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Integration of fire management systems in the Southern Cape region of South Africa

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ABSTRACT: Fire managers responsible for the planning and implementation of wildland fire prevention strategies, need integration of fire protection systems with various other disciplines such as nature conservation, riparian zone management, aesthetics, agriculture and forestry. In the Southern Cape, the different land uses form a complex mosaic in the landscape within contrasting topography, and subsequently create varying degrees of fire hazard in the region, particularly as a result of lack of concerted fuel reduction measures and wrong placement of fire break systems. In certain metropolitan districts a high population influx was also experienced, which aggravated urban interface problems in adjoining wildland vegetation communities. As a result, fire hazard has increased dramatically in most areas, and the past five years have seen a substantial increase in the number of wildfires and area burned, causing millions of Dollars of damage to properties, and even the loss of lives.

In this study a holistic approach was followed to address the fire hazard problems of the region as follows:

- Major wildfires that occurred in the past were mapped.
- The most important vegetation (fuel) bases were classified.
- A fire risk analysis in the area was done to identify assets that needed critical protection.
- Existing fire protection systems were evaluated, such as:
- Fire break routes and other fire-line specifications, considering the outcome of fire hazard rating.
- Dynamic and static (natural and man-made) fuel changes over time.
- Water flow management was integrated with prescribed burning regimes; with particular emphasis on fire management within riparian zones, in mountain catchment areas.
- Integration of weed control programs.
- Integration of nature conservation policies for natural temperate forests and fynbos, and considering the maintenance of biodiversity of each biome.
- Identifying – and incorporating solutions for – urban interface problem areas.

The improved, integrated, fire management system, provided for the region, will not only result in a reduction of wildland fire damage, but will also be more cost-effective. Continuous fire breaks will now be situated along strategic lines in the landscape, with specifications that will

form significant fire protection buffers during wildfire conditions, from which wildfires can be controlled effectively. While considering population pressure and ecological requirements in particular, but also the sustainability of forestry and agricultural crops, integrated fire protection has proved to be an internationally acceptable solution to combat increased fire hazard.

1 BACKGROUND

The Southern Cape forms part of the Western Cape Province of South Africa, and is situated between the Indian Ocean in the south and the Outeniqua mountains in the north. The region presents a landscape full of topographical, floristic and man-made contrasts. The two main topographical features found in the region are the broken terrain of the mountain range, mainly covered with fynbos vegetation, and the lower lying plateau bordering the Indian Ocean. The vegetation mosaic of the plateau is mainly consisting of a mixture of coastal fynbos vegetation, indigenous montane forests, even-aged industrial timber plantations and agricultural land (Fig.1).

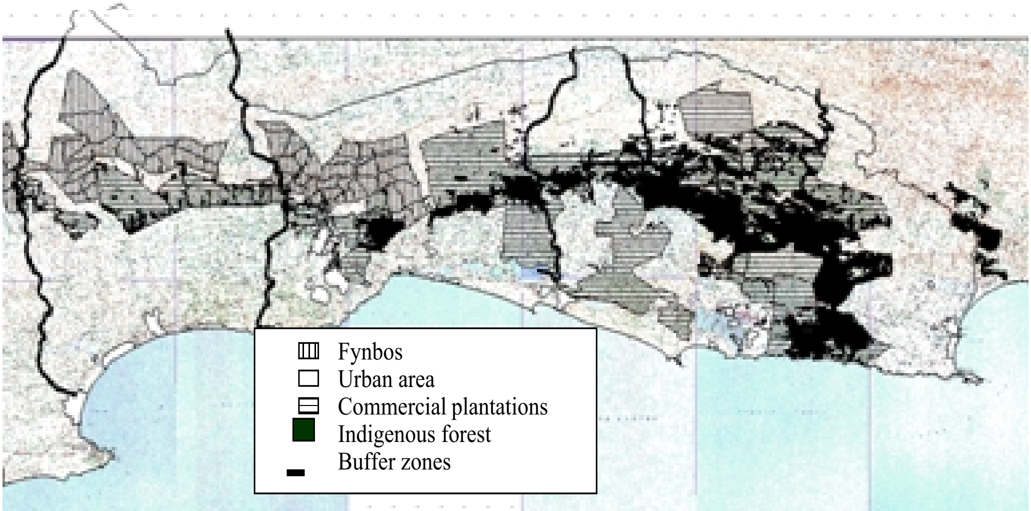

Figure 1. The Southern Cape (R. Basson).

1.1 *Weather*

The climate of the region has been classified as Cfb (moderate humid) according to the Koppen classification (Thwaites, 1987). This indicates that temperatures during the coldest months are between –3°C and 18°C, while during the warmest months the average temperature is below 22°C, with no distinct wet season. The weather is largely controlled by the passage of cold fronts (Tyson, 1971). Mean annual precipitation for George (situated in the centre of the region) is 962 mm (Thwaites, 1987). However, a sharp rainfall gradient exists between the mountains and the ocean, which ranges from a low 350 mm/year near the coast, to more than 1200 mm/year on the highest mountain peaks of the Outeniqua mountains. Bergwinds occur during the winter months, which blow from the general northwesterly direction, towards the sea. These strong winds create high air temperatures and a low relative humidity, mainly during the winter period. They then create favourable conditions for extreme fire hazard (Tyson, 1971).

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1.2 *Demographic profile*

The Southern Cape has a population of approximately 270 000 people, of which 14% can be classified as rural-urban, and 86% as urban (South Cape District Council, 1999).

This region was traditionally associated with a forestry industry, linked to the indigenous forests. When these forests were over decades over-exploited, exotic (mainly *Pinus*) species were established in the form of even-aged industrial plantations to replace this timber source, which currently covers approximately 6% of the region (Norman & Horn, 2001).

Mixed farming is another important form of land use in the region, while fynbos covers most of the land at higher altitude, or on the plateau, where it is in most cases growing on poor sites, unsuitable for agriculture.

1.3 *Fire ecology*

In the Southern Cape region, three natural biomes are found:

- Fynbos: This unique floral kingdom of the world is well adapted to fire. It requires an optimum fire frequency of 12 - 15 years, when the climax succession stage is reached (Kruger and Bigalke, 1984). Fynbos needs a high intensity fire to maintain biodiversity, but if it reaches the scenescent phase (older than 30 years of age), or if it has been invaded by exotics such as *Acacia*, *Hakea* or *Pinus* species, fynbos regeneration might be adversely affected by fires of extreme intensities. Fires occur mainly during summer, but can also occur during other seasons. The optimum burning season is between late November and mid-April (summer to early autumn).
- Afromontane forest: This biome is usually fire resistant and will not support a wildfire, unless disturbed by man (*e.g.* as a result of timber exploitation). The eco-tone of forests requires fire to maintain biodiversity of forest pioneer species (Rutherford & Westfall, 1994). Most of these forests occur on the coastal plateau, but they are also found in patches on the foothills, and in depressions of the Outeniqua Mountains.
- Grassland: The grassland in this region cannot be regarded as a natural biome, but rather as a combination of grassy fynbos during the young phase of development, human activities and disturbances of natural vegetation communities (Low & Rebelo, 1998).

2 METHODS

Local authorities maintain records of most of major fires. This data was analysed to study fire frequency. Results from this preliminary analysis are illustrated in Figure 2. It was also determined that the most serious fire hazard was from a northwesterly direction. The approximately 70 000 ha indigenous (montane) forest forms a natural buffer zone against wildfires, and is situated mostly in wind-shadow areas in the landscape (Fig. 2). These forests can be used to advantage when they are incorporated as regional buffer zones in fire protection systems, as they are highly resistant against fires (Geldenhuys, 1994).

A broad regional fuel classification was developed for the region by using both the natural vegetation biomes of the region (*e.g.* fynbos and indigenous forests), as well as manipulated fuel systems (*e.g.* industrial plantations and agricultural land) as classes. These classes were mapped with different colours to indicate fire behaviour, based on criteria developed by de Ronde (1980), who used parameters such as fuel load, fuel depth, fuel density, fuel availability, plant succession characteristics, and topographical features to arrive at such a classification.

A fire hazard risk analysis was created during a workshop, where most of the important landowners and managers of the Southern Cape region were present. An electronic version of the analyses was distributed amongst to landowners in the region for comments.

Information gathered, in the way described above, is necessary to draw up an integrated fire management plan. This plan is implemented in three phases, namely the regional, evaluation and application phases (de Ronde and Masson, 1998).

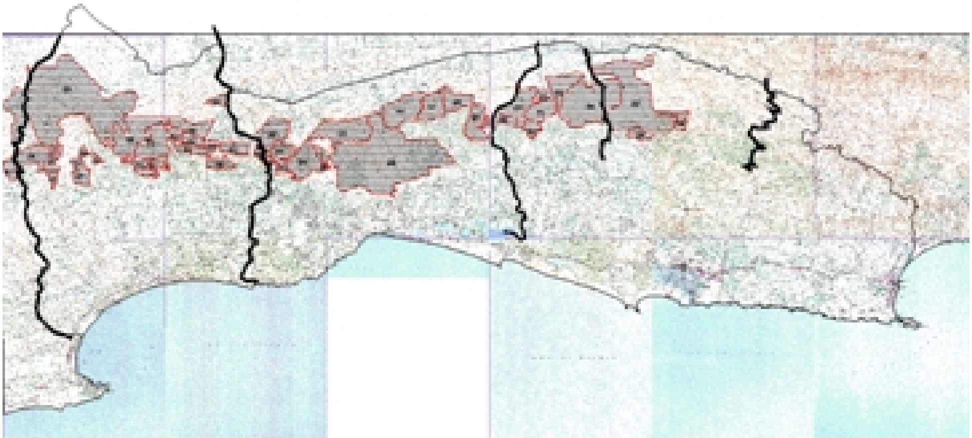

Figure 2. Fire history occurrence pattern, and buffer zones, of the Southern Cape (R. Basson). Black lines represent buffer zones and the horizontally striped areas represent fire history (year of burning provided in each case).

3 FIRE HISTORY AND STASTISTICS

Fires have always been a significant part of the ecology of the Southern Cape. The unique characteristics of the natural vegetation, that has adapted to survive and maintain biodiversity in the presence of fire, provides adequate prove of this phenomena (Kruger & Bigalke, 1984). As early as during 1862, devastating fires have been reported in the region (Hall, 1984). Figure 3 provides an overview of fire losses that were recorded in the Southern Cape industrial plantations between 1979 and 1997.

Causes of fires are a big concern and need to be investigated, to prevent future uncontrolled fires, particularly during extreme fire danger periods. Van der Sijde (in press) states that 41% of the fires that occurred in industrial plantations of the Western Cape (including the Southern Cape region) between 1994 and 1999 were serious, large, fires. Of this percentage, 1.7% of the fires caused 93% of all the losses experienced in these plantations. Although only 534 fires were recorded during this period, it appears that fires are usually large in terms of area burned. The main causes of fires are illustrated in Table 1.

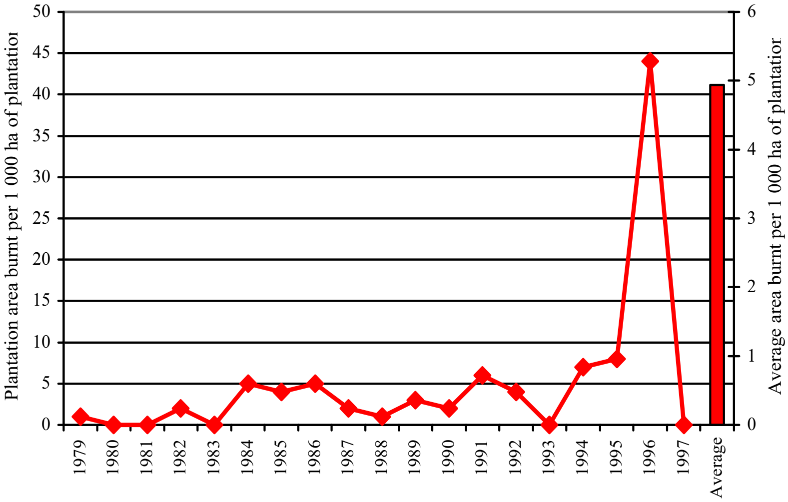

Figure 3. Plantation area burnt per 1000 ha, in the Southern Cape (van der Sijde, 1999)

Table 1. Causes of fires in SAFCOL industrial plantations, that occurred during the 1996-2000 period (van der Sijde, 1999).

Cause	**Average**
Arson	35.5
Unknown	15.6
Lightning	7.2
Honey hunters	12.2
Neighbors	7.3
Fire breaks	5.5
Power lines	1.7
Smokers	4.6
Other	10.5
Total %	**100.0**

4 FIRE HAZARD

A hazard can be defined as any condition (chemical, physical, social or political) that has the potential of causing damage to people, property/produce or the environment (Shields, 2002).

The Southern Cape is experiencing an increased fire hazard, and this can be attributed to the following: (i) Increased urban development, (ii) spreading of alien invaders in natural plant communities, (iii) increased fire risk associated with forestry (primarily) and agricultural activities (secondary) and subsequent fuel management problems and (iv) a general decrease in the use of prescribed burning for fuel management purposes, particularly in fynbos reserves and industrial plantations.

The impact of wildland fires on the various industries and people of the Southern Cape - particularly on the rural poor - cannot be over-emphasized. To classify fire hazard in the region, a simple matrix was developed (Table 2).

Table 2. Hazard/Chance of Fire (Shields, 2002).

LEVEL	DESCRIPTION	EXAMPLES
5	Almost certain	Expect to occur each year
4	Likely	Every 2nd year
3	Possible	Every 5 years
2	Unlikely	Every 10 years
1	Rare	Might occur every 25 years

Fire hazard is dependent on vegetation types (natural biomes) and fuel types and are influenced by factors such as elevation, aspect, urbanization, local weather conditions, distance from public roads and railways, and human activities.

Fuel classification can assist in determining the status of fire hazard. Fuel modeling, and the application thereof to assist in classifying fuel using fire behaviour models such as BEHAVE (Rothermel, 1972 and Burgan & Rothermel, 1984), has been used to advantage to arrive at a regional classification for the Southern Cape (de Ronde, 2000):

4.1 *A - Extremely high fire hazard (Red)*

This fuel class is classified as a heavy fuel load (> 18 tons/ha), with a fuel depth > 2.5m, and a >70% available fuel load.

A1 Fynbos >15 years (mature and senescent phases). Total dry biomass reaching up to 75 tons/ha (Kruger and Bigalke, 1984)

A2 Unmanaged *Acacia mearnsii* (Black Wattle) and *Acacia melanoxylon* (Blackwood), with a total dry biomass >30 tons/ha.

A3 Weed infested young plantation (1 –6 yr old). Up to 3 m fuel depth strata, with a biomass of up to 10tons/ha.

A4 Rural settlements situated on the dangerous, bergwind-exposed, side of commercial plantation boundaries.

A5 Coastal fynbos invaded by *Acacia Cyclops* (Rooikrans). Biomass: Up to 25 tons/ha (pers. comm. Scholes)

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4.2 *B – High fire hazard (Orange)*

Fuel loading 13 – 18 tons/ha, with a fuel depth of 1.8 – 2.5 m. Available fuel 50 – 70%.

B1 Mature plantations, with a high fire hazard during bergwind conditions. Total fuel biomass can reach 150 tons/ha, but with a wide range of ignition classes. The forest floor litter layer is easily ignited when dry, and can have a biomass of up to 5 tons/ha. Crown biomass (mainly living fuel) can be up to 10 tons/ha, which can only be ignited from a high intensity surface fire. The crown biomass also consists of approximately 10 tons/ha of branches.

B2 Young wattle or weed jungles (unmanaged), reaching up to 15 tons/ha in available fuel loading.

B3 Old Eucalypt fire breaks with a total fuel biomass of up to 100 t/ha, but with only an average of 10 tons/ha available fuel (mainly litter and bark).

B4 Areas adjoining rural settlements have a high ignition frequency, but a typically low and fragmented fuel load due to grazing, paths and cultivation.

B5 Approx. 8-year old fynbos, with a total biomass of up to 10 tons/ha.

B6 Weed infested riparian zones (approx. 8 tons/ha) (pers. comm. Scholes).

4.3 *C - Medium fire hazard (Yellow)*

This fuel class has as a medium fuel biomass of 8 – 13 tons/ha. Fuel depth: 1.0 – 1.8 m and available fuel 40 – 50%.

C1 4 – 6 year old fynbos (approx. 8 tons/ha, Kruger and Bigalke, 1984)
C2 Patchy young weed or Wattle jungles, with a total biomass of approx. 10 tons/ha.
C3 8 – 12 year old industrial plantations, with a total crown canopy biomass of up to 60 tons/ha, of which approx. 10 tons/ha is available fuel.
C4 Recently pruned plantation stands with an approx. 10 tons/ha slash biomass (pers. comm. Scholes, 2001).

4.4 *D - Low fire hazard (Green)*

Low fuel loading: 4 – 8 tons/ha. Fuel depth: 0.5 – 1.0 m, with low available fuel level (25 – 40%).

D1 Areas adjoining well managed industrial plantations. Biomass: up to 10 tons/ha
D2 Mechanically prepared and sown, static, grazing camps (pastures). Mostly green biomass: <2 tons/ha with fuel levels controlled by means of grazing.
D3 4 – 5 Year old industrial plantations. Total Biomass up to 20 tons/ha, of which 3 tons/ha will be available fuel (pers. comm. Scholes).

4.5 *E – Very low fire hazard (Blue)*

This fuel class is classified as a very low fuel load (<5 tons/ha), with a fuel depth of < 0.5 m and < 25% available fuel.

E1 0 – 2 year old fynbos, with <5 tons/ha biomass.
E2 Mature plantations with little on no undergrowth, up to 5 tons/ha litter layer.
E3 Heavily grazed grassland, reaching a biomass less than 1 tons/ha.
E4 One-year old industrial plantations with <6 tons/ha total biomass (pers. comm. Scholes).
E5 Indigenous Forest: Fire damage to forests occurring along the forest edges and seldom to the main forest, due to high maintained moisture conditions (Kruger and Bigalke, 1984).

5 PLACEMENT OF BUFFER ZONES

Wildfire history, regional fuel classification, fire hazard mapping and landscape studies were used to determine where the main regional buffer zones should be placed in the Southern Cape. The following criteria were considered for this purpose:

- Incorporate natural protection features where possible, such as watersheds, constantly flowing rivers and indigenous forests,
- Include major roads, suitable prescribed burning areas/compartments (natural as well as plantations) and cultivated lands,
- Where possible, incorporate recent wildfire areas,
- Place the zones as near as possible at 90 degree angle with the most likely direction of maximum fire spread,
- Ensure that the buffer zones form continuous lines, from the safest possible starting to ending points, and
- Provide adequate width, using favourable topography from where a counter (back-) firing

line can safely be constructed in the event of an approaching wildfire.

Four buffer zones are proposed for Southern cape region, and their routes are illustrated in Figure 2. Placement of these buffer zones will form the final step in the regional phase programme of the integrated fire management plan for the Southern Cape, and the compiling of the strategic (regional) fire protection plan. This will then form the basis for the next two phases (evaluation and application phases still to be conducted) to complete the integrated fire protection plan:

E*valuation phase*

- Fuel modeling, fuel classification (at a smaller scale) and fire hazard rating
- Mapping of fire hazard over time
- Evaluating existing fire protection measures

Application phase

- Placing of local (internal) buffer zones
- Calculating and placing external fire breaks
- Reducing the internal areas at risk
- Prioritizing fire break preparation and prescribed burning priorities
- Fire protection plan maintenance

6 CONCLUSIONS

The complicated mosaic of land use, vegetation types, topographical contrasts and population spread dynamics in the Southern Cape, required a unique approach to regional, integrated fire protection. Elsewhere in southern Africa similar regional fire protection strategies have been followed in the past (de Ronde, various unpublished reports), but they were in most cases applied in a dominating, dynamic grassland base, with some industrial plantations. The Southern Cape provided us with a rare opportunity to test the effectiveness of the approach in a significantly different landscape mosaic.

The regional phase of this study proved that the integrated fire management approach can be applied in regions with a range of characteristics, and its use in southern Africa and abroad is strongly is recommended.

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