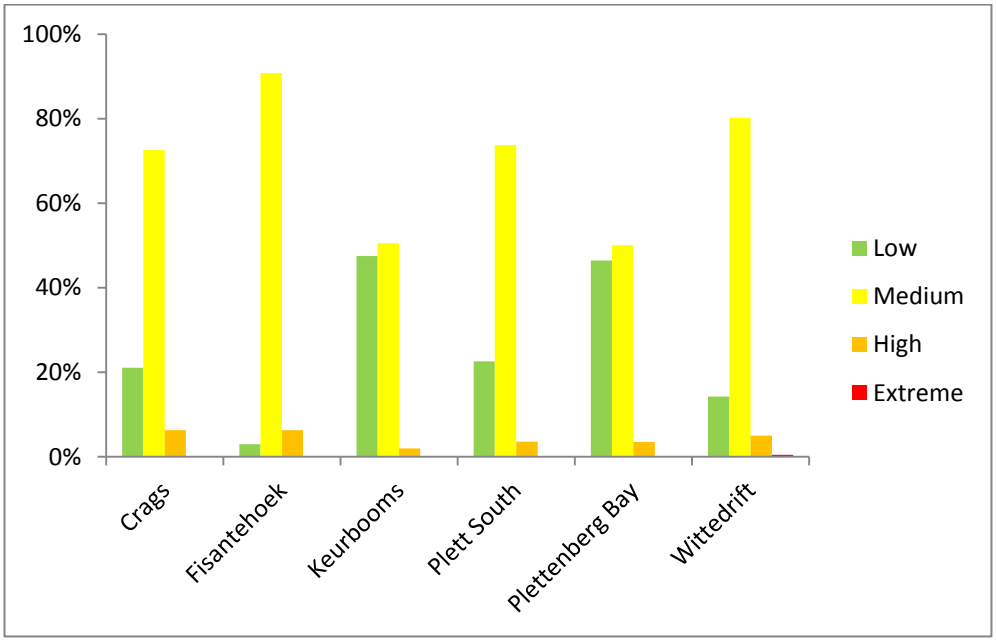

Figure 25: Levels of economic risk for the Plettenberg Bay Wildland-Urban Interface presented as percentages in four risk classes for each fire management unit.

Step 8: Map the risks

The life and economic risk levels assigned to each building in Step 7 were then mapped for the 3704 buildings on the WUI. The distribution of the levels of risk to human lives for the Plettenberg Bay Wildland-Urban interface differs between the fire management units (Figure 26). In most of them buildings are concentrated near main roads but in Wittedrift they are more spread out.

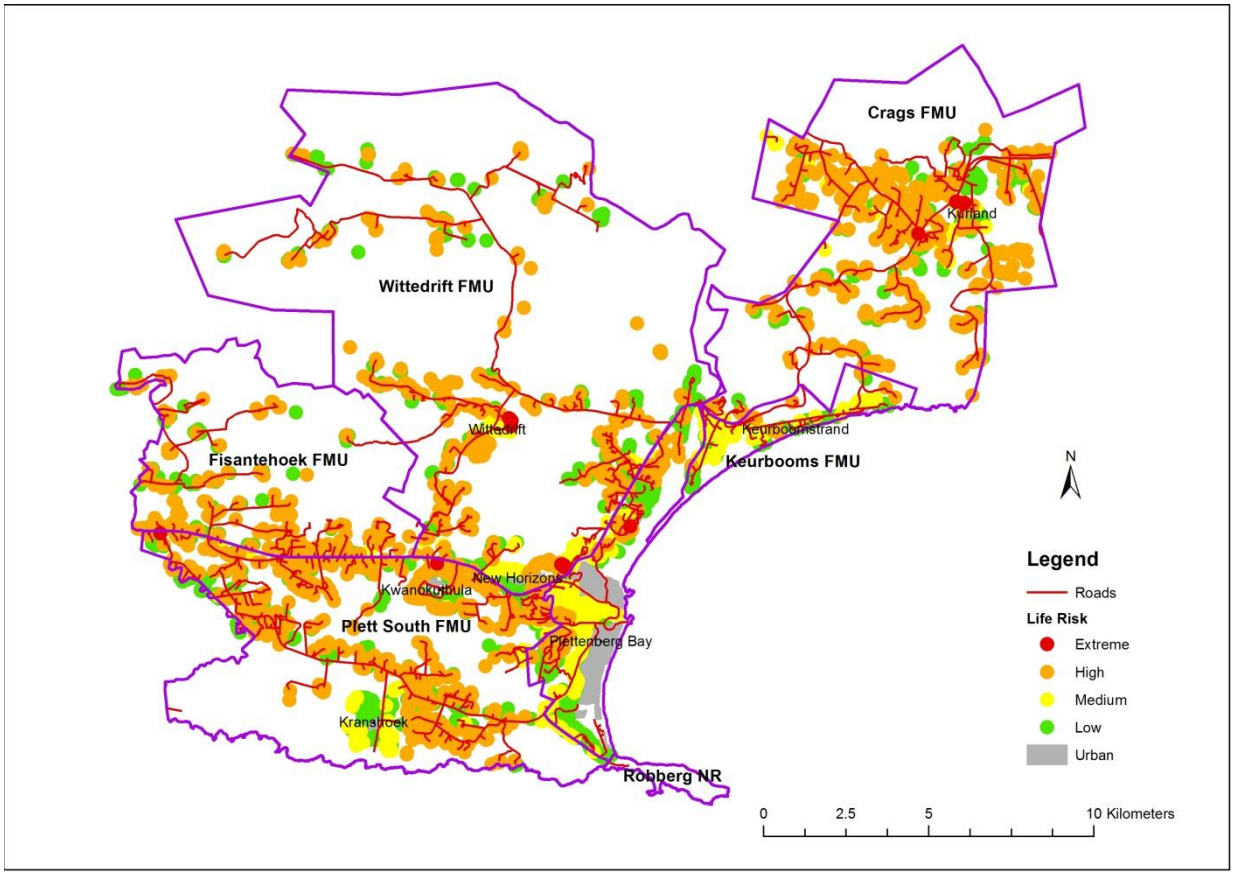

Figure 26: The distribution of the level of risk to human life for the Plettenberg Bay Wildland-Urban Interface in four risk classes for each fire management unit.

Unlike the life risk, the distribution of the economic risk levels for the Plettenberg Bay Wildland-Urban interface (Figure 27) is strongly concentrated the Plettenberg South, Keurbooms and Crags fire management units.

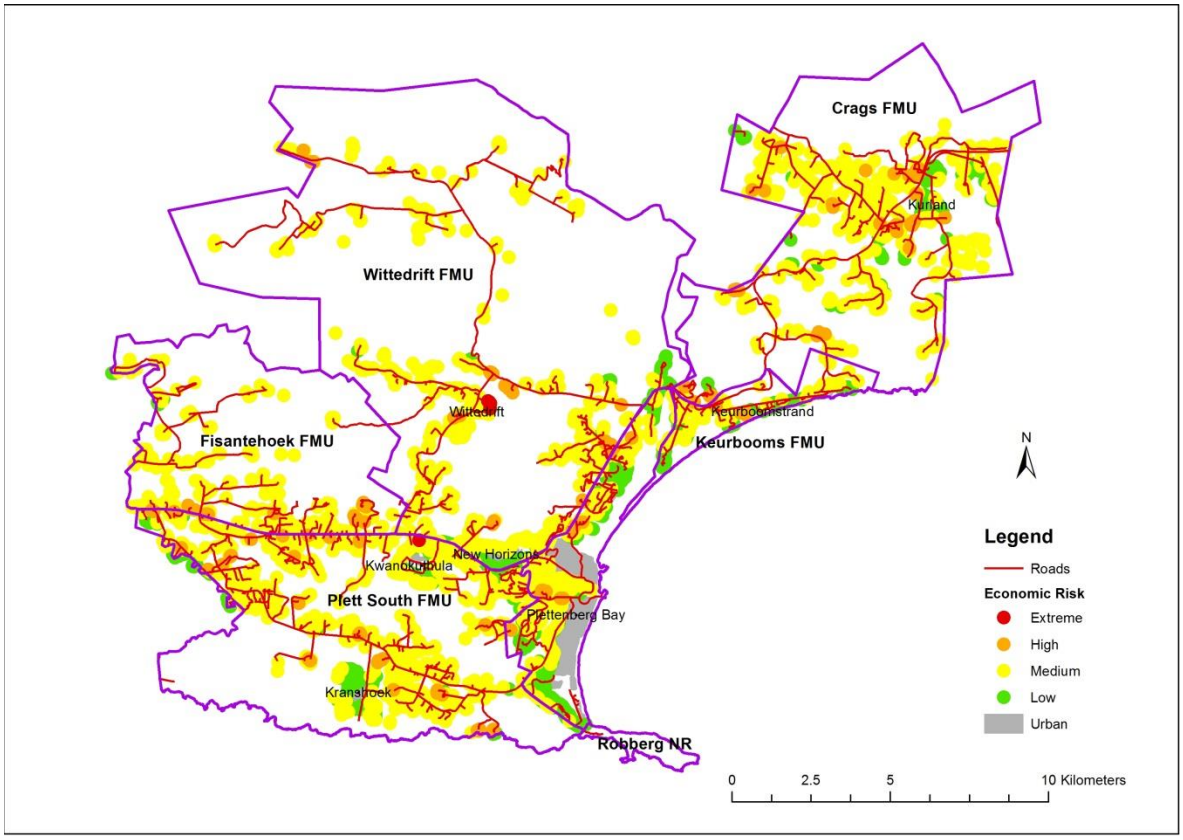

Figure 27: The distribution of economic risk for the Plettenberg Bay Wildland-Urban Interface in four risk classes for each fire management unit.

Step 10: Assess the identified risks annually

Risks associated with the WUI should be revisited annually before the start of each fire season to determine if they are decreasing, staying the same or increasing along sections of the WUI. This is especially so if new urban development has taken place or a wildfire or prescribed burning has taken place in the preceding 12 months. Mitigating actions taken to reduce risk such as preparing firebelts or fire wise landscaping of gardens also need to be taken into consideration on an annual basis.

3.4 Discussion

The Plettenberg Bay WUI was defined by identifying 3704 buildings where flammable vegetation occurred within 100 m of buildings on the boundary of Plettenberg Bay and the fire surrounding fire management units of Crags, Fisantehoek, Keurbooms, Plettenberg South and Wittedrift. The area examined covered 35 266 Ha (Table 7) and the settlement types within this area were classified as; a) country estate, b) farm, c) industrial area, d) nature reserve, e) recreation and tourism site, f) formal or informal residential area, g) small holdings, and h) small holding with a focus on a nature based life style rather than on commercial activities. Dwellings are the

dominate building type in all settlement types except the recreation and tourism type, where holiday chalets are most common, and industrial areas where warehouses dominate (Table 8). This is a substantial and complex area for the Southern Cape FPA to manage and each of the fire management areas has particular features.

A large part of Plettenberg Bay town does not border directly on the WUI however in certain places structures are built on steep ground immediately adjacent to wildlands.

The Crags area north of the N2 national road consists of a mixture of farms, ranging from dairy, fruit orchards, cut flowers and vegetables. The community of Kurland has a high proportion of RDP houses, as well as many tourist attractions such as Birds of Eden, Monkeyland Primate Sanctuary, Elephant Sanctuary and Tenikwa Wildlife Centre are also found nearby. There are also many tourist resorts and small holding where the focus is on life style in this fire management unit.

Keurbooms is the smallest fire management unit and has the fewest buildings, most of which are dwellings situated close to the coast. The Wittedrift fire management unit inland of Keurbooms consists mainly of wheat, feed, cattle and game farms but includes the small town of Wittedrift. Many farms also have guesthouses on them. Fisantehoek is also a predominately farming area in a hilly landscape with extensive indigenous forests to the west. There are no small towns in the Fisantehoek fire management unit. However the area immediately north of the N2 has many small holdings and tourism facilities and invasive alien plants. The same situation occurs immediately to the south of the N2 in Plettenberg South.

Plettenberg South has 1192 buildings classified as being on the WUI, which is the highest of all fire management units. The area is fragmented with many activities ranging from brick making, stables, holiday resorts, tourism attractions, quarries, mushroom farming and dairy farming taking place. In various places invasive alien plants are contributing to high fuel loads. This fire management unit has the highest number of buildings in the small holding settlement type. Typically these small holdings have limited resources to contain invasive alien plants and often only have single narrow entrance roads. The town of Kranshoek is also found here as is the Plettenberg Bay airfield with a number of hangers housing expensive aircraft.

Plettenberg South has the highest number of buildings rated as having a high risk for life (710), followed by Wittedrift (417) and Fisantehoek (190). There are very few buildings in the extreme risk class with Wittedrift having the most (9) and the Crags next with six.

Economic risks posed by wildland fires to buildings are mostly in the medium class with the Crags having the most in the high class at 48 followed by Plettenberg South with 43. This is mainly because most of the buildings are single dwellings and sheds and although a fire would cause economic losses to individual owners but in this area it is only in a few cases that economic losses would be of a regional rather than a local nature.

The pattern of risk follows the local and district road network as most buildings are in the proximity of the road network. Generally fuel loads are lower in the intensely cultivated areas that are mostly found on the lower gentler slopes while higher fuel loads are often found on steeper uncultivated slopes.

3.5Recommendations

The wildland fire risks determined along the Plettenberg Bay WUI should be used by the Southern Cape FPA to embark on a FireWise approach to mitigating the risks (Erasmus 2011), especially in those areas identified as high and extreme. Such a plan has already been formulated by another component of the FynbosFire project for the Kranshoek community that falls within the Plettenberg Bay WUI (Anon 2013b).

It is recommended that:

1. Efforts to recruit new FPA members should be focused on properties identified as having high or extreme risk.
2. Establish more FireWise communities in areas identified as having high or extreme risks.
3. Review and improve the information contained in the GIS risk assessment, compiled as part of this project, annually before the start of each fire season.
4. Focus FPA awareness and prevention and protection measures, including law enforcement, training, and construction of firebreaks on properties with high and extreme risks.
5. Compile a list of fire-fighting resources (equipment, training and infrastructure) for each property along the WUI, starting with the properties (or groups of properties) identified as having high or extreme risks.
6. Conduct an assessment of the types of buildings found along the WUI in terms of their ability to withstand wildfires. For example: (i) buildings that would withstand wildland fires without any assistance on the part of fire-fighting services as the property owners have sufficient fire-fighting resources and know how; (ii) where some assistance during a wildfire would be necessary; and (iii) where the fire authorities would not be able to assist. The FireWise property check list would aid doing this (Erasmus 2011).
7. Establish what mitigation measures are in place and decide on what should be put in place for each risk class within each risk zone on individual property to reduce the level of risk. This should include first response capabilities, the position and condition of firebreaks, and where invasive alien plant management is needed.
8. Clarify what risk reduction activities local authorities (including Fire Protection Associations) are responsible for and which are individual property owner responsibilities. For example, who is responsible for the management of vegetation fuels?
9. Make the results of any WUI wildland fire risk assessment available to local authorities for incorporation into their emergency response plans.
10. Influence local authorities to improve property and building regulations to design-in wildfire risk mitigation by restricting the use of flammable building and roofing materials for structures built along the WUI.

4. CONCLUSION

We have formulated a systematic assessment procedure. This involves following a number of sequential steps, within a generic template (framework), for Fire Protection Associations to use when assessing fire risk in on the wildland-urban interface in the fynbos biome. We have done this in terms of potential loss of human lives and loss or damage to economic (buildings) assets.

We have tested this approach by applying it at two scales at two locations in the fynbos biome. In the Helderberg Basin we have applied it a localised scale in a predominantly urban setting (distinct WUI). The other test case was in the Plettenberg Bay area where it was applied to five fire management units within the Bitou Local Municipality. This is a peri-urban and rural environment and the approach has to accommodate disperse buildings intermixed with wildlands and involved more work. We believe that these two approaches capture the majority of situations encountered in the fynbos biome in terms of WUI risk.

In testing the framework we endeavoured to use data that is available in the public domain and is current. However, information on fuels is not easy to come by. Lack of fire records makes it difficult. But it is essential to establish fuel loads to determine the hazard posed. We have done this by classify fuels into broad classes that can be can be visually assessed and combined with veld age where such records are available. Consequence ranking is dependent on the knowledge of the stakeholders.

The steps contained in the framework need to be applied annually to determine if they are decreasing, staying the same or increasing and to determine timeously what mitigation to put in place.

Using the sequential steps outline in this document we have been able to determine a first approximation of the relative levels of risk posed to human life and economic assets on WUI in the vicinity of Plettenberg Bay. This then serves as a generic wildfire risk template to assess risks on the Wildland-Urban interface.

The results for both case studies are being made available to the Cape Peninsula and Southern Cape FPAs as ArcGIS 10.1 shapefiles together with their related attribute tables. They can then add to and improve the information gathered through this study on a continuous basis to best meet there local needs.

5. ACKNOWLEDGEMENTS

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Appendix A: The likelihood and consequences of a wildland fire occurring along the Helderberg Basin Wildland-Urban Interface (WUI) in terms of life and economic risk

(See Tables 1 and 2 for complete settlement type and fuel descriptions).

Paired Zone	Suburb / Farm	Settlement Type	Fuel		Consequence		Risk	
		Inside buffer	Outside buffer	Likelihood	Life	Economic	Life	Economic
1	Helderberg Estate, Bel Aire	Residential suburb	Vineyard	Unlikely	Minor	Moderate	Low	Medium
2	Helderberg College (Educational institution)	Educational institution	Pastures, old fields and orchards	Possible	Moderate	Moderate	High	High
3	Helderberg College	Educational Institution	Previously burnt pine plantation (Pine jungle)	Likely	Moderate	Moderate	High	High
4	Helderberg College	Educational Institution (no buildings)	Old agricultural fields and some trees	Possible	Insignificant	Minor	Low	Medium
5	Spanish Farm	Residential suburb	Fields and olive orchards	Possible	Minor	Moderate	Medium	High
6	Silverboomkloof (Spanish Farm)	Residential suburb	Public open space (Natural Heritage Site) and undeveloped residential stands. Heavily invaded by woody invasive alien plants	Likely	Minor	Moderate	Medium	High
7	Top Cliffe	Small farm	Timber plantation with some dwellings in trees on lower slopes	Likely	Minor	Moderate	Medium	High
8	"Finger #1" (Parel Vallei)	Residential suburb	Public open space, with tall Eucalyptus trees, protruding into suburb. Adjoins Top Cliffe on upper side.	Likely	Minor	Moderate	Medium	High
9	Kings Kloof	Small farm	Young fynbos with some vineyards and dwellings near the downslope	Rare	Moderate	Moderate	Low	Low

Paired Zone	Suburb / Farm	Settlement Type	Fuel		Consequence		Risk	
		Inside buffer	Outside buffer	Likelihood	Life	Economic	Life	Economic
			border of the property					
10	"Finger #2" (World's View, Helderrand and Golden Hill)	Public open space	Public open space, with tall Eucalyptus trees, protruding into suburb. Adjoins Kings Kloof on upper side	Likely	Minor	Moderate	Medium	High
11	World's View (Shady Glen)	Residential suburb	Young fynbos (<4 years) in Helderberg Nature Reserve. Last burnt in 2011	Rare	Minor	Moderate	Low	Low
12	Helderberg Nature Reserve	Single house on Nature Reserve	Fynbos and pine trees currently being felled. Slash piles to be burnt in the coming winter	Possible	Moderate	Minor	High	Medium
13	Golden Hill	Residential suburb	Fynbos and pine trees currently been felled. Slash piles to be burnt in the coming winter	Likely	Minor	Moderate	Medium	High
14	Nature's Valley	Residential suburb	Fynbos growing on old fields below storage dam	Possible	Minor	Moderate	Medium	High
15	Helderberg Nature Reserve	Bulk water infrastructure (Buildings)	Water storage and fynbos growing on old fields	Possible	Minor	Major	Medium	High
16	Helderberg Nature Reserve	Offices and staff housing	Fynbos and recently felled pine trees. Slash piles to be burnt in the coming winter	Unlikely	Minor	Moderate	Low	Medium
17	Helderberg Nature Reserve	Restaurant and offices	Fynbos	Possible	Minor	Moderate	Medium	High
18	Helderberg Nature Reserve	Parkland with large trees and grass	Fynbos and recently felled pine trees. Slash piles to be burnt in the coming winter	Likely	Insignificant	Insignificant	Low	Low
19	Nature's Valley	Residential suburb	Fynbos and recently felled pine trees. Slash piles to be burnt in the coming winter	Likely	Minor	Moderate	Medium	High
20	Erinvale	Golf Estate (Fairways)	Fynbos and recently felled pine	Likely	Insignificant	Minor	Low	Medium

Paired Zone	Suburb / Farm	Settlement Type	Fuel		Consequence		Risk	
		Inside buffer	Outside buffer	Likelihood	Life	Economic	Life	Economic
			trees. Slash piles to be burnt in the coming winter					
21	Erinvale	Golf Estate (Fairways)	Fynbos	Possible	Insignificant	Minor	Low	Medium
22	Erinvale	Golf Estate (Dwellings)	Fynbos (5 - 9 years)	Possible	Minor	Moderate	Medium	High
23	Erinvale	Golf Estate (Fairways)	Fields and vineyards	Unlikely	Insignificant	Minor	Low	Low
24	Erinvale	Golf Estate (Dwellings)	Deciduous fruit orchards and fields	Unlikely	Minor	Moderate	Low	Medium
25	Lourensford Estate-Nuwedorp	Large farm (Dwellings)	Pine plantation and farm dam	Unlikely	Minor	Insignificant	Low	Low
26	Lourensford Estate	Large farm (Dwellings and offices)	Vineyard	Unlikely	Minor	Moderate	Low	Medium
27	Lourensford Estate - Vyeboom	Large farm (Dwellings - occupied and vacant)	Vineyards and deciduous fruit orchards	Unlikely	Insignificant	Moderate	Low	Medium
28	Lourensford Estate – “Die Ou Varkhokke”	Large farm (Offices and sheds)	Vineyards and fields	Unlikely	Minor	Minor	Low	Low
29	Lourensford Estate	Large farm (Seasonal worker hostel)	Vineyard	Unlikely	Moderate	Minor	Medium	Low
30	Lourensford Estate	Large farm (Sawmill)	Deciduous fruit orchards, vineyards and some IAPs	Possible	Minor	Major	Medium	High
31	Lourensford Estate	Large farm (Fields with trees)	Vineyards and deciduous fruit orchards	Unlikely	Insignificant	Insignificant	Low	Low
32	Lourensford Estate	Large farm (Packing shed)	Fields and vineyards	Unlikely	Moderate	Moderate	Medium	Medium
33	Lourensford Estate	Large farm (Wine cellar, restaurant and offices)	Deciduous fruit orchards and fields	Unlikely	Minor	Major	Low	High
34	Lourensford Estate	Large farm (Scattered dwellings)	Fields and IAP	Possible	Moderate	Minor	High	Medium
35	Lourensford Estate	Large farm (Parkland)	Deciduous fruit orchards	Unlikely	Insignificant	Insignificant	Low	Low
36	Fleur de Cap	Large farm (Manor House)	Fields	Unlikely	Minor	Moderate	Low	Medium

Paired Zone	Suburb / Farm	Settlement Type	Fuel		Consequence		Risk	
		Inside buffer	Outside buffer	Likelihood	Life	Economic	Life	Economic
37	Vergelegen	Large farm (Restaurant, historical buildings and old Camphor trees)	Fields and orchards	Unlikely	Minor	Major	Low	High
38	Vergelegen	Large farm (Offices and sheds)	Fields	Unlikely	Minor	Moderate	Low	Medium
39	Vergelegen	Large farm (Scattered dwellings)	Fields (degraded veld)	Unlikely	Moderate	Minor	Medium	Low
40	Vergelegen	Large farm (Worker houses)	Vineyards and fields	Unlikely	Moderate	Moderate	Medium	Medium
41	Vergelegen	Large farm (Wine cellar)	Vineyards	Unlikely	Minor	Major	Low	High
42	Vergelegen	Large farm (Vacant land)	Fields and orchards	Unlikely	Insignificant	Insignificant	Low	Low
43	Morgenster	Large farm (Cellars, sheds and offices)	Vineyards, olive orchards and field.	Unlikely	Minor	Major	Low	High
44	Morgenster	Large farm (Parkland)	Orchards	Unlikely	Insignificant	Insignificant	Low	Low
45	Riverside Park	Residential suburb (Cluster housing)	Orchards and Lourens River	Unlikely	Minor	Moderate	Low	Medium
46	Radloff Park	Sports field	Orchards and parkland along Lourens River	Unlikely	Insignificant	Insignificant	Low	Low
47	Heather Sage	Small farm (Scattered dwellings)	Orchard	Unlikely	Moderate	Minor	Medium	Low
48	Rome Glen	Residential suburb	Orchards and vineyards	Unlikely	Minor	Moderate	Low	Medium
49	Rome Glen	Residential suburb	Invaded natural veld	Likely	Minor	Moderate	Medium	High
50	Boskloof Eco Estate	Home owners association	Invaded natural veld	Likely	Moderate	Moderate	High	High
51	Fairhaven Country Estate	Development in progress	Invaded natural veld	Likely	Insignificant	Insignificant	Low	Low

Paired Zone	Suburb / Farm	Settlement Type	Fuel		Consequence		Risk	
		Inside buffer	Outside buffer	Likelihood	Life	Economic	Life	Economic
52	Pine Creek Estate	Residential suburb (Cluster housing	Agricultural fields	Possible	Minor	Moderate	Medium	High
53	Chris Nissan Village	Residential suburb (RDP type)	Fields	Possible	Major	Minor	High	Medium
54		Vacant land	Agricultural fields	Possible	Insignificant	Insignificant	Low	Low
55	AGS Pinkster Park	Church association	Invaded fields	Likely	Moderate	Moderate	High	High
56		Small holding	Agricultural fields	Possible	Moderate	Minor	High	Medium
57	Waterkloof	Small farm	Agricultural fields, vineyards, and invaded fields and natural veld (fynbos)	Likely	Moderate	Moderate	High	High
58	Waterkloof	Restaurant	Vineyards and Natural veld (fynbos)	Possible	Moderate	Moderate	High	High
59	Capelands Estate	Small farm	Vineyards and fynbos veld with invasive alien woody plants	Possible	Moderate	Moderate	High	High
60		Small holding	Vineyards and agricultural fields	Possible	Moderate	Moderate	High	High
61		Small farm	Vineyards and agricultural fields	Unlikely	Moderate	Minor	Medium	Low
62	Ingwe Wine Estate	Small farm	Vineyards	Unlikely	Moderate	Moderate	Medium	Medium
63		Small holding	Vineyards	Unlikely	Moderate	Minor	Medium	Low
64	Firlands Equestrian Park	Small holding and petrol station	Invaded agricultural fields	Likely	Moderate	Moderate	Medium	High
65	Elandskloof	Small holding	Natural Veld (Fynbos 10-16 years old)	Possible	Moderate	Minor	High	Medium
66	Blue Rock Cable Ski	Recreational area	Agricultural fields	Possible	Moderate	Moderate	High	High
67	Sir Lowry's Pass Village	Formal residential	Invaded agricultural fields	Likely	Minor	Moderate	Medium	High
68		Small holdings	Fields	Possible	Moderate	Minor	High	Medium

Paired Zone	Suburb / Farm	Settlement Type	Fuel		Consequence		Risk	
		Inside buffer	Outside buffer	Likelihood	Life	Economic	Life	Economic
69		Small holdings	Fields	Possible	Moderate	Minor	High	Medium
70		Small holdings	Vineyards	Unlikely	Moderate	Minor	Medium	Low
71	Ingwe Wine Estate	Small Farm	Vineyards and fields	Unlikely	Moderate	Moderate	Medium	Medium
72		Small Farm	Vineyards and fields	Unlikely	Moderate	Moderate	Medium	Medium
73	Kariba Farm	Small farm	Invaded agricultural fields	Possible	Moderate	Moderate	High	High
74	Mamerow and Onderkloof Farms	Small farm	Vineyards	Unlikely	Moderate	Moderate	Medium	Medium
75		Small holding	Agricultural fields	Possible	Moderate	Minor	High	Medium
76		Small farm	Vineyards	Unlikely	Moderate	Moderate	Medium	Medium
77		Small farm	Vineyards	Unlikely	Moderate	Moderate	High	Medium
78		Formal residential	Fields	Possible	Minor	Moderate	Medium	High
79	Gey Van Pittius Irrigation Schemes	Commercial	Fields	Possible	Minor	Moderate	Medium	High
80	Myrtle Grove, Ravensburg , etc	Small holdings	Vineyards	Unlikely	Moderate	Minor	Medium	Low
81	Journeys End Vineyards	Small farm	Vineyards	Unlikely	Moderate	Moderate	Medium	Medium
82	Groot Intimis	Small farm	Vineyards	Unlikely	Moderate	Moderate	Medium	Medium
83	Journeys End Vineyards	Small farm	Vineyards	Unlikely	Moderate	Moderate	Medium	Medium
84	Highberry Vineyards	Small farm	Vineyards	Unlikely	Moderate	Moderate	Medium	Medium
85	Wedderville Estate - Ridge	Property owners association	Fields and woodlot	Likely	Moderate	Moderate	High	High
86	Wedderville Estate – Westridge and Water's Edge	Property owners association	Fields	Possible	Moderate	Moderate	High	High
87	Wedderville Estate – Eastridge and De Werf	Property owners association	Fields	Possible	Moderate	Moderate	High	High
88	Wedderville Farming Partnership	Wine cellar	Vineyards and orchards	Unlikely	Minor	Major	Low	High
89	Wedderville Farming Partnership	Property owners association	Vineyards, orchards and fynbos	Possible	Moderate	Moderate	High	High

Paired Zone	Suburb / Farm	Settlement Type	Fuel		Consequence		Risk	
		Inside buffer	Outside buffer	Likelihood	Life	Economic	Life	Economic
90	Decapo Vineyards	Office building	Vineyards, trees , railway line	Unlikely	Minor	Minor	Low	Low
91	Wedderville Estate - Glades	Property owners association	Fields with some IAPs	Likely	Moderate	Moderate	High	High
92	Wedderville Estate – Farm 4 Meridien	Property owners association	Vineyards with IAPS	Likely	Moderate	Moderate	High	High
93	Wedderville Estate – Farm 2	Property owners association	Fields with IAPS	Likely	Moderate	Moderate	High	High
94	Wedderville Estate – Farm 1 Mellifera	Property owners association	Fields with IAPS	Likely	Moderate	Moderate	High	High
95	Knorhoek	Property owners association	Fields with trees	Possible	Moderate	Moderate	High	High
96	Knorhoek	Property owners association	Vineyards and woodlots	Likely	Moderate	Moderate	High	High
97	Bezweni Lodge (Casa Maris)	Boutique hotel / restaurant	Fynbos with invasive alien plants	Likely	Major	Moderate	Extreme	High
98	Knorhoek	Property owners association	Fields with woodlots	Likely	Moderate	Moderate	High	High
99	Tre Donne	Home owners association	Woodlots	Likely	Moderate	Moderate	High	High
100	Tre Donne + Goedverwachting Farm (Small farm)+Farm 42 + Woodlands Farm	Home owners associations & small farms	Fields with IAPs	Possible	Moderate	Moderate	High	High
101	Sir Lowry's Pass Village	Residential suburb & informal settlement	Fields	Possible	Catastrophic	Minor	Extreme	Medium
102	Sir Lowry's Pass Village	Residential suburb	Woodlots	Likely	Minor	Moderate	Medium	High
103	Sir Lowry's Pass Village	Informal settlement	Fields	Possible	Catastrophic	Minor	Extreme	Medium
104	High Riding	Home owners association	Fields with IAPs	Possible	Moderate	Moderate	High	High

Paired Zone	Suburb / Farm	Settlement Type	Fuel		Consequence		Risk	
		Inside buffer	Outside buffer	Likelihood	Life	Economic	Life	Economic
105	High Riding	Home owners association	Fynbos. fields and IAPS	Likely	Moderate	Moderate	High	High
106	High Riding	Home owners association	Fynbos and trees along railway	Possible	Moderate	Moderate	High	High
107	High Riding	Homeowners association	Invaded fynbos	Likely	Moderate	Moderate	High	High
108	Blue Rock Cable Ski	Recreational area	Invaded fynbos	Likely	Minor	Moderate	Medium	High
109	Firlands Park	Small holding	Old agricultural fields	Possible	Moderate	Minor	High	Medium
110	Sweetwaters Road	Small holdings (Protea Heights & Apricot Gardens)	Invaded fynbos (SANRAL & ASLA properties)	Likely	Moderate	Minor	High	Medium
111	Sweetwaters Road	Small holdings (# 57)	Invaded fynbos (ASLA properties)	Likely	Moderate	Minor	High	Medium
112	Blank							
113	Steenbras Lower Dam	Infrastructure (Bulk water supply)	Fynbos (10-15 years)	Possible	Insignificant	Insignificant	Low	Low
114	Steenbras Lower Dam	Infrastructure (Dwellings, Firlands sub-station & woodlot)	Eucalyptus woodlot	Likely	Minor	Minor	Medium	Medium
115	Gordon's Bay Dump	Dumpsite	Eucalyptus woodlot	Likely	Insignificant	Insignificant	Low	Low
116	Mansfield	Residential suburb (Cluster housing)	Eucalyptus woodlots	Likely	Minor	Moderate	Medium	High
117	Mansfield	Residential suburb	Fynbos (10 - 16 years)	Possible	Minor	Moderate	Medium	High
118	Mansfield	Residential suburb	Woodlot	Likely	Minor	Moderate	Medium	High
119	Mountainside	Residential suburb	Flammable fynbos	Possible	Minor	Moderate	Medium	High
120	Mountainside		Invaded natural veld (Fynbos with IAPs)	Likely	Minor	Moderate	Medium	High
121	Mountainside	Residential suburb	Natural veld (Old fynbos)	Possible	Minor	Moderate	Medium	High
122	Mountainside	Residential suburb	Fynbos (5 - 9 years old)	Possible	Minor	Moderate	Medium	High
123	Mountainside	Residential suburb	Natural veld (Fynbos)	Possible	Minor	Moderate	Medium	High

Paired Zone	Suburb / Farm	Settlement Type	Fuel		Consequence		Risk	
		Inside buffer	Outside buffer	Likelihood	Life	Economic	Life	Economic
124	Mountainside	Residential suburb	Natural veld (Fynbos)	Possible	Minor	Moderate	Medium	High
125	Mountainside	Residential suburb	Natural veld (Fynbos 5 - 9 years old)	Possible	Minor	Moderate	Medium	High
126	Die Vyf Huise	Staff housing – City of Cape Town	Natural veld (Fynbos 5 - 9 years old)	Possible	Minor	Moderate	Medium	High
127	Sunbird Resort	Resort	Natural veld, sea, river	Possible	Major	Moderate	High	High